This document was produced
by scanning the original publication.

Ce document est le produit d'une
numérisation par balayage
de la publication originale.

GEOLOGICAL
SURVEY
OF
CANADA

1890-91

PT. 1

Department of Mines & Technical Surveys
GEOGRAPHICAL
BRANCH
LIBRARY

GEOLOGICAL SURVEY OF CANADA

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

ANNUAL REPORT

(NEW SERIES)

VOLUME V

PART I

REPORTS A (1890), A (1891), D, E, F, G, L, M

1890-91

OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY

1893

To the Honourable
T. MAYNE DALY, M.P.,
Minister of the Interior.

SIR,—Herewith I have the honour to submit Volume V. (new series) of the Reports of the Geological Survey of Canada.

This volume of 1566 pages consists of 13 separate reports, bound in two parts, with maps and illustrations descriptive of the geology, mineralogy and natural history of the various sections of the Dominion to which the several reports relate. These have been published separately at intervals during the past eighteen months, and can be purchased at prices from ten to twenty-five cents each. Any of the maps published by the Survey can also be purchased on application to the librarian at ten cents each.

I have the honour, Sir, to be
Your obedient servant,

ALFRED R. C. SELWYN,
Director.

TABLE OF CONTENTS.

PART I.

REPORT A (1890).

SUMMARY REPORT ON THE OPERATIONS OF THE GEOLOGICAL SURVEY FOR THE YEAR 1890, BY THE DIRECTOR.

	(A.) PAGE
Act relating to the Geological Survey of Canada	3
Preparation of Annual Report, Vol. IV., 1888-89	7
Explorations and Surveys	8
Examinations by the Director	8
British Columbia	16
Athabasca	21
Manitoba	26
Ontario	37
Quebec	44, 57
New Brunswick	53
Nova Scotia	58
Museum and Office Work.	62
Mineral Statistics and Mines	62
Chemistry and Mineralogy	66
Palæontology and Zoology	70
Botany	80
Maps	83
Library	85
Visitors, Staff, Appropriation, etc	86

REPORT A (1891).

SUMMARY REPORT ON THE OPERATIONS OF THE GEOLOGICAL SURVEY FOR THE YEAR 1891, BY THE DIRECTOR.

	(A.) PAGE
Usefulness of Geological Survey	3
Assistance from Foreign Scientists	5
Explorations and Surveys	6
Examinations by the Director	6
British Columbia	16

(A.)

	PAGE
Explorations and Surveys—Con.	
Alberta	18
Manitoba	19
Ontario	25
Quebec	35
New Brunswick	48
Nova Scotia	52
Museum and Office Work	60
Mineral Statistics and Mines	60
Chemistry and Mineralogy	64
Palæontology and Zoology	75
Botany	85
Maps	89
Library, Visitors	91
Staff, Appropriations, etc	92

REPORT D.

ON A PORTION OF THE DISTRICT OF ATHABASCA, COMPRISING THE COUNTRY BETWEEN PEACE RIVER AND ATHABASCA RIVER, BY R. G. McCONNELL.

(D.)

	PAGE
Introductory	5
Previous Explorations	5
Physical Features	6
Description of Routes	8
Athabasca River to Peace River by way of Pelican, Wabiscaw and Loon Rivers	8
Peace River	13
Red River	15
Lesser Slave Lake	17
Lesser Slave Lake to Wabiscaw River by Whitefish, Bear and Trout Lakes	18
Athabasca River	22
Athabasca River to Moose Lake	24
List of Elevations	26
Geological Sections	27
Little Slave River to Lake Athabasca	27
On tributaries of the Athabasca	36
Lesser Slave Lake, Wabiscaw and Loon Rivers	40
On Red River	42
Plateaus	43
Peace River	45
General Geology	50
Archæan	50
Cambrian, Devonian	51
Cretaceous	52
Glacial Geology	59
Economic Geology	62

REPORT E.

ON NORTH-WESTERN MANITOBA, WITH PORTIONS OF ASSINIBOIA AND SASKATCHEWAN, BY J. B. TYRRELL.

	(E.) PAGE
Introduction	5
Historical Sketch	12
Physical Geography	22
Table of Meteorological Observations	56
The Lacustral Plain	34
Lake Manitoba	34
Lake Winnipegosis	46
Lake Dauphin	69
Mossy River	73
Swan Lake and Shoal River	75
Red Deer Lake and River	78
Cedar Lake and Saskatchewan River	79
Physical Geography and Geology	81
Country west of the Lakes	81
Swan River and Tributaries	105
Porcupine Mountain	118
Red Deer River	121
Duck Mountain	126
Assiniboine River	135
Descriptive Geology	144
Saskatchewan River	144
Lake Winnipegosis	153
Dawson Bay	172
Red Deer River and Swan Lake	187
Lake Manitoba	190
Systematic Geology	199
Silurian	200
Devonian	204
Cretaceous	209
Pleistocene	215
Economic Geology	219, 231

APPENDIX.

LIST OF PHOTOGRAPHS TAKEN IN THE SUMMERS OF 1887–90.

REPORT F.

ON THE SUDBURY MINING DISTRICT, BY R. BELL.

(F.)
PAGE

Introduction 5
Surveys 6
Geology 8
Vermilion River 8
Spanish River 9
Onaping Lake and River 9
The Straight Lake Huronian Outlier 38
General Remarks 41
Economic Minerals 46

APPENDIX I.

NOTES ON THE MICROSCOPIC CHARACTER OF ROCKS FROM THE SUDBURY MINING DISTRICT, BY PROF. G. H. WILLIAMS 55

APPENDIX II.

LEVELS OF LAKES ABOVE THE SEA 83

APPENDIX III.

REPORT BY H. H. LYMAN ON LEPIDOPTERA FROM THE COUNTRY NORTHWARD OF LAKE HURON 87

APPENDIX IV.

MEANINGS OF INDIAN GEOGRAPHICAL NAMES 91

REPORT G.

ON THE GEOLOGY OF HUNTERS ISLAND AND ADJACENT COUNTRY, BY W. H. C. SMITH.

(G.)
PAGE

Introduction 5
Physical Features 9
Archæan Rocks 17
Laurentian 18
Coutchiching Series 31
Character of the Rocks 31
Isolated Bands and Areas 32
Thickness of the Series 33
Keewatin Series 56
Character of some of the Rocks 62
Dikes 70
Glacial Phenomena 71
Economic Geology 74

REPORT L.

ON THE GEOLOGY AND ECONOMIC MINERALS OF THE SOUTHERN PORTION OF PORTNEUF, QUEBEC AND MONTMORENCY COUNTIES, QUEBEC, BY A. P. LOW.

	(L.) PAGE
Introductory	5
Archæan	7
Jambro-Silurian	26
Disturbance and Faulting	28
Distribution of the Trenton	33
Loraine	41
Superficial Deposits	47
Glacial Phenomena	48
Stratified Deposits	54
Marine Terraces	58
River Terraces	65
Economic Materials	67

APPENDIX.

NOTES ON THE MICROSCOPICAL CHARACTER OF SOME ROCKS OF THE COUNTIES OF QUEBEC AND MONTMORENCY, BY W. F. FERRIER.... 73

REPORT M.

ON PORTIONS OF THE PROVINCE OF QUEBEC AND ADJOINING AREAS IN NEW BRUNSWICK AND MAINE, BY L. W. BAILEY AND W. McINNES.

	(M.) PAGE
Introductory	5
Silurian	7
Cambro-Silurian	13
Cambrian	14

MAPS AND ILLUSTRATIONS.

VOL. V., PART I.

		PAGE
1.	Index map of the Peace River and Athabasca Region*	D
2.	Cliff of tar sands, Athabasca River	5D
3.	Vermilion Falls, Peace River	15D
4.	Nodules in Grand Rapids' sandstone, Grand Rapids, Athabasca River	28D
5.	La Saline, Athabasca River, showing deposit from mineral spring	35D
6.	View on Athabasca River, showing tar sands overlying Devonian Limestone	59D
7.	Section along the Athabasca Valley	D
8.	Section along the Peace Valley,	D
9.	Geological Map of North-western Manitoba, scale 8 miles to 1 inch.	E
10.	Map showing forest distribution in North-western Manitoba. Scale 8 miles to 1 inch	E
11.	Cliff of Middle Devonian dolomite, Dawson Bay, Lake Winnipegosis.	4E
12.	Plan and elevation of Mossy Portage, Lake Winnipegosis	54E
13.	Ice-shoved boulder, Pelican Bay, Lake Winnipegosis	62E
14.	" " "	64E
15.	Rounded bosses of Dakota sandstone, Kettle Hill, Manitoba	76E
16.	Sections, South Manitou Island and Devil's Point, Lake Winnipegosis.	168E
17.	Cliff of Upper Devonian limestone, Swan Lake, Manitoba	189E
18.	Sudbury Sheet, Districts of Algoma and Nipissing. Scale 4 miles to 1 inch	F
19.	Copper Cliff mine	1F
20.	Roast yard, Copper Cliff mine, Sudbury	41F
21.	General view of Murray Mine, Sudbury	47F
22.	Matte in stock, Copper Cliff mine	55F
23.	Sheet 7, Province of Ontario, Hunters Island Sheet. Scale 4 miles to 1 inch	G
24.	Unconformable contact of gneiss and Trenton limestone, near Montmorency Falls	5L
25.	Gorge in Trenton limestone at St. Alban bridge on the Ste. Anne de la Pérade, Que	34L
26.	Fault between Archæan gneiss and Trenton limestone and Utica shale, Montmorency Falls	44L
27.	Quarter sheet 18 S.E., Province of Quebec. Portions of Temiscouata and Rimouski counties and of New Brunswick. Scale 4 miles to 1 inch	M
28.	General section of Cambrian rocks, Temiscouata Lake to Rivière du Loup	20M

* The large scale maps mentioned on this Index Map are not yet completed for issue.

GEOLOGICAL SURVEY DEPARTMENT
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1890

BY

THE DIRECTOR

OTTAWA
PRINTED BY S E DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1893

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1890.

GEOLOGICAL SURVEY DEPARTMENT,
OTTAWA, 21st December, 1890.

The Hon. EDGAR DEWDNEY, M.P.,
Minister of the Interior.

SIR,—In submitting the customary annual summary of the work accomplished by the Geological Corps during the calendar year, 1890, it seems desirable to commence by stating that during the last session of Parliament the "*Act relating to the Geological and Natural History Survey of Canada and the Museum in connection therewith*," 40 Victoria, Chap. 9, was repealed and a new Act, 53 Victoria, Chap. 11, was passed, and assented to 16th May. 1890. The provisions of this Act read as follows:—

HER Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

Interpretation.

1. In this Act the expression "Department" means the Department of the Geological Survey hereby constituted.

Department constituted. Minister of Interior to preside.

2. There shall be a Department of the Civil Service which shall be called "The Geological Survey," over which the Minister of the Interior shall preside; and the said Minister shall have the management and control of the Department.

Staff of Department. To be under "The Civil Service Act."

3. The Governor in Council may appoint an officer who shall be the Deputy-Head and Director of the Department and such other officers, clerks and servants as are required for the proper conduct of the business of the Department, all of whom shall hold office during pleasure, and shall be appointed and classified under Schedule A of

"*The Civil Service Act;*" and in accordance with and under the terms of section six of the said Act:

Technical officers.

2. Such officers of the Department as are continuously engaged in the prosecution of original scientific work or investigation shall be classified as technical officers, under class (*b*) of Schedule A of "*The Civil Service Act,*" and the Governor in Council may cause to be prepared a list of such officers of the Department as are considered to be entitled to be thus classified with any designations that may be deemed expedient to indicate the scientific work in which they may be engaged.

Governor in Council may confer designations.

Qualification requisite in certain cases.

4. No person shall, after the passing of this Act, be appointed to this Department under class (*b*) of Schedule A of "*The Civil Service Act,*" unless—

Graduates of certain institutions.

(*a.*) He is a Science Graduate of either a Canadian or foreign University or of the Mining School of London or the *Ecole des Mines* of Paris or of some other recognized science school of standing equal to that of the said universities and schools, or a graduate of the Royal Military College, and in each case only after having served a probation of not less than two years in the scientific work of the Department; or unless—

Service in Department.

(*b.*) He has served a probation of not less than five years in the scientific work of the Department; or unless—

Experience elsewhere.

(*c.*) He has had experience for the same number of years in similar work, official or otherwise, elsewhere.

Objects.

5. The duties, object and purposes of the Department shall be:—

Geology, mines, natural history.

(*a.*) To make a full and scientific examination and survey of the geological structure, mineralogy, mines and mining resources of Canada and of its fauna and flora;

Collections and arrangements thereof.

(*b.*) To maintain a museum of geological and natural history and to collect, classify and arrange for exhibition in the museum of the Department such specimens as are necessary to afford a complete and exact knowledge of the geology, mineralogy and mining resources of Canada; to collect, study and report on the fauna and flora of Canada; to carry on chemical and palæontological investigations, and to make such other researches as will best tend to ensure the carrying into effect the objects and purposes of this Act;

(*c.*) To prepare and publish such maps, plans, sections, diagrams and drawings as are necessary to illustrate and elucidate the reports of surveys and investigations ; Maps, &c.

(*d.*) To collect and to publish, as soon as may be after the close of the calendar year, full statistics of the mineral production and of the mining and metallurgical industry of Canada ; to study the facts relating to water supply, both for irrigation and for domestic purposes, and to collect and preserve all available records of artesian and other wells, and of mines and mining works of Canada. Statistics. Water supply.

6. The Deputy-Head and Director of the Department shall, as soon as may be after the close of each calendar year, make a summary report to the Minister, of the proceedings and work of the Department for the year, and shall also furnish final and detailed reports to be issued from time to time in such a manner and form as the Minister directs ; and the Minister shall cause the same to be laid before Parliament, with such remarks, explanations and recommendations as he thinks proper. Reports. To be submitted to Parliament.

7. The Department shall be furnished with such books, instruments and apparatus as are necessary for scientific reference and for the prosecution of the survey ; and the Governor in Council may, from time to time, cause the enlargement of the museum, and the distribution of duplicate specimens to scientific, literary and educational institutions in Canada and other countries, and also the distribution or sale of the publications, maps and other documents issued by the Department. Enlargement of museum. Distribution of specimens and publications.

8. The Minister may, for the purpose of obtaining a basis for the representation of the geological features of any part of Canada, cause such measurements and observations and physiographic, exploratory and reconnaissance surveys to be made as may be necessary for or in connection with the preparation of geological maps, sketches, plans, sections or diagrams. Surveys.

9. Persons employed in one section of the Department may be directed by the Minister to perform any duty in or with respect to any other section. Duties of employees.

10. No person employed in or under the Department shall— Employees not to deal with public lands.

(*a.*) Purchase any Dominion or Provincial lands except under authority of the Governor in Council ;

(*b.*) Locate military or bounty land warrants, or land scrip, or act as agent of any other person in such behalf;

Nor to disclose information obtained.

(*c.*) Disclose to any person, except his superior officer, any discovery made by him or by any other officer of the Department, or any other information in his possession in relation to matters under the control of the Department or to Dominion or Provincial lands, until such discovery or information has been reported to the Minister of the Interior, and his permission for such disclosure has been obtained;

Work for individuals Interest in mines, &c. Saving.

(*d.*) Make investigations or reports relating to the value of the property of individuals, nor hold any pecuniary interest, direct or indirect, in any mine, mineral lands, mining works or timber limits in Canada.

11. Nothing in this Act shall be construed to invalidate or interfere with the commissions, as assistant directors, heretofore issued under Orders in Council to certain members of the scientific staff.

R.S.C. c. 23, repealed.

12. This Act shall be substituted for chapter twenty-three of the Revised Statutes, respecting the Geological and Natural History Survey of Canada, which is hereby repealed.

Date of coming into force of Act.

13. The foregoing provisions of this Act shall come into force on the first day of July, one thousand eight hundred and ninety.

Hitherto the Geological Survey has been regarded as a branch, or sub-department of the Department of the Interior; by the present Act it has been made a separate Department, and while the official designation of the organization has been changed, no change has taken place in its functions or in the duties with which it is charged, as set forth in section 5, subsections *a*, *b*, *c* and *d*, and in section 8. By the provisions of section 4 it is hoped to maintain the efficiency and high scientific standing of the Department, but in order to ensure this desirable result a scale of remuneration should be established in the Department, more in accordance than it is at present with that which obtains elsewhere, and even in other departments of the public service and in the universities of Canada, for acquirements and experience such as is required of the technical officers of the Geological Survey, and in view of the risks, hardships and responsibilities they are often called upon to undertake. It should further be borne in mind in considering this matter that the officers of the Department are strictly prohibited from engaging in the private practice of their profession, for which there

are many opportunities, and by which their incomes could be often largely augmented. As professors in the universities, there are no such restrictions laid on them, while the salaries are larger and the vacations longer. The result is that our best and most capable men seek employment elsewhere. Since July, 1887, four such cases have occurred. Three of these are now university professors with considerably larger salaries than they would have received had they remained on the Geological Survey.

In this connection it may not be out of place to quote the words of a leading article which appeared in the Montreal *Herald* on the 24th of February, 1885, as follows :—

"The field of operations of the Canadian Geological Survey is so vast, the interests involved so great and so far-reaching, the staff provided for the work so weak numerically, that it is important to all the interests at stake that such officers as are called upon to bear the responsibility of the duties of the Survey, should be the best obtainable, and their salaries in keeping with their high attainments."

The truth and applicability of the above remarks cannot be refuted; they are as pertinent now as they were in 1885, and, therefore, I venture to express a hope that in the consideration of the estimates for the Department for the ensuing year, they will receive due consideration.

The early part of the year now closed was, as usual, occupied by the members of the staff in the preparation of maps and reports, in studying collections gathered during the summer, and in otherwise working out the results of the observations made in the field in 1889. Some of the reports relating to this work have already been published, and others are passing through the press. These will together constitute the Annual Report, Vol. IV., 1888-89, to be issued during the winter.

Those already issued since the 31st December, 1889, are :—

Part A.—Vol. IV.—1888–89. Summary Report of Operations.

" B.—Report on a portion of the West Kootanie District, British Columbia.—Dawson.

" E.—Report of Exploration of the Glacial Lake Agassiz, in Manitoba.—Upham.

" K.—Report on the Mineral Resources of the Province of Quebec.—Ells.

" S.—Report on the Mining and Mineral Statistics of Canada for 1888.—Brumell.

" S.—Report on the Mineral Statistics and Mines for 1889.—Ingall.

" T.—Annotated List of the Minerals occurring in Canada.—Hoffmann.

Early in April arrangements were made to send out fourteen field parties. Four of these parties worked in two divisions, thus making practically eighteen parties in the field, distributed as follows :—

British Columbia	2	Quebec	4
North-west Territories, Athabasca District	1	New Brunswick	1
Manitoba	2	Nova Scotia	3
Ontario	2	Labrador	1

A brief summary of the operations of these several parties is submitted herewith, as also of the work done in the several divisions of the Department as under :

1. Mineral Statistics and Mines.
2. Chemistry and Mineralogy.
3. Palæontology and Zoology.
4. Botany.
5. Entomology.
6. Topography and Mapping.
7. Library. Sale and Distribution of Publications.
8. Visitors.
9. Staff, Finances and Correspondence.

The general progress of the field work has been satisfactory, though the resignation of members of the staff, already referred to, and others having to take up their work, has occasioned considerable delay in completing maps and reports and in the publication of result.

On the 17th of June I left Ottawa for Shelburne, Nova Scotia, to visit the gold fields first opened in 1886 at and near Caledonia Corner, and to investigate the probability of the same leads continuing southward and westward, into the county of Shelburne, and also to ascertain what would be the best plan of operation in commencing a detailed examination and survey of these western parts of Nova Scotia in connection with the occurrence of gold, in quartz veins or in placer deposits, or in regard to other economic minerals. I had, in 1870, visited and cursorily examined the same part of the Nova Scotia coast, having then made detailed notes on a journey from Digby *viâ* Weymouth, Cape St. Mary and Salmon River to Yarmouth ; and thence to Tusket, Shelburne, Liverpool and Bridgewater to Lunenburg, the Ovens and Chester, returning to Bridgewater and Liverpool *viâ* New Ross and Dalhousie, and from Liverpool to Annapolis *viâ* Caledonia. The present trip has enabled me to do little more than refresh my memory and to confirm the general accuracy of the conclusions then arrived at respecting the distribution of the granitic and gneissic rocks and the gold-bearing series, as subsequently delineated on the geological map.

On the 23rd of June a trip was made 28 miles up the river from Shelburne to Indian Fields, where some pits have been sunk searching for gold. The country here is tolerably open, much of it flat and swampy and covered with drift and a fine granitic gravel or sand, with few exposures of the underlying rocks, though doubtless such would be

found by following up the beds of all the brooks and small streams in the district. On the 24th of June I examined the route from Shelburne to Lockeport, and thence *viâ* Sable River, Port Joli and Granite River to Liverpool. On the 25th I drove from Liverpool to Caledonia, 30 miles inland, and found the rocks to be alternations of the "whin" and black slates of the Atlantic coast Gold Series or Lower Cambrian, as indicated on the published geological map. The gold field of Whiteburn, six miles south-west of Caledonia, was visited on the 26th. It is of limited extent, on an oval shaped anticline outcrop of the lower "whin" rock, surrounded by the upper black slate. The veins are parallel with the stratification. They are not more than from six to nine inches thick, and therefore costly to work, as about four feet of hard barren rock has to be mined in driving or sinking on them. Consequently, though the quartz is of more than average richness the profits are not large. The beds dip about 45° to S.E. On the 27th I left Caledonia for Bear River, on the Annapolis Basin. As regards the extension or recurrence of anticlines like those in which the Malaga and Whiteburn leads occur, further to the south-west, no definite statement can be made. That some such areas should be found in the unsettled country where the boundaries of the counties of Digby, Yarmouth, Shelburne, Queen's and Annapolis meet, and especially along the flanks of the central granite mass, the limits of which have not yet been traced, but which certainly occupies a considerable area in this district and which is crossed with a width of ten or twelve miles on the road between Maitland and Bear River, is most probable.

On the 2nd of July I returned to Ottawa, and then made arrangements with Professor Bailey of Fredericton, to commence a detailed examination of the south-eastern coast of Nova Scotia. His summary report of the work done in pursuance of this arrangement is now presented.

On the 11th July, after attending to correspondence and other departmental work, I left Ottawa again for Manitoba, the North-west and British Columbia. Deloraine, Morden and the Lowe Farm were visited in connection with the water supply question. The Turtle Mountain coal field was also examined.

In the summary report for 1889, the well then boring at Deloraine was referred to, and I said: "There seems every probability, when a sufficient depth has been reached, a good supply of artesian water will be obtained." I was at Deloraine on the 22nd of September, 1889, and the boring, then 1,340 feet deep, was progressing, but the available funds were exhausted. On the 29th of October, on my arrival in Ottawa, I recommended that a further special grant should be made

to continue the boring to the required depth, and stated that water might be expected between 1,500 and 1,600 feet. The grant recommended was assented to and in December, 1889, a depth of 1,475 feet had been reached when the contractor reported that he could not go deeper without enlarging the hole. The work incidental to this occupied him several months and in July, 1890, when I again visited Deloraine, I found the hole had been re-bored to only 1,180 or 295 feet less than it was in the previous December. On the 21st of October, 1890, the expected water was struck at a depth of 1,570 feet. It is of fairly good quality and has since stood at about 8 feet from the surface. Unfortunately at this point, the soft mud began to run in and block the hole and no efforts of the contractor were successful in clearing it, or in going deeper. It was essential that this should be done to give free flow to the water and to ascertain whether it would not overflow at the surface when the obstructions referred to were removed. The work requisite to effect this has proved both difficult and tedious, but is now, the 31st December, 1890, progressing favourably and it is hoped will terminate satisfactorily early in the ensuing year.

The total expenditure to date on account of it has been $8,648.62. This has been derived and paid to the Deloraine Well Finance Committee, who had charge of the boring, as follows:—

Raised by municipal loan, grant from the Local Government and by subscription..	$4,482 78
From Geological Survey appropriation, 1889-90.....	500 00
From special appropriation of $2,000 voted by Parliament in 1890.....	1,997 54
From special appropriation of $10,000 voted by Parliament in 1891.....	1,668 30
	$8,648 62

The well is still incomplete and it is impossible to state what further amount will be required to complete it, but it is hoped the cost in 1891 will not exceed an additional sum of $2,000.

There seems little or no hope of finding any deep seated sources of fresh water in the Red River valley, east of the Pembina escarpment, or the first prairie-step. In places, however, a limited supply of fairly good water is obtained from shallow wells sunk in the superficial deposits of sand, clay and gravel with which the region is overspread. These deposits are very irregular in character and vary greatly in thickness, ranging from 0 feet to nearly 300. At the Lowe Farm, range 1, township 4, section 31, they were penetrated to a depth of 170 feet, leaving off in sand, with a supply of salt water which stands at 3 feet from the surface. Seven miles to south-west on range 2, town-

ship 4, section 17, a well was sunk 205 feet, the bottom being in similar sand with salt water which flows over slowly. Whether fresh water or salt water will be found in wells sunk in these deposits, within the area under consideration depends, in the first case, on the occurrence of permeable strata, that are not inclosed between others of an impermeable character, but communicate with the surface, and in the second case, on the character of the beds which immediately overlie the rocks from which the saline waters issue, with a strong upward pressure. If these beds are impermeable, then no salt water would be found in the wells above referred to that do not penetrate into the underlying salt water-bearing strata, as is the case at Rosenfeld, and at Morden, where, last year, a boring was made to a depth of 600 feet, and as had been predicted, salt water only was found. The upper strata of the superficial deposits in the Red River valley are largely impermeable dark clays sometimes reaching, as in the Lowe Farm wells, a thickness of 140 feet. These, of course, prevent any direct downward percolation and thus account both for the original swampy condition of large areas in the magnificent fertile belt of country which lies between the Red River and the base of the Pembina escarpment, and also for the general absence, or only very limited supply of fresh water in the wells of this district.

In the Turtle Mountain coal field, range 24, township 1, several pits and bore holes have been sunk and in all seams of lignite-coal of workable thickness have been struck. In one pit, now full of water, but said to be 50′ 6″ deep, strata are stated to have been passed through as follows :—

	Feet.	Inches.
Surface	3	0
Dark clay	4	0
Coal	5	6
Clay shale	10	0
Coal	3	6
Sandy brown shale	6	0
Soft whitey brown sandstone	2	0
Sandy clay	6	0
Coal	1	6
Friable whitey brown sandstone	12	0
Bored from bottom of shaft—sandstone	20	0
	73	6

In another pit, 150 yards south of the one above described and about 15 feet higher, the coal was struck at 40 feet 4′ 6″ thick, then 12 feet sandy shale and thin bands of iron ore; coal 1′ 6″, then bored 35 feet through sandy shale; total 78′ 6″. This is the only pit from which any coal has been raised. An engine with winding gear and

shaft house have been erected here and a few tons of coal raised. This section is probably the most reliable, and omitting the upper 5′ 6″ seam of coal given in the first section which is probably a mistake—the two sections are much alike. The coal or lignite like that of the Souris at Roche Percée slacks on exposure and would not bear distant transport. The seams probably underlie the whole of the Turtle Mountain except where deep ravines have been cut out and have been filled in again with the superficial drift deposits. They will probably be found in places in township 1 from range 19 to 24. They could be mined at small cost, and for use among the settlers in the treeless country to the north and north-west between the Souris River and the Mountain would prove a cheaper and more economical fuel than wood.

I examined this district in 1883, and in the summary report for that year, page 2, it was stated "the evidence obtained clearly shows that there is every likelihood of workable seams being found here, as on the south flank of the mountains, at the head of Willow Creek in Dakota a seam has already been found showing from 3 to 5 feet of lignite of fair average quality." The seams now opened are doubtless the extension of those above referred to on Willow Creek, and as soon as railways are constructed to the mines, the lignite could be very advantageously distributed over a wide extent of country in which wood is even now scarce and costly and yearly becoming more so.

Leaving Manitoba on the 3rd of July, the first week in August was spent examining the sections between Banff, Field and Ottertail. Several promising deposits of silver-lead ore and copper ore were opened in this district in 1885-87. Some of them have changed hands since, more than once, at high figures, but the attempts to work them have been intermittent and insignificant. The Monarch mine, three miles and a half east of Field Station, is the only one on which any work was being done. At the time of my visit it was temporarily suspended, and the door of the gallery and level which have been constructed around the perpendicular face of Tunnel Mountain at 800 feet above the rails of the Canadian Pacific railway, was locked, and I could not examine the mine. This portion of the mountains and the mines that have been opened in them are well described in the Annual Report of the Geological Survey, Vol. II., Part D, by Mr. McConnell, 1886, and in Vol. III., Part R, by Dr. Dawson, 1888, and my present cursory examination has only enabled me to verify and to appreciate the accuracy of the reports referred to. That so little actual development has been achieved on these promising deposits on the Bow and Kicking Horse rivers since their discovery in 1886 is certainly to be regretted. It may in a great measure be attributed to the high prices at which the claims are held, the low grade of the ore and the cost of transport

to the smelter. The latter difficulty will, however, now be obviated by the construction this year of a smelter at Golden, already nearly completed.

A fine smelting plant has also been erected on the bank of the Columbia at Revelstoke. It was completed in the spring of 1890, but has not yet been put in operation. Last spring and summer, however, there was no immediate prospect of a sufficient supply of ore being available to keep the smelter running, nor was there likely to be till the Sproat-Nelson railway was completed. This, it is expected, will be accomplished this spring, and a great stimulus will then be given to the development and *bonâ fide* working not only of the West Kootanie mines, Nelson, Toad Mountain, Hendryx, Hot Springs and others, but also to the many promising but more distant deposits already discovered in the Selkirk and Rocky Mountain ranges between Golden, on the Columbia, and Castle Mountain, on the Upper Bow River. Seven days, from the 9th of August to the 16th, were occupied in a trip to Victoria, including two days with Dr. G. M. Dawson at Kamloops.

At Victoria very satisfactory arrangements were made by which to secure statistical and other information respecting the progress of mining development in the several remote and scattered mining districts in British Columbia. To effect this object, the Honourable John Robson, Provincial Secretary, very kindly issued the following circular letter to each of the District Commissioners of Mines :—

"VICTORIA, 18th October, 1891.

"SIR,—The Director of the Geological Survey Department, Ottawa, being desirous of obtaining full and prompt information appertaining to the mining and quarrying industries of the province, has suggeste the appointment of 'local correspondents' as a medium by which his purpose can be accomplished.

"In response to the desire expressed by Mr. Selwyn, I have to request that you will act in the capacity of local correspondent in your respective district, your functions as such, to consist in collecting general information on matters relating to new discoveries, new operations undertaken, and the progress of industries already established, and embodying the results of your inquiries in a letter at the end of each month. And also to supply information asked for in the accompanying directory book, which has been forwarded by Mr. Elfric Drew Ingall, the Mining Engineer in charge of the Division of Mineral Statistics and Mines.

"It is further requested that you will commence to exercise your functions on the lines indicated without delay, it being clearly understood that your monthly letter to Ottawa, will not interfere with your Annual Report to the Minister of Mines.

"All communications should be addressed to the Geological Survey Department, Division of Mineral Statistics and Mines, Ottawa, and need not be stamped, as all mail matter addressed to the Government Departments in Ottawa, is carried free by the post office.

"I am, Sir, your obedient servant,

(Signed) "JOHN ROBSON,

"*Provincial Secretary.*"

In response, already some valuable and interesting information has been received, and the Mining Bureau of the Department may now expect to be fairly well posted on mineral production and mining development in British Columbia.

Returning eastward to Illecillewaet on the 16th of August, the next day was occupied in a visit to the Lanark and Maple Leaf mines situated 3,000 feet above the railway. Except driving a prospecting tunnel, then in progress, to cut the leads at a lower level, not much work has been done and no important developments appear to have been made since the date of my visit in 1886. On the 18th I visited the newly opened Gold Hill camp. A good pack trail to this camp has been made by the Provincial Government; it starts from the right bank of the Illecillewaet at about five miles above the village and ascends rapidly for three miles and a half in a northerly direction to about 2,800 or 3,000 feet above Illecillewaet. The country is quite open and well grassed with scattered groves of spruce and fir in sheltered places. The whole ridge was marked off in claims, and a number of small openings had been made, nearly all on bands of a rusty red weathering calcareo-magnesian rock associated with dark calcareous and brown shades or schists, very similar to those seen in the section on the railway in the vicinity of Illecillewaet; irregular and mostly thin bands of galena are seen in all the openings. What those veins may turn out when further developed it is impossible to predict. As regards most of them, however, my impression of their probable value was not favourable. The ridge on which they are situated is a triangular block of country about twelve miles long which lies between the Illecillewaet River and its north branch and in which also the Lanark Maple Leaf and other mines are situated. The dip is fairly regular to E.N.E. $<35°$-$85°$, the veins run with the strike; but in dip appear often to pass from one bed plane to another, and are probably more nearly coincident with the planes of schistosity or cleavage than with those of bedding. In my Summary Report for 1887 in reference to the Illecillewaet black slates it was suggested they might be of Silurian (Ordovician) age. It is now almost certain they are near the base of the Cambrian and probably represent nearly the horizon of the silver-bearing Animikie rocks of Lake Superior; beneath them there is a

great thickness of flaggy, brown and grey quartzites and gneissic schists becoming more granitoid and crystalline to the westward. Much more detailed examinations, however, are required in eastern and south-eastern British Columbia before the precise relations of the different groups of strata can be definitely determined.

At Albert Cañon, near the base of the Illecillewaet dark slaty series, is a bed of excellent crystalline grey limestone apparently about 25 to 40 feet thick, it crosses the rails at the look-out platform with a dip of about 30° to N.N.E. and is very favourably situated for the establishment of a lime-burning industry. The occurrence of limestone in this region was not known when I mentioned it to gentlemen in Revelstoke. All the lime hitherto used there, and for considerable distances both east and west, having been brought from the Pacific coast.

From the 21st to the 29th of August was devoted to a trip from Revelstoke to the Kootanie mining camps, Sproat, Nelson, Hendryx and Hot Springs. For description and map of the district, Part B. of the Annual Report, Vol. IV., '89-90, can be referred to and my brief visit does not enable me to add anything of importance to Dr. Dawson's report above referred to. I may, however, express an opinion from what I saw that the mines in this district will prove much richer and more permanent than those of the Illecillewaet district. My reason for so thinking being based on the fact that experience has shown that the association of granitoid and other crystalline rocks, porphyries, felsites, diabases, &c., generally exerts a favourable influence on the productiveness of metalliferous deposits, and that, while such rocks are abundant in the Kootanie district, they appear to be entirely wanting or of very exceptional occurrence, in the ranges at the sources of the Bow and the Kicking Horse or Wapta rivers. As, however, they often occur in narrow bands or dykes they easily escape the notice of prospectors; they should, therefore, be carefully looked for, as in the richest mining districts to the south, they almost invariably accompany and are indicative of the most productive ore bodies.

On the 29th of August, a short time was spent at Canmore to look at the coal mines newly opened there on the seams on the right bank of the river described, pages B–132 and 133, Annual Report, Geological Survey, Vol. I., 1885. The three-feet seam is now being worked by a slope which starts on a terrace about 200 feet above the river, where a small outcrop of the measures is exposed dipping 50° to 60° to westward. In a level being driven into the hill to cross-cut the seams, about 100 feet below the slope, the dark shales associated with the coal had been struck at about 30 feet in dipping 30° to north-east, so that there must be either a fault or a steep anticlinal fold along the face of the hill. The coal is much crushed and slicken-

sided. It is apparently a semi-anthracite, like that from Cascade River—see analysis, Part M., Annual Report, Geological Survey, Vol. I., 1885. There can be little doubt that the Canmore seams are the extension of those of Cascade River and Anthracite on the opposite side of the Bow River valley. The mine is already connected by a branch railway with the station at Canmore ; an incline tramway and shipping stages have been constructed at the mine and there is now every convenience for handling a large output.

On the 30th of August I left Calgary for Macleod, with the intention of visiting the Crow's Nest Pass petroleum discoveries, but being unfortunately prevented from doing so, returned *viâ* Lethbridge and Dunmore to Manitoba and after again visiting the Deloraine boring reached Ottawa on the 19th of September.

The greater part of October and up to the 5th of November, was occupied with matters relating to the formal invitation from the Canadian Government to the members of the Iron and Steel Institute of Great Britain and the Association of German Iron Masters, then assembled in New York, to visit Canada. Nearly 100 members accepted the invitation and on the 29th of October, they were received at Niagara by a committee on behalf of the Canadian Government and were accompanied thence *viâ* Hamilton, Toronto and Sudbury to Ottawa and Montreal.

Dr. G. M. Dawson left Ottawa for field work in the southern part of the province of British Columbia on the 5th of June, returning on the 28th of October. He was assisted as before by Mr. J. McEvoy, and for a portion of the season by Mr. A. T. Kirkpatrick. Dr. Dawson furnishes the following summary of the work carried out :—

" At the conclusion of field work in 1889, there still remained a part of the area comprised in the ' Kamloops sheet ' of the geological map which had not been examined, and for which both geological and topographical information was required. This portion of the area of the proposed map included a belt of mountainous country to the west of the Fraser River, together with several other smaller separated areas, and the work necessary for the completion of the sheet naturally first received attention. As in former years, the topographical work was carried out chiefly by Mr. McEvoy, while the concurrent geological examinations occupied the greater part of my own time. The size and boundaries of the Kamloops sheet having been noted in the last Summary Report (p. 7), need not here be further alluded to.

" After finishing the work above referred to, necessary for the completion of this sheet to the degree of accuracy and detail which appears to be at present practically requisite, some time was spent on the area

of the adjoining sheet to the east, which it is proposed to designate the 'Shuswap sheet,' and before returning, in the autumn, a preliminary examination was also made of the geological section found in the Selkirk Mountains in the vicinity of the line of the Canadian Pacific Railway. This examination was undertaken principally with the object of connecting our knowledge of the rocks of the Interior Plateau (in the area of which the Kamloops sheet and most of the Shuswap sheet are included) with that of the formations of the Rocky Mountains proper, where palæontological evidences of age are more abundant and in which one section has been carefully examined and described by Mr. McConnell. Part D, Annual Report, Geological Survey, Vol. II., 1886.

"The working up of the topographical and geological data obtained for the Kamloops sheet, the plotting of sections and study of specimens brought back, are now in progress in the office, and will fully occupy the entire winter. No detailed report can be prepared till this work shall have been completed, but some points connected with last summer's field operations may be mentioned.

"It was found impossible to examine in much detail the Alpine region to the west of the Fraser, constituting the eastern border of the great Cascade or Coast Range of British Columbia, without the expenditure of a large amount of time; and as the rocks were found to consist for the most part of gray granites, monotonous in character and apparently of no economic importance, it was considered sufficient to gain a general knowledge of this region. In 1889, several high summits opposite the eastern front of this range and to the east of the Fraser valley had been occupied as transit stations and observation points, but in consequence of stormy weather and the smoky state of the atmosphere, even the main features of the range had been very imperfectly seen or delineated. To fix the main peaks in the range, two additional summits, each about 6,000 feet in height, were first occupied one being to the north and the other to the south of Lytton, and both on the east side of the Fraser. The Fraser River was then crossed at Lytton and three summits in the eastern part of the Coast Range itself were successively occupied as transit stations and look-out points, the heights of these being 8,130, 8,960 and 7,430 feet respectively. Some excursions were also made in the range, and the entire belt of foot-hills between its base and the Fraser was examined. In the course of this work several zones of schistose rocks which traverse the granites were outlined and the border of the Cretaceous rocks was definitely located for the whole distance. These latter rocks occur in the form of a long narrow trough (very imperfectly shown on the general map of 1877), which is followed by the Fraser River. They are most-

ly of Earlier Cretaceous age, being equivalent to the Queen-Charlotte Islands and Kootanie series,* and to the Shasta group of California. A small collection of fossil plants obtained at one place appears, however, to show that strata as new as those of the Dakota series are also included. The occurrence of these plant remains, together with the presence of carbonaceous shales in several places, affords some reason to hope that coal may exist in some part of the area occupied by the Cretaceous rocks in this portion of the province, though none has so far been discovered.

"A good general idea of the character of that part of the Coast Range which lies between the Fraser and Harrison and Lillooet Lakes, to the west of the Kamloops sheet, was gained from the high peaks ascended. The culminating mountains are rough and wide in outline, and though none of them are specially dominant in altitude, several attain or somewhat exceed a height of 10,000 feet. They include very extensive snow-fields and numerous small glaciers, and will afford an interesting and not extremely difficult field for alpine climbing and exploration.

"Later in the summer a log-survey of Kuk-waus or Bonaparte Lake was made. This lake was seen by Mr. McEvoy in 1889, but has not appeared on any published map. It lies forty miles north of Kamloops and proved to be ten miles in length. The Bonaparte River issues as a small stream from its west end, and the rocks along its shores are entirely granitic, though Tertiary basalt caps many of the hills at no great distance from it. On the south from this lake the eroded edge of the basaltic rocks to the west of the North Thompson was traced in detail.

"While the volcanic rocks of the Tertiary, just alluded to, and which cover large parts of the Kamloops sheet, often rest directly on granites or other ancient rocks, they also in certain districts form the upper member of a Tertiary series of some thickness, of which the lower part consists of ordinary stratified rocks locally characterized by the occurrence of coal or lignite. One of the more important results of the work now done on this sheet, is the definition of the areas in which such fuels exist or in which they may be sought for with reasonable prospects of success.

"The best known occurrences of coal or lignite in the area of the Kamloops sheet or in its immediate vicinity are those on the Nicola and North Thompson rivers and Hat Creek with that near the town of Kamloops. These have already been described, and no new facts of importance concerning them can be obtained till further exploratory work has been carried out by boring or otherwise. A reported coal

* Am. Journ. Sci., Vol. XXXVIII, p. 120.

discovery on the Bonaparte, within a few miles of Ashcroft, was visited, but proved to be unimportant, because of the thinness of the seam, and the very small area of the Tertiary outlier in which it is contained. It is, however, of interest as showing the occurrence of coal in the base of the Tertiary rocks of this vicinity, and points to the desirability of testing the adjacent larger Tertiary areas by boring, for which a site might be chosen to the north of the road between Câche Creek and Eight-Mile Creek. The further investigation of the coal-bearing basin near the town of Kamloops, should be made by boring near the line of railway and west of the town, or on the opposite side of the lake near the point at which the main irrigation ditch leaves the Tranquille River. A boring near the mouth of the Nicola would also be desirable, in order to test the possible extension of coal westward from the known outcrops near the mouth of the Coldwater, to the Thompson; while a boring in the western edge of the Tertiary near the mouth of the Nicoamen River, below Spence's Bridge, would not be without importance in the same connection.

"The metalliferous deposits in the vicinity of Stump Lake, referred to in the Summary Report for 1888 (p. 8) and in the Mineral Wealth of British Columbia (p. 69 R.), notwithstanding the favourable conditions for their development and the high assay value of some of the ores, have not yet assumed a position of permanent importance. The Nicola Mining and Milling Company have now sunk in the 'Joshua' shaft to a depth of about 400 feet, and have done considerable drifting, for the purpose of exploration, but with this exception 'assessment work' only has been carried out on the various claims taken up in this vicinity. The general parallelism and the evident connection of the veins of this locality with the outline of the great granitic area to the west rendering it important that this should be done, the remaining part of the line of contact of this granite with the stratified rocks was traced in detail. The vicinity of this line of contact, like that of several other similar contact lines and numerous places not distinctly connected with granitic masses, is characterized by a great abundance of vein quartz. Many specimens of such veins have been collected for the purpose of assay, the results of which it is hoped will afford some definite information as to the habitus and mode of occurrence of the gold and silver ores.

"A point of some interest in connection with the stratigraphy of the Kamloops sheet, is the discovery of fossils representing the characteristic Alpine Trias fauna, which was made last summer in the hills north-east of Savona. The evidence heretofore obtained pointing to the existence of these rocks in this part of the Interior Plateau region had been rather imperfect.

"In the course of the preliminary work done on the Shuswap sheet, the Monashee Mine, situated on the watershed between Cherry Creek and Kettle River, in process of development by Mr. D. McIntyre, was visited. There are at this place several distinct veins of auriferous quartz in which specks of free gold are frequently visible. These veins, in which points of gold are often visible, traverse Monashee Mountain, composed of quartzite, diabase (?) and limestone strata, near to the margin of a wide granitic mass, which lies to the south. Several small tunnels and openings have been made on the veins, and a small mill has been erected with a view to commencing work on the ore in the spring. A number of small specimens selected from the ore at the mouth of the principal working drift at this place, have been proved on assay by Mr. Hoffmann, to contain, gold 0·583 oz, silver 2·683 oz. to the ton.

"The preliminary examination of the section across the Selkirk Range, near the line of railway, which has already been alluded to, shows that the western part of this portion of the range consists of gneissic rocks and other crystalline schists of the Shuswap series,* probably Archæan. Above these, and further to the east, is a mass of rocks composed principally of dark argillites, passing into micaceous schists, with a thickness of about 15,000 feet. These evidently represent the Nisconlith series of the Interior Plateau and correspond in a general way to the Bow River series of the Rocky Mountains. The argentiferous lead ores of the vicinity of Illecillewaet occur in these rocks, which are believed to be of Lower Cambrian age.

"Overlying the Nisconlith series and forming a great synclinal in the axial part of the range, is a series chiefly composed of schists and quartzites, with apparently a total thickness of about 25,000 feet. This is believed to correspond to the Adams Lake schists on the west, and to the Castle Mountain group, with a portion of the upper part of the Bow River group in the Rocky Mountains, and very probably includes beds ranging in age from the Lower Cambrian to the Cambro-Silurian. Still newer strata appear to be represented on the eastern flanks of the Selkirk Range, probably representing the Graptolitic shales and Halysites beds of the Rocky Mountain section. The partial correlation of the beds of the Rocky Mountains proper with those of the Interior Plateau which this section enables us to reach, is a point of some importance, but the Selkirk and Columbian ranges require to be studied in greater detail before the different parts of the Cordillera in British Columbia can be satisfactorily compared."

---

* See Report on a Portion of West Kootanie District, 1889, p. 31B.

Mr. McConnell left Ottawa on the 2nd of May to continue the exploration of the Athabasca petroleum region, commenced in 1889. (See pp. 10 to 13 of the Summary Report for 1889.) On this season's work he reports as follows :—

"On the 19th of May I left Athabasca Landing, ninety miles north of Edmonton, with one canoe and two men. It was considered advisable to utilize the early part of the season in examining as many of the tributary streams as possible, as after July most of these become unnavigable, therefore little work was attempted in descending the river. Records of a number of interesting sections were, however, obtained at various points.

"We reached Fort Chipewyan, on Lake Athabasca, on the 3rd of June, and on the 15th left for the Birch Mountains. We ascended the Quatre Fourche Fork of Peace River, crossed Lake Mammawee and then by utilizing a number of old river channels and making a few short portages reached Lake Claire. This lake, together with Lake Mammawee and a large number of smaller water basins, occupies the delta-plain which stretches from the west end of Lake Athabasca far up the Athabasca and the Peace. They represent portions of Lake Athabasca separated from the main basin by accumulations of stream detritus. They are everywhere very shallow, and at ordinary stages of the water seldom exceed nine feet in depth even in their deepest parts. In seasons of exceptionally high water the low marshy plain separating them from the main lake and from each other is flooded, and they become united into one broad sheet of water. Lake Claire is the largest of the group, and has a width of from ten to fifteen miles and a length of from twenty-five to thirty miles. The northern part has not yet been surveyed. The shore line is irregular and is broken by a succession of long points and deep bays. At Pointe de Roche on the west side of the lake a greyish, granular limestone is exposed which holds *Atrypa reticularis* and is probably a continuation of the same Devonian limestone which is found along the Athabasca. This was the only exposure of the older rocks noticed on the part of the lake examined.

"The two principal streams flowing into Lake Claire are Cut-bank River and Birch River, both of which head in the Birch Mountains, the former draining the eastern and the latter the western slopes of the range. I ascended both these streams for some distance. Cut-bank River was followed for about thirty miles by the course of the stream, but probably not more than fifteen miles in a straight line, and then leaving the main stream I followed a tributary which led through a deep valley directly into the Birch Mountain plateau. In the lower part of Cut-bank River Devonian limestones cross the valley at several

points and form small rapids, but in the upper part only recent sands and clays are seen.

"The Birch Mountains were examined for the first time during the present season's exploration. They consist of an elevated plateau, runing in a north-and-south direction, or nearly parallel to the course of the Athabasca, from which they are separated by a flat, fifteen to twenty miles wide. The plateau is from fifteen to thirty miles wide. The surface is undulating and is broken by numerous lakes, most of which drain eastward into the Athabasca. Around the northern end the slopes are steep, and the highest points rise to an elevation of about 1,200 feet above Lake Claire, or about 2,000 feet above the sea. Further to the south the slopes become less abrupt and the relative elevation above the bordering plains is also somewhat less.

"Genetically the Birch Mountains are simply a denudation plateau and consist of almost horizontal Cretaceous strata. A band of yellowish and greyish sands and soft sandstones outcrops at various points around the northern end of the hills. These beds are destitute of fossils, but were referred on stratigraphical grounds to the horizon of the Niobrara. They contain small coaly seams, and some of the beds are blackened with bituminous matter, and resemble in this respect the Dakota tar-bearing sands found along the Athabasca. The sands exposed here have a thickness of 200 feet, but the base was not seen. They are overlaid by 150 feet of dark Pierre shales. The beds underlying the Niobrara and forming the base of the mountains were concealed at the point examined.

"Birch River and one of its tributaries, Swift-current Creek, were explored for some distance, but offered little geological information, as they have not cut through the alluvial mantle which covers in this region the older rocks.

"After returning from Birch River I coasted along the southern shore of Lake Athabasca as far as Point William, where I was stopped by the ice (June 25). This shore as a rule is low, and is bordered for long distances by low bluffs of stratified sands and clays. At Pointe de Roche, and at a couple of other places, the basement rocks come to the surface and were found to consist of a granular siliceous sandstone which, from its general character and position may be referred to the Cambrian, and probably belongs to one of the lower divisions of this system. For reference it may be called the 'Athabasca sandstone.' No fossils were found in it, nor was its contact with the overlying or underlying rocks observed. This sandstone is usually coarsely granular in texture, but occasionally passes into a fine-grained conglomerate. Its colour varies from white to dull red. Its bedding planes have been obliterated, but its general horizontal attitude is betrayed

by the textural differences. It is cut by two systems of jointage planes, and in weathering breaks up into huge blocks, some of which contain several hundred cubic yards of material. Numerous fragments, some of large size, of a mottled rather fine-grained sandstone, somewhat similar in appearance to that occurring at Sault Ste. Marie were noticed strewn along the beach, but were not found *in situ*. The Athabasca sandstone apparently extends all along the southern shore of Lake Athabasca, as specimens brought by Mr. Cochrane in 1882, from the east end of the lake cannot be distinguished in appearance from those collected at Pointe de Roche and neighbouring localities. Its extension southwards cannot be as yet approximately determined. On the north, its junction with the Archæan is concealed beneath the waters of Lake Athabasca.

"After leaving the lake, I ascended the Athabasca River, and on the way up examined portions of Muskeg River, Lower Steep-bank River, of Dr. Bell's map, Jackfish River, Steep-bank River, Red River and the North Pembina. A second trip was also made into the Birch Mountains, with Moose Lake situated on the summit of the range for its objective point. At the lake I was fortunate enough to obtain a couple of birch bark canoes, and on the return journey, Moose River, the outlet of Moose Lake, was followed in its headlong career down the mountain side and across the bordering plain to near its junction with the Athabasca. This river has a fall of 1,200 feet in about thirty miles, and in its course cuts through all the Cretaceous strata from the Pierre shales down to the Dakota sands.

"The valley of the Athabasca for a hundred miles above Lake Athabasca shows only alluvial sands, and the boulder-clays associated with stratified sands and gravels. Beds of rolled tar-sand pebbles occur in the latter in a number of places. A coarse gravel bed which immediately underlies the surface, and overlies the boulder clay was found to be completely saturated with soft tar. Ten miles below Calumet River the Devonian limestone rises to the surface of the valley from beneath the glacial beds and almost immediately afterwards is overlaid by the tar-bearing sands of the Cretaceous. From this point the Devonian limestones undulating at low angles, and accompanied by the tar-sands, are exposed at frequent intervals as far as Crooked Rapid, a distance of about eighty miles. At Crooked Rapid they become affected by a slight south-westerly dip and sink below the surface of the valley, and eight miles farther on, at Boiler Rapid, the tar-sands disappear, and are replaced by higher divisions of the Cretaceous.

"The tar-sands mentioned above belong to the Dakota formation and constitute in this region the basal member of the Cretaceous system. They rest uncomformably on the Devonian limestones. Litho-

logically they may be described as soft sandstone, the cementing material of which is a bitumen or inspissated petroleum derived from the underlying limestones. The sands are siliceous and usually rather fine-grained, but also grade occasionally into a coherent grit. The eastern boundary of the tar-sands was not precisely defined, but their outcrop was estimated to have a minimum distribution of fully 1,000 square miles. In thickness they vary from 150 to 225 feet. The tar is unequally distributed through the sands, in some places merely staining the grains, but in most of the sections examined it is present in sufficient quantity to render the whole mass more or less plastic. An analysis by Mr. Hoffmann of a specimen collected some years ago by Dr. Bell gave by weight:—

Bitumen	12·42
Water (mechanically mixed)	5·85
Siliceous sands	81·73

A cubic foot of the bituminous sand rock weighs, according to Mr. Hoffmann, 117·5 lbs. This figure multiplied by the percentage of bitumen, 12·42, gives 14·59 lbs. as the amount of bitumen present in a cubic foot, or $\frac{14 \cdot 59}{63 \cdot 7} = 22 \cdot 9$ per cent in bulk. At the minimum thickness of 150 feet, and assuming the thickness as given above at 1,000 square miles, the bituminous sand rock in sight amounts to 28·40 cubic miles. Of this mass, if the preceding analysis is taken as an average, although this is probably rather high, 22·9 per cent in bulk or 6·50 cubic miles is bitumen. This calculation can, of course, only be regarded as an approximation, but will serve to give some idea of the enormous outpouring of bituminous substances which has taken place in this region. The amount of petroleum which must have issued from the underlying limestones required to produce 6·50 cubic miles of bitumen cannot be estimated, as the conditions of oxidation and the original composition of the oil are unknown. It must, however, have been much greater than the amount of bitumen.

"A few miles west of the Athabasca the sand rock, still saturated with tar, passes below the higher divisions of the Cretaceous, and its extension in this direction can only be ascertained by boring. It was not recognized on Peace River nor on the lower part of Red River, and must disappear somewhere in the intervening region.

"In ascending the Athabasca the tar-sands, after an exposure of over twenty miles, pass below the surface at Boiler Rapid and are not seen again. Above this the upper divisions of the Cretaceous, influenced by a light south-westerly dip, and also by the grade of the stream descend gradually in the banks of the valley and disappear in succession. The Cretaceous section is as follows in descending order:—

		Feet.
Cretaceous.	Pierre shales	700
	Niobrara sand and sandstone	35
	Niobrara shales	90
	Niobrara sand and sandstone	300
	Benton shales	275
	Dakota tar-sands	175
		1,575
	Devonian limestone	

"The commercial value of the tar-sands themselves, as exposed at the surface, is at present uncertain, but the abundance of the material and the high percentage of bitumen which it contains makes it probable that it might, in the future, be probably utilized for various purposes. It proves a flow of petroleum to the surface unequalled elsewhere in the world, but its more volatile constituents have long since disappeared, and the rocks from which it issued are probably exhausted. In their extension under cover, however, the case is different, and it is here that oils of economic value must be sought. Above Boiler Rapid the tar-sands are overlaid by a cover of shales sufficient to prevent the oil from rising to the surface, and as we ascend the river this cover gradually thickens. The geological attitude of the cover is not the most favourable, as the beds dip away from the outcrop at the rate of about six feet to the mile, and it is possible that part or even the whole of the oil may have flowed northwards and eastwards through the Dakota sands and escaped where these come to the surface. It is unlikely, however, that all the oil has escaped in this manner, as small anticlinals in the covering beds are almost certain to exist, and a differential hardening of the sands themselves may serve to inclose reservoirs or pools of large capacity. It is also possible that the sands at their outcrop may, by the deposition of tarry substances, be plugged tightly enough to prevent further egress.

"Favourable indications of the presence of oil are afforded by the existence of several natural gas springs in the valley of the Athabasca above Boiler Rapid. One of these occurs at the mouth of Little Buffalo River and is twenty miles distant in a straight line from the outcrop of the tar-sands. The gas here forces its way from the sands up through a covering of 250 feet of Benton shales and issues from the surface in numerous small jets distributed over an area fifty feet or more in diameter. Some of the jets when lighted burn steadily until extinguished by heavy rains or strong wind, and afford sufficient heat to cook a camp meal. A second spring was noticed thirteen miles below the mouth of Pelican River, or forty miles in a straight line from the outcrop of the tar-sands at Boiler Rapid. The volume

of gas escaping here is less than at the mouth of Little Buffalo River, and in order to reach the surface it is obliged to penetrate 570 feet of shales and sand. Escaping jets of gas were also noticed at several points further up the river, but these were mostly small and may possibly be due to decaying vegetable matter.

"The question of the continuity of the tar-sands, and their petroliferous character under cover, can only be settled in a decided manner by boring, and it is highly desirable that drilling operations should be undertaken for this purpose. The indications seem amply sufficient to warrant the small expenditure involved, and the advantages which would accrue from a successful issue of the search to this portion of the North-west are almost incalculable. The southern limit of the field cannot, with our present knowledge or without boring, be defined; it may possibly extend to the Saskatchewan or beyond, as, even as far as Manitoba, the rocks are more or less petroliferous.

"Two bore holes, one at the mouth of Lac la Biche River, and the other at the mouth of the Pelican, would add largely to our knowledge of the underground geology of this region, and would either settle positively the question as to the presence or absence of petroleum in paying quantities, or at least afford valuable data for future action. At the mouth of the Pelican River, a bore hole, in order to reach the tar-sands, would require to be sunk 700 feet, and at the mouth of Lac la Biche River about 1,200 feet. The former locality is 50 miles distant in a straight line from the outcrop of tar-sand at Boiler Rapid. The latter is 106 miles distant from the same point, and is only 110 miles from Edmonton."

Mr. J. B. Tyrrell spent the winter examining the large collection of rocks and fossils gathered in North-western Manitoba during the previous summer, and preparing for the publication of a report on that district.

A specimen of phosphatic shale collected by him from the Niobrara formation on Wilson River, on the Lake Dauphin Plain in Manitoba, was given for analysis to Mr. Hoffmann, who reports that it contains 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. A very small outcropping of this shale, which is largely composed of fragments of fish remains, was seen in the bank of the river, but if the bed proves to be an extensive one, it will furnish a very valuable source of supply of phosphate of lime for the benefit of Manitoba and the country further west, being very similar in character to the coprolite beds of England and France.

During the past summer Mr. J. B. Tyrrell, assisted by Mr. D. B. Dowling, continued the geological survey of the northern portion of the province of Manitoba. Mr. Tyrrell reports as follows:—

"Leaving Ottawa on the 2nd of June, I proceeded to Winnipeg, where preliminary arrangements were made for obtaining money and supplies for the year. From Winnipeg I instructed Mr. Dowling to proceed to Minnedosa *via* the Manitoba and North-western railway, and there obtain horses and men and drive north on the Lake Dauphin trail to the crossing of Ochre River, in order to complete the geology and topography of the south-eastern corner of the map of North-western Manitoba, shortly to be published. On his return from Minnedosa he was instructed to start from Selkirk with a boat and two men, and survey with compass and micrometer or floating boat log the many islands in the northern and western portions of the lake, to note their character, mark any rock exposures, and collect fossils whenever they were to be found.

"This partition of the party was considered advisable as a larger amount of work could thus be performed during the present season, and a reliable map obtained with which to carry on the geological exploration of Lake Winnipeg during the coming summer.

"At the same time I proceeded by rail to Russell, where I had the good fortune to find Mr. Donald Sinclair, who has formed one of my party since 1887. From Russell we drove northward to Fort Pelly at the elbow of the Assiniboine River, from which point I purposed descending the river to Portage la Prairie.

"On the 15th of June, accompanied by one man, I started down this stream in a little canvas canoe. The river is very narrow and tortuous, winding too and fro in a shallow secondary valley in the bottom of a basin-like trough west of the northern portion of the Duck Mountain. Proceeding a short distance, low banks of dark grey clay belonging to the Millwood subdivision of the Pierre shales begin to put in an appearance in little scarps on the outer banks of the river. Near the first of these lies a large boulder consisting of a spherical nodule of Dakota sandstone quite similar to the large nodules which form a conspicuous feature on Kettle Hill at the south end of Swan Lake. If this nodule has been carried by the Laurentide glacier from Kettle Hill, its occurrence here would determine the direction of flow of the ice for this locality at one time in the glacial period as S. 55° W. or directly up the wide valley of the Swan River, rising, in the seventy-three miles travelled, more than four hundred feet. In the same vicinity many rounded or lenticular nodules of calcareous ironstone are to be seen sliding down the face of the bank.

"Proceeding down the river the channel was found to be very tortuous, winding through the alluvial bottom land. The valley gradually becomes more sharply defined till, just below the mouth of Little Boggy Creek, its banks rise abruptly on either hand to a height

of more than two hundred feet. At some of its bends the river impinges on the outer bank of the valley, and either cuts a cliff of dark grey Millwood shale, holding occasional nodules of ironstone, or grey jointed till from which striated boulders of gneiss and limestone are falling. At the base of these cliffs the accumulation of boulders gives rise to miniature rapids, which break the usual quiet flow of the stream. It is a circumstance very worthy of remark that the river does not appear to carry boulders any considerable distance down its channel, as they are found for only but a very little way below the cliff from which they are falling.

"The sides of the valley are everywhere seen to be composed of Millwood shale, till, or alluvial deposits all the way down to the mouth of Bird Tail Creek. In this distance the banks are in places beautifully terraced, the terraces rising as regular grass-covered steps, one above another. They are well shown at the village of Shellmouth, which has a most charming situation on the open sandy terraces that rise from the east bank of the Assiniboine River till they abut against the side of the main valley.

"Near Fort Ellice the banks of the river in some places are composed of boulders beaten down to an even slope by the ice, showing excellent examples of boulder pavements formed by river ice. Their surfaces were, however, neither worn nor scratched like the glaciated pebbles seen in the till.

"Shortly below the mouth of Bird Tail Creek pebbles of Pierre shale, Odanah series, begin to appear in the till.

"A few miles above the mouth of Arrow River, the top of the bank of the valley is found for the first time to be composed of the light green grey hard fissile shales of the Odanah series. These shales form a prominent feature as far east as Oak Lake, often giving rise to bare rounded buttes on the sides of the valley, reminding one strongly of the bad lands of many of the arid regions of the west.

"At the Sioux Indian Reserve the valley becomes wider and more open, and at a point north of Alexander a gravel plain indicates the position of the ancient mouth of the Little Saskatchewan.

"From this gravel plain to near the mouth of Cypress Creek no Cretaceous rock is seen in place, but the banks are composed of till or alluvial deposits, while the channel is occasionally blocked by an accumulation of boulders.

"At the mouth of Cypress Creek a dark grey shale outcrops in low exposures near the edge of the water, possibly representing the bottom beds of the Millwood series of the Pierre. A short distance further down the river fragmental limestone and marl, typical of the Niobrara

formation, gradually rise above the water to a height of 15 feet. This rock is directly overlain by till and at the lowest exposure in S. 23, T. 9, R. 10 W., where the marlite rises highest above the water, its surface is beautifully and evenly striated, the striæ bearing S. 38° E. As the valley is here 120 feet deep it is possible that these striæ do not give the exact direction of flow of the ancient glacier, but they would indicate that it had an easterly rather than a westerly trend. From the lowest outcrops of the Niobrara marlite to Portage la Prairie, no cliffs of rock are seen on the river, but its bed appears to be composed of the dark grey shale of the Benton formation which usually weathers with a very lightly sloping surface.

"We arrived at Portage la Prairie on the 15th of July, having spent precisely a month on our journey down the river from Fort Pelly.

"I proceeded at once to Winnipeg and found that Mr. Dowling had completed the survey of the small area on the face of the Riding Mountain, south of Lake Dauphin, and had gone at once to Selkirk.

"On the 17th of July I went from Winnipeg to Morden, and there, through the kindness of Mr. Dunsford and other gentlemen, obtained the log of the well that had been drilled by the village for the purpose of obtaining a large and permanent supply of fresh water. A few specimens had been kept typical of the various strata passed through by the drill, and these were kindly handed over to me and are at present under investigation. A hurried examination made on the spot showed that the well had been begun in the Pierre shales, had passed through the Niobrara, Benton, and Dakota formations, and had penetrated a considerable distance into Palæozoic shales and limestones. A large flow of salt water had been obtained in the Dakota sandstone. The record of the Rosenfeld well shows that fresh water is not to be hoped for from the Palæozoic strata, so that I was obliged to advise the people of Morden that there was no probability of obtaining fresh water by sinking the well to a greater depth. The work of boring was therefore discontinued, having been carried to a depth of 600 feet.

"It is quite probable, however, that the village can readily obtain a large supply of water from the gravel bed that stretches eastward from the mouth of Horse Creek.

"The next day I returned to Winnipeg and thence went on to West Selkirk where I found that the boat built under my instructions by Wm. Watts & Co., of Collingwood, for coasting work, had already arrived. I was also met by Mr. L. M. Lambe, the artist of the Palæontological branch of the Geological Survey, who had come from Ottawa to join my party to assist in collecting fossils from the Cambro-Silurian rocks on the shores and islands of Lake Winnipeg.

"James Collins, who had already spent eight years on Lake Winnipeg, was hired as sailor, and supplies and any goods necessary to complete the outfit were obtained from Messrs. Robinson & Co.

"On the evening of the 22nd of July, we embarked on the steam barge *Red River*, bound for the Grand Rapids at the mouth of the Saskatchewan. On the way we left Mr. Lambe at Dog's Head to join Mr. Dowling.

"Shortly before noon on the 25th of July we arrived at the fish-packing station at Grand Rapids, and from there we took our goods and supplies in the small sailboat up to the Hudson Bay Company's warehouse at the lower end of the tramway, a mile further up the river. That evening, Abraham Scott, an Indian, who was thoroughly acquainted with the river as far up as Cedar Lake, was added to the party.

"The next morning we loaded the boat, with all necessary supplies for two weeks, on a flat car; to this car a horse was hitched and we rode to the other end of the tramway at the landing above the Grand Rapids. At this place we launched the boat and ascended the Saskatchewan River with oars, poles or tow line to Cedar Lake. A survey was made with compass and floating boat log of the south shore of Cedar Lake, and the river examined up to the Hudson Bay Company's Post at Chemahawin. Here an Indian showed me a piece of amber, and stated that he had found it in the vicinity. The next day I had the pleasure of meeting Mr. King, of the Hudson Bay Company, who kindly accompanied me to the place where the amber was found, on the west shore of Cedar Lake, near the mouth of the Saskatchewan River.

"It occurs mixed with sand and many fragments of partly decayed wood, on a low beach behind a gradually shelving shore and along the face of a deep, wet spruce swamp. The pieces were for the most part smaller than a pea, but could be readily seen glittering among the sand and vegetable débris. Some pieces were found as large as a robin's egg, and Mr. King informed me that he had collected pieces very much larger. It has evidently been washed up on the shore by the waves, but its exact age has not yet been positively determined.

"The first place at which it was seen was in a small bay behind a limestone point projecting towards the north, but the most extensive deposit is more than a mile south of this point, where a rounded beach stretches across the margin of a low swamp. This beach is about a mile in length, and from eighty to one hundred and twenty feet in breadth. The amber is found most plentifully along its ridge, where it constitutes between five and ten per cent by volume of the sand and

vegetable débris, and holes dug to a depth of two feet show no diminution in its quantity. Towards the edge of the lake, however, the sand is freer, both from fragments of wood and amber.

"It is difficult to make an accurate estimate of the quantity of amber on this mile of beach, but it may confidently be said to be found throughout the distance in a band thirty feet wide, with a minimum depth of two feet. This band has thus a total bulk of 316,800 cubic feet. A number of specimens collected from various parts of it showed an average of a little over ten per cent of amber, which, in natural fragments, weighed forty-six pounds to the cubic foot. The amount of amber on this strip of beach would, therefore, be about 31,680 cubic feet, or 1,457,280 pounds. At a minimum value of twenty-five cents a pound, this would represent a total of $364,320. This estimate refers merely to the material that is now washed up on the ridge of the beach, without considering the source from which it is originally derived.

"Returning down the river, the rocky islands at the western end of Cedar Lake, and the islands and the shore of the east end of the same lake were surveyed. Instead of again taking advantage of the tramway we ran our boat through the Grand Rapids, and for a few short moments enjoyed the exhilaration of being tossed about on the surging waters of the grandest part of one of the grandest rivers in the Canadian North-west. There is some error in the computation of the fall of this rapid made by Mr. John Fleming, when acting as Professor Hind's assistant. The fall is given by him at 43½ feet, whereas the actual fall from top to bottom of the rapid is in the vicinity of 100 feet.

"The rock outcropping on Cedar Lake was found to be the same as that on the north-east shore of Lake Winnipegosis. It was, however, here found to contain a much larger number of fossils, which clearly determine its age as about that of the Niagara formation of Iowa and Wisconsin. The rock through which the river has cut its gorge at the Grand Rapids also belongs to the same formation.

"On the tramway between the upper and lower ends of the rapids several well defined gravel ridges are crossed at altitudes from 100 to 120 feet above Lake Winnipeg. These probably represent the shore lines of Lake Agassiz when it stood at the Stonewall Stage described by Mr. Upham in Part E. Ann. Rep. Geol. Survey, Vol. IV., 1888-89.

"Leaving the mouth of the Saskatchewan we coasted northward down the shore of Lake Winnipeg to its extreme north-west angle in Limestone Bay. Wherever rock outcrops were observed they were found to be Cambro-Silurian limestones of about the age of the Trenton or Utica formations.

"Limestone Bay is cut off from the rest of the lake by a narrow spit of sand twelve miles in length projecting towards the south-west. From the base of this spit an even unbroken sand beach stretches eastward to near Mossy Point, while behind the beach is an almost vertical cliff, rising in some places to a height of forty feet, composed at the bottom of a stiff blue alluvial clay, and at the top of a mossy peat. Rounding Mossy Point we descended Nelson River through Playgreen Lake to Norway House, and on our return made a log survey through Little Playgreen Lake, by a channel not previously mapped, into Playgreen Lake and thence by Warren's Landing to Lake Winnipeg. Nelson River at the discharge of this lake flows over a bed of Laurentian gneiss which it has not worn sufficiently even to obliterate the well defined glacial striæ that may be seen on almost any of the rocks along its shore. It is, however, enlarging and deepening its channel by cutting away the alluvial point lying to the west of it, on which the store-house of the Hudson Bay Company is at present situated. This point, which stretches as a long narrow arm between Winnipeg and Playgreen Lakes is also being rapidly worn away by the waves of both these lakes, and the time is not very remote when the site of the present narrow arm of alluvial clay and peat will be at the bottom of the united lakes.

"A deposit of clay similar to that on Mossy Point extends all along the east shore of Lake Winnipeg, and the waves washing against the soft cliffs become charged with the mud from which the lake derives its name.

"This clay is also of great economic interest, for instead of the east shore of the lake being an uninhabitable rocky wilderness, as is generally supposed, it is largely covered with a rich blue alluvial soil, and the area of rock surface is relatively small. Much of this land is covered with forests of poplar and spruce, while on account of the retentive impervious nature of the clay soil much of it is also boggy and wet, but when it is cleared and drained it will form rich agricultural land. At Bad Throat River, Mr. Wood, the local Inspector of Fisheries, had cleared a beautiful farm out of the midst of the poplar-forest, and he informs me that he grows successfully all the crops ordinarily raised in Ontario. Mr. McKay, the Indian Agent at Berens River, has also a clearing situated on the south side of the river in the midst of what was a dense forest of small spruce. He has under cultivation a nice garden, and this year the potatoes were not cut down by frost till the middle of September.

"On the evening of the 1st of September, we pitched our tents near Warren's Landing, beside that of the Mounted Police lake-patrol, under my old college friend, Mr. H. E. Morphy. He was travelling

in an excellent yacht built by Matthew Watts, of West Selkirk, who was employed on it at the time in the capacity of skipper.

"On the following morning we rowed to the east shore of the lake and travelled along it without interruption until Wednesday evening, when we camped in the mouth of a small creek south of Spider Island Point. The same evening we saw the police yacht sail into the harbour of Spider Islands. On Thursday a heavy storm set in from the north-west and we were unable to move from the mouth of the little creek till about sunset, when taking advantage of a lull in the tempest we sailed across to Spider Islands and again camped beside the police detachment. On Friday the gale continued with redoubled fury, and the day was spent in closely examining the small island of gneiss on which we were forced to remain, and photographs were taken of the camp and of the surrounding rocks. About sunset the wind fell and we at once furled our tents and ran to the mouth of Little Black River, three miles distant, where we remained for the night.

"On Saturday morning the weather was beautifully clear with a light air blowing from the north-west, and as I walked along the sandy beach I saw the ill-fated police yacht sail out from Spider Islands and disappear in the distance towards the south-west. That afternoon a very heavy storm of rain and north-west wind set in and continued throughout the night, and before morning the police yacht had struck on a reef off Pigeon Point and gone over on her side. The two policemen were drowned, but Matthew Watts, the skipper, lashed himself to the side of the boat and, twelve days later, was taken off by some passing Indians.

"Sunday was still dark and rainy, with a high wind from the north-west, but on Monday, the 8th of September, we continued southward along the shore, and on Friday, the 12th, reached Berens River, where we camped beside the Hudson Bay Co.'s trading post. For most of the distance from Nelson River I had travelled on foot along the beach, while the boat followed as near the shore as the many reefs would allow. The rock was everywhere found to be Laurentian gneiss without any constant dip or strike. It was also found to be strongly glaciated, and in several places two sets of striæ could be clearly recognized. It was generally covered by the soft blue imperfectly stratified alluvial clay mentioned above.

"At Berens River inclement weather detained us for several days, and during this time we were indebted to Mr. Angus McKay, Indian Agent, for continued hospitality. On Tuesday evening, the 16th of September, the Rev. Mr. Butler, Methodist Missionary, informed me

that a skiff had been found by an Indian on the shore, but it was not till the following evening that we ascertained that this was the tender of the police yacht, and that a boot and last had also been found on which was written the name of one of the unfortunate policemen.

"The next morning, the 18th of September, we started before daybreak, and ran out to Pigeon Point, followed by Mr. Angus McKay, and examined the shore closely from Pigeon Point southward to the mouth of Catfish River, but a heavy gale striking us, we were unable to take our boats more than four miles south of Pigeon Point. About three miles south of this point the first wreckage was found, and from this place southward for three-quarters of a mile to a prominent point, which might be called Police Point, light wreckage, such as pine boxes, etc., was scattered on the beach, much of it several feet above the level of the water. On the south side of Police Point, no wreckage was found, but from the bottom of the next bay to Catfish Point, heavier pieces of wood, such as oars, etc., were discovered, often half buried in the sand, having evidently been thrown on the beach by a heavy northwest wind.

"The next day was beautifully calm, and Mr. McKay proceeded along the shore in his canoe to Flower Point, while we examined the reefs and islands between Swampy Island and the main land. We also left a letter with Mr. Plunkett at the lighthouse, near Swampy Island, to be forwarded as soon as possible to Hon. John Schultz, Lieut.-Governor of Manitoba, informing him of the probable wreck of the police yacht 'Keewatin.' No trace of a wreck was to be seen on any of the reefs or islands, but Mr. McKay found further signs of wreck on the shore, but up to that time we had not found the boat itself.

"Friday night was spent at Flathead Point, and on Saturday a heavy wind blew from the south, so that we were unable to proceed. On that evening, however, several Indians arrived from the south, and informed us that they had found a large sail boat, with an old man lashed to its side, lying on the beach between Flower and Rabbit Points; that the old man had been taken care of, and brought to a house on Rabbit Point, and that the boat had been righted and taken into a harbour. Also that the old man, Matthew Watts, had told him that his two companions had fallen off the side of the boat several days before.

"Nothing further could be done, therefore, for the ill-fated policemen, and as the stormy weather presented every appearance of continuing for some time, I decided to leave the great northern expansion of the lake, and to run at once to Dog's Head, and work southward in the less open water south of the narrows.

"From the point east of Dog's Head the east shore was closely followed most of the way on foot, to the mouth of the southern Black River, and at the same time Black Island and many of the adjoining smaller islands were also examined. This proved to be much the most interesting part of the lake, as the shore from Dog's Head to Loon Strait was found to consist of altered gneisses and quartzites with a regular and long continued strike down the shore, having quite a distinct field appearance from the Laurentian gneiss further north. These rocks continue along the shore for a short distance south of Loon Strait and are then gradually replaced or overlaid by green quartz porphyries possibly of the Keewatin series. In a group of islands lying off Delay Point and north-east from Big Grindstone Point this quartz porphyry island is well seen in the eastern members of the group, while the most south-westerly island is conspicuously high and wooded and was found to be composed of massive green soft serpentinous rock, through which are running many veins of magnetic iron ore.

"Black Island was found to be composed of dark green schistose or massive chloritic rock which in the bottom of Hole Bay was found to present a sharp line of contact with the quartz porphyries. Overlying these schists is a considerable thickness of Palæozoic sandstones, apparently of the age of the Chazy ('St. Peter's Sandstone') of Minnesota, which at the south-west end of the island are found to run up conformably into the Trenton limestone.

"This sandstone evidently extends northward as the basal formation of the Palæozoic and the basin of Lake Winnipeg has been largely eroded out of its soft and easily disintegrated beds.

"From Black Island the supposed Keewatin rocks were followed round the bottom of Hole Bay, to near the mouth of Bad Throat River, where they suddenly end, and the shore is found to be composed of dark gray micaceous schists and light reddish gray granites, which are thence found to continue at least as far south as Black River.

'From Black River we crossed to the south of Red River and reached Selkirk just as the first heavy snow storm of the season set in. Here I learned that Mr. Dowling had arrived in from the lake a few days earlier. The following is his account of the work done by him during the summer:—

'I left Winnipeg on the 10th of June, and proceeded to Minnedosa, stopping at Westbourne to ship the large boat and camp outfit, stored here last year, to Selkirk. At Minnedosa a team was hired, and we proceeded northward on the trail known as the "Dauphin Road." For twenty miles we passed through a well settled country, and the road was well beaten, but from Scandinavia north it runs through

bush, following a meridian township line in to the settlement at Lake Dauphin. From Minnedosa, 1,670 feet above the sea level, the mountain rises gradually to 2,300 feet above sea, the trail then descending the northern slope into the valley of the Ochre River, 1,000 feet below. The top of the mountain is covered by a series of morainic hills, and the trail following a meridian line is forced over hills that otherwise might have been avoided.

'Having completed our observations in this district, I returned to Minnedosa and thence to Selkirk, where supplies and men were obtained for the summer work on the islands of Lake Winnipeg.

'Leaving Selkirk on the 28th of June, we proceeded north to Punk Island, were our work commenced. This island and Deer Island were traversed along their shores, the measurements being made with a patent floating log, and the position of the islands fixed by bearings taken from known points on the main shore.

'North of Dog Head, in Fisher Bay, are several large islands, which were surveyed, and the rock exposures examined, and a collection of fossils made.

'On the 25th of July, Mr. Lambe, of the Palæontological branch, joined our party for a month, and aided materially in making our collection of fossils more comprehensive.

'Berens Island and the bars and islands south of it were all traversed, and the month of September was spent among the islands on the west side of the lake between the mouth of the Little Saskatchewan and Long Point. Reindeer Island which has not been shown on any map, was found to be twenty miles long and five miles wide.

'Soundings were taken whenever practicable and noted, more particularly in the shoaler parts.

'Observations for latitude were taken at the following places: Cat Head, mouth of Little Saskatchewan, north end of Reindeer Island, south-east side of Reindeer Island, Fishing Station, Berens Island and at Berens River Post. Owing to the delay occasioned by the many storms during the season, the northern part of the lake was not visited, and we returned to Selkirk on the 8th of October.'

"At Selkirk the goods and smaller boat were stored in the warehouse of the North-west Navigation Company, and the larger boat was left in charge of Messrs. Wright and Howell, and on the 16th of October we left for the east.

"During the season eighty-three photographs were taken of points of especial geological and economical interest."

Cost of season's exploration, $1,976.59.

Mr. McInnes left Ottawa on the 5th of June for the purpose of continuing the work previously carried on by Dr. A. C. Lawson, in the districts of Rainy Lake and Thunder Bay. He was joined at Toronto by Mr. Smith, with his assistant, Mr. Lawson, and by Mr. Thos. Wiggins, of Napanee, who was appointed assistant for the season's field work.

A summary of Mr. Smith's work is appended.

Mr. McInnes reports as follows :—

"The party arrived at Port Arthur on the 9th of June. Some difficulty was experienced there in obtaining canoemen, who were in great demand on account of the activity of prospecting and surveying work in the district. Very good men were, however, eventually obtained from Rat Portage, through the kindness of Mr. Alex. Matheson, of the Hudson Bay Co., and were sent to Wabigoon Tank, on the Canadian Pacific railway, whence a start was made, on the 17th of June, southward on the Manitou route. This route follows a chain of lakes and waterways to Manitou Lake, and, still southerly, through this long, narrow lake to Rainy Lake. The valley occupied by this chain of lakes lies altogether in Huronian (Keewatin) strata. The long, narrow shapes assumed by the lakes being determined by the trend of the schists whose strike is followed in a remarkable way by the contours of the lakes. This feature which Dr. Lawson speaks of (p. 17, Part F, An. Rep. Geol. Survey, Vol. III.) is a very striking one, and characterises not alone this route but all the great water routes of the region. It seems to be due to the greater readiness with which the calcareous beds of the Huronian give way under denuding agencies. The valleys on these routes, generally narrow, are often of great depth ; narrow lakes, less than one mile in width, will frequently show a depth of more than 200 feet. Some of those belonging to a chain running north from the Seine River were found by Mr. Smith to be very remarkable in this respect, and soundings in Dog Lake gave a very uniform depth of from 180 to 220 feet.

" Rainy Lake was followed southerly to its south-westerly corner at Fort Francis, and thence easterly to the north of Seine River. This traverse led through the centre of the Rainy Lake sheet already published, and afforded an opportunity of proving the immense advantage to one travelling through the district of so carefully compiled a map as the one here referred to.

" From Rainy Lake the Seine River was followed upwards to Lac des Mille Lacs. From this lake the Kaministiquia River was reached by way of Lakes Kashabowie Shebandowan and the Matawin River

" The Kaministiqua River was followed to Port Arthur and the re-

mainder of the season devoted to an examination of the Dog Lake region and to a micrometer survey of Greenwater Lake—a large lake hitherto unsurveyed, which lies south of Shebandowan and which flows into that lake.

"In general character the region is a rolling country of low hills, generally well rounded and glaciated, and often with a surface almost bare of soil. It is exceedingly well watered—a district of lakes and watercourses which afford ingress to it, and by means of which intercourse is carried on through it in every direction.

"The rocks of the region under consideration may be divided into the two great divisions of Laurentian and Huronian. The former, chiefly gneisses and granitoid gneisses, occur in detached areas and bands, which are surrounded on all sides by Huronian (Keewatin) rocks. Only in the south-western part of the Aticokan sheet were rocks noticed which seem referable to Lawson's Coutchiching series. Everywhere else the Huronian is represented by the so-called Keewatin series, consisting largely of trappean material, sometimes massive, but often with a schistosity developed by pressure. There is, however, in addition to the trappean beds mentioned, a considerable amount of clastic strata—of conglomerates, altered argillites and quartzites, generally calcareous. The quartzites, alternating with thin bands of limestone, are in places shattered, and re-cemented by calcite.

"Considerable activity was shown in prospecting in the district during the past summer, and the iron-bearing area of the Aticokan River is already largely taken up.

"The reports from many of the mines in the silver-bearing Animikie series to the south were very encouraging and the completion of the Port Arthur and Duluth railway through the silver districts will afford the outlet so long needed by these mines, and will enable them to carry on their work to much greater advantage.

"Although the district as a whole cannot be called a good agricultural one, there are in it numerous areas of good lands suitable for cultivation. Some good red pine was noticed at different points, though for the most part it is scattered and poor. That seen around some of the lakes connected with the Seine River could be driven down that river to Rainy Lake and thence to Rat Portage.

"During the season about 400 miles of lakes and streams were surveyed by prismatic compass and boat-log, and by estimated distances, and 40 miles by micrometer telescope. In addition to the above, traverses were made during the summer for the purpose of examining the region geologically, where no surveys were necessary."

Mr. Smith left Ottawa for the field on the 3rd of June and was joined in Toronto by Mr. William Lawson, his assistant. On their arrival at Port Arthur, a few days were occupied in procuring supplies and equipment, and some delay was caused in securing suitable men.

The party with Mr. Smith left Savanne on the 14th of June, and the first seven weeks were occupied in making micrometer and compass surveys of a chain of lakes, which extends from Clearwater Lake, on the Seine River, to Little Wabigoon River; of the Eye River route, connecting the latter with Seine River; in a partial survey of a chain of lakes hitherto unknown, which extends from Clear Lake, on the Wabigoon route above mentioned, to the Big Turtle River; and in a partial survey of the upper lacustrine expansions of the Seine River.

The second trip, of three weeks' duration, was occupied in making a micrometer and compass survey of the upper part of the Seine River from its junction with the Fire Steel River to the entrance of Partridge River; of the Brush Creek route to English River on the Canadian Pacific railway, and partially of the Partridge Lake route to Lac des Mille Lacs.

At Savanne four days were lost through bad weather and delay in securing men to replace those who had left, and on the 30th of August the party left Savanne, travelled down the Dawson route to Windigonstigwan Lake, thence through Crooked Pine Lake and down the Aticokan River, finishing surveys of some short routes running northward which afforded sections across the Keewatin belt of rocks here traversed; thence down the Seine River, completing the surveys of the last season, to within eight miles of Sturgeon Falls. Here the party was divided, Mr. Lawson returned up the Seine River, and completed all the unfinished topography on this route to the eastern boundary of the sheet, while Mr. Smith, with one man and a light canoe, passed by a winter route across the headwaters of the Little Turtle River, and thus gained another section across the northern limit of the Seine River Band of Keewatin rocks; passing by this route into the chain of lakes explored in the earlier part of the season, he finished the surveys west to the Turtle River and east to Clearwater Lake. Thence he descended the Seine River to the next lake south, and then passed through a chain of small lakes running easterly to the old Indian Reserve No. 23 on the first expansion down the Seine River. He then proceeded to Savanne, *viâ* the Partridge Lake route, and arrived there on the 4th of October, the day after Mr. Lawson.

The band of Keewatin rocks shown on the "Rainy Lake sheet" as following up the Seine River, as far as the eastern limit of the map, has been traced all the way up the river in somewhat broader development as far as Steep Rock Lake. Here the band bifurcates the

northern portion, strikes N.N.E. and skirts the N.W. side of Clearwater Lake, with a width of three miles. Thence it curves to the N.E. and E., crosses the Brush Creek route, with its southern boundary on First Lake and its northern boundary on Pyramid Lake, and is again seen at the first falls up the Fire Steel River, where its strike is a little south of east.

The other band, varying in width from four to seven miles, passes in a general easterly direction up the Aticokan River, encompasses Crooked Pine Lake, and the north-western and north-eastern arms of Elbow Lake, and it is again seen on Baril Bay of Lac des Mille Lacs. The iron ores of the Aticokan and Whiskey Jack rivers are found in this band, and iron ores have also been found below the bifurcation of the band on the Seine River. The "Star Island" gold location is in a spur from this band which outcrops on Partridge Lake.

Between the bands and to the northward the country is entirely occupied by Laurentian gneisses and granites.

The broad band of Coutchiching mica schists so extensively developed on Rainy Lake, extends into the country shown on the south-western part of this sheet, but a few miles from its western boundary they are replaced by and interbanded with gneiss, which, as we proceed eastward, becomes the predominant rock, holding narrow bands of mica schists, which become less frequent further to the east. But this characteristic of the rocks is fairly constant throughout the whole of the gneissic area embraced in the southern portion of the Seine River sheet.

The work of the season was somewhat scattered and isolated, and an unusual amount of time was lost through wet weather.

The topography of the Seine River sheet has, however, now been completed, and all the accessible lakes in an area of about 1,600 square miles accurately outlined. About 300 miles of compass and micrometer lines, 250 miles of log and compass lines, and 50 miles of time traverses were run, serving as base lines for the compass triangulation of islands and intermediate points.

In addition careful notes were taken of all rock exposures, on the lake shores and on the rivers, from which the geographical distribution of the several bands can be accurately mapped.

Mr. McInnes returned to Ottawa on the 30th of September, and Mr. Smith on the 30th of October.

The cost of the season's work and pay of assistants was $2,556.13.

Dr. Bell was again engaged in the vicinity of Sudbury, working out the details of the structure, and studying the affinities, mode of occurrence and associations of the very interesting rocks with which the nickel, copper and other economic minerals of this district are associated. The subdivisions and their geographical distribution will now be shown on a map, scale four miles to one inch, covering an area of 3,456 square miles around Sudbury. This map is now nearly ready for the engraver. It will be sheet No. 130 of the projected series of the geological maps of Ontario, and will accompany and illustrate Dr. Bell's detailed report of his investigations in the great Sudbury Huronian belt during the seasons of 1887-88-89.

Mr. A. E. Barlow, as during the seasons of 1887, 1888 and 1889, assisted Dr. Bell in both the geological examinations and in the topographical measurements.

Mr. Barlow left Ottawa for the field on the 8th of July and returned on the 27th of September. Dr. Bell left on the 15th of July and returned on the 30th of October.

Three students, Messrs. A. M. Campbell, H. H. Walker of McGill College and T. L. Walker of Queen's, were attached to the party, and H. Skill and D. McLaren were engaged as canoe men and general assistants.

Dr. Bell reports on the work as follows :—

"Most of my time was occupied in the northern, central and western portions of the district represented on the map, while Mr. Barlow worked principally on the south-eastern half of the Huronian belt which traverses it. The work of both consisted largely in tracing out more closely the limits of the lithological divisions of the Huronian system and in ascertaining more details respecting the Laurentian. Special study was given to the geological relations of the nickel and copper deposits. Incidentally to these investigations, a good deal of topographical surveying required to be done.

"For the purpose of delineating more accurately the outlines of Lake Wahnapitæ and connecting it with the towns to the westward, I re-surveyed its western side, and the lakes and portages thence to the Vermilion River, and also made a micrometer survey of this river from the point reached by Mr. Barlow last year to a position beyond Proudfoot's east and west line. In connection with this survey, fourteen traverses, each occupying one or two days, were made to the right and left of the Vermilion River as a base. Other explorations were also undertaken in the Laurentian country between the Onaping and Vermilion rivers, in the townships of Morgan, Levack and Lumsden, and between these and Proudfoot's base line. Besides

these a track survey was made of seven lakes lying eastward of Wahnapitæ Lake, the largest of which (Koo-ka-ga-ming) is nine miles long. Some additional geological work was done in the Geneva Lake Huronian outlier, which is first entered upon by the Canadian Pacific railway at a distance of thirty-three miles north-west of Sudbury. Mr. Barlow re-surveyed Ramsay Lake and some smaller bodies of water in the townships of McKim, Garson, Blezard and Snider. Surveys were likewise made of the roads which have been lately opened in the townships of McKim and Snider, Sudbury district, and also of the Emery Lumber Company's railway north-westward from Wahnapitæ station, in the township of Dryden.

"The following are among the geological results of the season's operations: The numerous exposures of gneiss and red quartz-syenite between the Wahnapitæ road and the township of Denison have been traced out and connected together, showing that they all belong to a continuous range of these rocks lying in the centre of this part of the Sudbury trough. It was found impossible to separate on the map the gneiss and quartz-syenite of this range or of the main body of these rocks on the northern west side of the trough. An area of fine-grained, dark gray varieties of imperfect gneiss and quartz-syenite occurs around Wia-shai-gaming (or 'Fairbank') Lake, which connects this central range of the ordinary gneiss and quartz-syenite with the great area of these rocks on the north-west.

"A long and rather narrow mass of coarsely crystalline gray diabase was traced from Whitson Lake south-westward into the township of Denison, a distance of twenty-four miles. This cuts off a narrow belt all along the south-eastern side of the central range of gneiss and quartz-syenite. It is about a mile wide in the middle and runs to a point in either direction. The ore deposits of the following properties are situated along the south-eastern side of this mass or in the continuation of its course: Waddle's, the Dominion mine, Russell's, Stobie's, Murray mine, McConnell mine (in Snider), Lockerby and McIntyre's, lot 10, range I., Snider; the Crean or McConnell mine and the "Mineral Range," in Denison. The ores of the Stobie, Copper Cliff, Evans, lot 12, range 3, Graham, and the Vermilion mine, are associated with diorite, mostly brecciated, along the south-eastern or opposite side of the belt of gneiss and quartz-syenite which is cut off by this mass. Its confused character and the great number of angular fragments and masses of other rocks which it contains would indicate that we have here another line of ancient volcanic disturbance.

"A second mass of crystalline, gray diabase, similar to that of the first one which has been described, was traced from the north-eastern

part of the township of Levack south-westward for a distance of eighteen miles. This one is also about one mile wide in the centre and has the same form and course as the other. Several deposits of the nickeliferous pyrrhotite have been found on its course. Numerous masses of green crystalline diorite occur within the area chiefly occupied by the quartzite and greywacke series, and at the contact of these with the adjacent rocks several promising deposits of similar ores have been discovered.

"In regard to the stratigraphy of the district, the Sudbury Huronian trough, where it is traversed by the line of the Canadian Pacific railway, has a width of twenty-four miles. The Geneva Lake outlier has a breadth of seven and that of Onaping Lake of three miles. In the main or Sudbury trough the rocks on either side dip at high angles towards the centre. The lowest member is the quartzite and quartzose greywacke series, which prevails all along the south-eastern side from the southern border of the sheet at Lake Panache as far as the Wahnapitæ River, beyond which it becomes rapidly more argillaceous and spreads out over a wider geographical area.

"The green diorite masses in the midst of the quartzite and grey-wacke series vary in length from half a mile to ten miles, and as a rule, their longer diameters conform approximately with the prevailing strike of the surrounding rocks. On the north-west side of the trough this series is represented by a band of gray quartzite containing scattered pebbles of white quartz. This quartzite is overlaid by the remarkable black breccia referred to in last year's summary report. It appears to be several thousand feet thick, and was traced from Vermilion Lake north-eastward to a point on the upper Vermilion River beyond the latitude of Lake Wahnapitæ. Professor G. H. Williams, to whom specimens of the Sudbury series of rocks were sent for microscopical examination, has found that the irregular white spots with which this rock is flecked were originally fragments of pumice, but that they have been entirely replaced by silica.

"The highest member of the Huronian series in the district consists of thick gray argillaceous sandstones or greywackes, interstratified with more argillaceous bands. These rocks occupy a large tract of country between Vermilion Lake, in the township of Fairbank, and Lake Wahnapitæ, and generally dip at moderate angles."

The cost of the season's operations was $1,746.64.

The strata above referred to by Dr. Bell as the highest member of the Huronian resemble very closely the rocks known as the whin series in Nova Scotia, as they do also the Lower Cambrian (Harlech and Llanberris grits of North Wales).

Mr. A. S. Cochrane was again engaged in topographical work in the Ontario peninsula. He left Ottawa on the 23rd of July and returned on the 18th of October. His work was similar to that of previous years, and consisted in mapping the streams, hill features, etc., more correctly than they had been hitherto represented on the township plans. These plans are from the original surveys, which were made when the country was all under the primitive forest, and at that time the contours of the smaller hills could not be seen and the streams could only be noted where they intersected the concession and side-lines. As stated last year, the swamps, which existed while the country was in a state of nature, have been drained and have to a great extent dried up since the land has been cleared, so that in this respect the original maps do not correctly represent the country. In 1889, Mr. Cochrane had finished sheet number 115 and the past season he commenced on sheet 107, which is the next one to the south. He completed the topographical details in the townships of Kincardine, Huron, Kinloss and part of Greenock, which lie in the north-western corner of this sheet. In sketching in the above features Mr. Cochrane was guided by the lot lines, which are marked by boundary fences or by odometer measurements. The heights were determined by aneroid barometer.

Except near the shore of Lake Huron, where sand and gravel prevail and the surface is level, the townships examined are underlaid by a great depth of bluish-gray stone clay, with brown clay sometimes resting upon it; the surface being undulating and usually overspread by a rich loamy soil.

The fundamental rock was found in only one place, namely, about three miles east of the town of Kincardine, where a flat layer of gray limestone was exposed for several hundred feet in the bed of a branch of the Penetangore River. Some fossils were collected here which Mr. Whiteaves states belong to the Corniferous formation which had been already represented as occurring at this locality upon the geological map of the province.

Cost of this field-work, $350.

During the past summer Dr. Ells, assisted by Mr. Giroux, was occupied in continuing and extending the work of the previous season within the limits of the south-west quarter sheet of the Eastern Townships map. His own attention was devoted to a more careful and detailed examination of the area between the Grand Trunk railway and the Vermont boundary and between Memphremagog Lake and the Richelieu River, while the northern or St. Francis River area was

studied by Mr. Giroux, whose work included a careful examination of the section exposed down that river and up the Yamaska to St. Hyacinthe. Respecting these examinations, Dr. Ells states as follows :—

"Large collections of fossils from a number of points were obtained, in which work I was ably assisted by Mr. W. E. Deeks, B.A. Toward the latter part of the season, a few days were spent with Mr. C. D. Walcott, of the United States Geological Survey, in the study of the rocks about Philipsburg, Mystic and Highgate, in order to determine more accurately the exact horizon of the Philipsburg and Stanbridge series. Upon the setting in of bad weather in October, the rest of the season was devoted to the examination of the copper and asbestus mines of Sherbrooke, Thetford and Black Lake.

"While the surveys of the past season have not yet been fully plotted out, sufficient has been done to determine, with the aid of the fossils collected, the stratigraphical sequence and boundaries of the several formations east of the great St. Lawrence and Champlain fault. The black limestones of Farnham, which were supposed in 1863 to underlie the Levis formation, were found, as was pointed out in 1877 to be of Trenton age, as indeed the list of fossils, see pp. 239, 240 Geology of Canada, 1863, very clearly indicates. The stratigraphical sequence embraces, from the Cambrian through the Calciferous and Chazy to the Farnham limestones, which certainly represent a portion of the Trenton formation, the underlying Chazy being seen both to the east and west. Thus the Farnham rocks occupy the centre of a synclinal instead of the crest of an anticlinal, as supposed in 1863.

"The lowest rocks of the series, west of the Sutton Mountain pre-Cambrian and Cambrian strata, are the red and green slates and sandstones which constitute the prominent ridge of Granby, and which extend south-westerly almost to the line of the Canadian Pacific railway east of Farnham station, and also occupy the country between Granby and Abbotsford up to the great St. Lawrence and Champlain fault, which passes immediately to the west of Yamaska Mountain.

"The black Trenton limestones of Farnham centre do not appear to reach the Vermont boundary, the underlying Chazy limestone and dolomitic shales coming to the surface in this direction in a basin-shaped synclinal whose depression is to the north-east; but northward they can be traced continuously east of Granby and Roxton to and across the St. Francis to the Danville and Arthabasca areas.

"The country west of the St. Lawrence and Champlain fault is generally level, broken only by the intrusive masses of Rougemont, St. Hilaire, Mount Johnson, Monnoir, and kindred mountains. There

are very few rock exposures in this level country. Some outcrops which occur at Chambly, St. Jean Baptiste and St. Hyacinthe have yielded a numerous list of fossils; they have not yet been determined, but appear to indicate that the rock over the greater part of the area belongs to the Utica and Lorraine formations, as they are described in the Geology of Canada, 1863.

"The slaty belts on either side of the Central Anticlinal axis of Sutton Mountain, referred to in the Summary Report last year (1889) were traced for seventy-five miles, and the complicated relations of the rocks between these slaty belts and Lake Memphremagog were carefully examined. A complete micrometer survey of the lake on the Canadian side was made, and the intricate mixture of Silurian and Cambro-Silurian fossiliferous rocks, cut in places by very peculiar, often sheared dykes, clearly mapped out.

"The mining interests of the townships, though for the most part within the area adjoining that contained in the field of work just described, are on the increase. Two new copper mines in the Sherbrooke belt of schists, the Moulton Hill and the Howard, have been opened, and are now shipping ore to a considerable extent. The ore is very similar to that found at the Capelton mines, and, like that, is used for the manufacture of sulphuric acid. The copper contents of the lode apparently increase as the veins or lodes are opened downward. Further development, on properties abandoned some years ago in the district near Sherbrooke, are about to be undertaken; and the Huntington mine, lately acquired by Messrs. G. H. Nichols & Co., has been pumped out and mining operations resumed.

"The asbestus industry shows also a great increase, both in the amount of the output and in the prices obtained for the raw material, and probably not less than 8,000 tons have been shipped during 1890, though the complete returns are not yet in. The price of No. 1 has risen rapidly from $100 to $125 to $200, and even $250 per ton, with a further tendency upward. Several new mines have been opened and the work at the old mines has been pushed with greater vigour. The increase in the output is largely due to the fact that improved machinery is now employed in all the pits, in some of which compressed air for the purposes of drilling and hoisting is used; others use steam direct, the former being considered the more advantageous, owing to the ease with which the drill holes can be kept clean. Preparations are now being made for removing the dumps from their present sites to the barren ground near the Thetford River, and it is estimated that the crushing and cribbing of these will amply repay the cost of removal. The necessity of employing machinery for the purposes of crushing and

cobbing for the smaller veins at least is now recognized, and is being put in operation at the American and Anglo-Canadian mines at Black Lake. In addition to the mines already described in former reports, several new areas have been opened on the west side of the Quebec Central railway. While the veins at all these occasionally show good fibre, it is evident, upon examination, that the rock nearer the river and on the low ground does not yield such fine asbestus as in the mound where the mines were first opened. In Coleraine, also, several of the new companies which began operations last year at Black Lake have abandoned their locations, owing, probably, to an unfortunate choice of ground, while some of the Thetford companies—notably King Bros., A. S. Johnston and A. H. Murphy—have opened new areas here and found good veins. Among others, Dr. James Reed, on lots 27, 28, 29, has erected a first-class mining plant, with air compressors, for carrying on work on his areas, on which considerable work has been done during the past season, mostly by the contract system.

"On the west side of the upper part of Black Lake, near the inland line, Messrs. Grundy, Steel & Co., of the Beaver Mining Company, have begun work in Range B, Coleraine, but the work so far has been mostly exploratory. Numerous small veins and some of fair size have been found, but their value cannot yet be definitely pronounced upon.

"Great activity on the part of prospectors is manifested throughout the whole of the Serpentine belt of Thetford, Coleraine, Broughton and Wolfestown. Several finds of valuable areas are reported, none of which, however, in so far as careful inquiry could determine, are of very great importance.

"An interesting point discovered during the past year is the fact that the walls of so-called barren rocks encountered in nearly all the mines, owing to the presence of faults, and formerly supposed to be worthless, are now in good ground, the barren portions extending but a short distance. This is what might have been expected in such areas, the fault being only local and merely displacing masses of presumably equally rich serpentine.

"The serpentine areas of the south-western portions of the province have not yet disclosed the presence of workable veins of asbestus in quantity, with the exception of the mine at Danville, owned by Mr. Jeffrey, where some fine veins have lately been discovered. The Brompton Lake mine, which is the most southerly, worked to any extent, has been opened to a very considerable depth, and a large amount of money has been spent; but the prospects for workable veins in the lower workings are no better than at the surface, and no returns have yet been made. About Orford Pond on the south side of Orford Mountain,

and near Long Lake, at the northern extremity of the same ridge, excavations have been made in thin and irregular seams a fourth of an inch, and in the road west from Knowlton Landing to Bolton Pass, in the serpentine band to the east of the Missisquoi River, some exploratory work has been done without finding asbestus of any economic value, and in so far as yet ascertained this portion of the province does not present favourable indications for profitable asbestus mining.

"Of the work of the assistants in the field, Mr. N. J. Giroux, C.E., and W. E. Deeks, B.A., I can speak in the highest terms."

The party left Ottawa on the 11th of June and returned on the 11th of October.

Expenditure for the season, $1,490.

During the months of July and August the Rev. Abbé Laflamme, at my request, made some geological investigations in the county of Charlevoix, on which he furnishes the following report :—

"Attention has been more especially directed to the study of the Cambro-Silurian deposits on the north shore of the St. Lawrence, in the county of Charlevoix. The valleys of the Rivière du Goufre and of the Malbaie River are almost entirely occupied by limestones, extending in the first of these, to about ten miles from the St. Lawrence, and forming a band of nearly uniform width all through that distance, except at Cape Martin, where the outcrop of the calcareous strata, measured transversely to its direction, is notably narrower.

"In the Malbaie River valley the limestones disappear at a point nearer to the St. Lawrence, or at most seven or eight miles from it, but the area they occupy is considerably wider than on the River Goufre. Other limestone areas occur in the valleys of the Petit Lac and Lake Nairnes.

"Except in a very few places, it has been found totally impossible to trace with certainty the limits of the calcareous beds, the drift deposits which fill those valleys being so thick as to utterly prevent any such determinations, especially along the upper parts of the above-mentioned rivers.

"There are no Cambro-Silurian beds in the narrow valleys of the other streams of Charlevoix county, such as the Little Malbaie River and the numerous creeks falling into the St. Lawrence between St. Irénée and Baie St. Paul.

"The calcareous strata in both the large valleys referred to are only slightly disturbed. They generally take the shape of a broad synclinal, with only a few secondary folds.

"Other conditions obtain in the Cambro-Silurian band along the shore of the St. Lawrence, between Gros Ruisseau and Point Pères, and from Cape Martin to one mile above the wharf at Eboulements. This band is narrow from one end to the other, its maximum width being little more than a mile. It is not continuous, as shown on the map sent me from Ottawa last spring, but is interrupted for a long distance between Cape Martin and Point Pères, the only trace of it to be found in this distance being some unimportant and isolated knolls on the shore of Apple Cove (Anse aux Pommes).

"All the beds dip at a very high angle, mostly towards the St. Lawrence River. At points where they have not been too much disturbed there appear, both above and below, and lying conformably with them, beds of quartzite, frequently cut by large felspathic veins, of a pink colour, and apparently of Archæan age.

"Fossils are scarce in the basins of the Goufre and Malbaie Rivers, but they are plentiful at the mouth of the latter stream, especially along the line of contact of the limestone and sandstone beds which, with a thickness of a hundred feet, here constitute the base of the Trenton series.

"This great deposit of sandstone forms a building stone of excellent quality. The rock is cream-coloured in the upper part and becomes light green at the base of the series ; it can be quarried in blocks of any dimension. The material in the top beds is hard, fine-grained and is but slightly affected by exposure, being in consequence very well adapted for pavements. In fact, a large quantity is extracted every year for this purpose.

"There are but few economic minerals in Charlevoix county. In addition to the limestones and sandstones above referred to there may be found here rocks holding a large quantity of garnets, notably at St. Iréné and Malbaie. At the first mentioned place these garnets are very large, being frequently over six inches in diameter, but all are fissured and of no value. At Malbaie on the shore one mile above the wharf, the crystals are smaller, but their colour is better and their brightness greater than at St. Iréné.

"I have also visited the deposit of titanic iron ore at St. Urbain, but notwithstanding a careful examination of the place, its actual limits could not be defined, on account of the thickness of the drift there. One thing, however, is certain and that is that the quantity of titanic iron ore in the deposit is practically unlimited. The part already opened is immense, and many other similar deposits may be seen in various places.

"The iron works, formerly erected by an English company which, it is said, spent half a million of dollars on the spot, are totally ruined, there being only left to mark their site a few piles of old bricks, and the same must be said of the tramway which connected the mine with the village of Baie St. Paul, on the shore of the St. Lawrence.

"The silver mine which it is was alleged had been worked by the French and had been re-discovered recently never had any existence, except in the fancy of those interested in the selling of the property; and the galena veins on the west side of Baie St. Paul are so small and carry so little of the mineral that they are totally worthless. The alleged phosphate mines of St. Iréné are nothing but veinlets of sandstone imbedded in Archæan rocks and carrying fluorspar.

"It has been reported that asbestus and mica had been found at a point a few leagues distant, north-west of the St. Lawrence, but the truth of the report has not been ascertained and it should not be lightly credited."

The first description of these limestone areas was given in the Geology of Canada, 1863, Chap. IX., pp. 160-163.

Cost of exploration, $400.

Mr. A. P. Low was engaged during the past season on an exploration of the region around Lake St. John, in continuation of the work previously undertaken there by Mr. F. D. Adams and the Rev. Professor Laflamme. Respecting this work Mr. Low states :—

"The party left Ottawa on the 28th of May, and after spending ten days in Quebec copying plans of surveys in the district the work was commenced at Lake Edward. A complete geological examination was made of its shores and of the Jeannotte and Batiscan rivers, flowing out of it, to Laurentides Station on the line of the Quebec and Lake St. John railway.

"Along the southern shores of Lake Edward and on the upper part of the Jeannotte River a dark greenish, basic, dioritic gneiss occurs; this rock is highly impregnated with iron ore, usually occurring in the form of small grains, but frequently in masses several inches in diameter, and probably may be found in larger quantities and be of economic value. These dark basic rocks are also seen along the shores of Lake Batiscan and its outlet, also on the line of the Quebec and Lake St. John railway, to the north of Lake Edward.

"Having completed the exploration of the Batiscan valley, a canoe route from the headwaters of the Rat River was followed through Lake Najalouyand, on the Bostonnais branch of the St. Maurice, thence

across the height of land through Lakes Doré, Ecarté, Ouaquagamasis, Commissaires and Bouchette to the mouth of the Ouiatchouan River at Lake St. John.

"No economic minerals in quantity were found on this route, but on Lake Commissaires veins of pink pegmatite were seen carrying detached masses of hematite up to three inches in diameter, but generally smaller; some of these veins also hold large crystals of black mica, but these are considerably crumpled. A small detached area of anorthosite was found on the Ouiatchouan River similar to the great mass of that rock east of Lake St. John.

"Following this a close examination of all the rock cuttings along the Quebec and Lake St. John railway was made from Black River to the northern terminus. These cuttings afford admirable sections of the Archæan rocks in the area north of the St. Lawrence, which will be of great value in correlating the similar rocks found elsewhere in that region.

"A gray hornblendic granitite gneiss is found in the cuttings from Rivière à Pierre to Meguick. It is being quarried near the latter place for building stone. It is very valuable for heavy foundations and for exposed walls. About Lake Ouaquagamasis a red variety of the same rock would answer for building material quite as well as the gray, and would also likely prove valuable as a material for all purposes in which polished or worked granite in large blocks is required.

"Besides these building stones, the only other mineral of economic value observed was a small vein of mixed iron and copper pyrites, seen in the first cut south of Stadacona station; this vein in itself is insignificant, but indicates the possibility of finding these minerals in veins of larger dimensions.

"On the completion of this examination a trip was made up the Montmorency River to beyond the beaver meadows, and the country explored eastward from there to the Sault à la Puce River, in order to trace out the northern boundary of the mass of anorthosite which occurs behind Chateau Richer, and which holds lenticular masses of titaniferous iron ore scattered through it.*

"Two weeks were then spent in Charlevoix county, where, in conjunction with Prof. Laflamme, the outliers of Trenton limestone along the coast were traced out, as well as the southern boundary of the large anorthosite area are seen on either side of the Goufre River, near St. Urbain. This area is particularly rich in titaniferous iron ore, which often occurs in immense masses. One of these is on the hillside

* Geology of Canada 1863, pp. 34, 46 and 589.

west of St. Urbain,† where thousands of tons of ore are in sight. This deposit was worked some years ago, but owing to the high percentage of titanic oxide present and the high cost of fuel profitable reduction was impossible and an extensive plant was abandoned.

"In the valley of the Goufre River a bed of peat, eighteen inches thick, was found, apparently overlaid by marine clays; this peat would form excellent fuel.

"In a coarse garnetiferous gneiss on the land of Edward Martin, St. Jérôme road, two veins of pegmatite hold considerable quantities of graphite in disseminated scales.

"At the conclusion of the work in Charlevoix county the party returned to Lake St. John, where Mr. Smaill, B. Ap. Sc., had been engaged carefully tracing out the junction between the Archæan and Cambro-Silurian rocks on the west and south sides of the lake. The indications of petroleum at Point aux Trembles were investigated; the Utica shales were there found to be highly impregnated with oil, but as the shale and limestone appear to form a synclinal basin in the Archæan valley, with only a few low, narrow anticlinal ridges, the possibility of a large collecting area for oil under the shales is doubtful.

"The Cambro-Silurian rocks of Lake St. John are also, as in the west, the source of mineral springs. Several of them occur around the margin of the lake, one comes out on the shore between Chambord and the mouth of the Matabetchouan River. The water of this spring is at present under analysis here, and it may prove of medicinal value.

"During September an exploration was made in the country north of Lake St. John on the Wassiemeska, Rat and Ours rivers, branches of the Mistassini River. On the first named only Archæan gneisses were seen to the limit of the explorations some forty miles north from the lake; but here numerous boulders of jasper conglomerate, felsite and diorite, closely resembling the rocks of the Huronian north of Lake Huron, were found, indicating that a Huronian area will be found farther to the northward.

"At the sixth and seventh portages of the Mistassini River a large band of crystalline limestone was noted. This band is irregular in thickness, and appears to thin out at the upper portage; an extension of the same or a similar band is exposed for several miles along the course of Rat River, from which it crosses into the Rivière aux Ours, where it is seen below the first fall, but is there only five feet wide, and apparently near its eastern limit. This limestone or marble is occasionally found free from impurities, but having a coarse granular texture is unfit for building or ornamental purposes. The greater

† Geology of Canada 1863, p. 35.

part of the mass holds a varying quantity of light brown mica in small scales, while veins and detached masses of white orthoclase and pink and green scapolite are also common. In some of the bands rounded grains of green hornblende or pyroxene are found, chiefly near the junction with the enclosing gneiss.

"The Rat River was followed thirty-two miles along its course, the upper five being through an anorthosite area, probably an extension of the large area seen on the Peribonka River."

The Rivière aux Ours was ascended only ten miles, as the river there becomes unnavigable for a considerable distance. The rocks seen on this stream were orthoclase gneisses, with the exception of the limestone noted above.

"On the completion of this trip the party disbanded and Mr. Low returned to Ottawa, on the 27th of September. Cost of the explorations, $1,208.

Mr. Chalmers left Ottawa on the 5th of June to continue the survey and mapping of the surface geology of New Brunswick, his field work being the area included in the quarter-sheet map No. 2, S.E. This sheet embraces the county of Kent with adjacent portions of the counties of Westmoreland and Northumberland. His assistants were Mr. John H. McDonald, of Brockville, Ont., from the date of his leaving Ottawa till the 4th of October, and Mr. W. J. Wilson, of St. John, N.B., from the 30th June till the 15th of August.

The following is Mr. Chalmers's report on the season's work :—

"In the district to which this report relates the surface features are, generally speaking, uninteresting and monotonous, presenting the aspect of a low, level plain, which, however, rises gently towards the north-west margin. Between river valleys this flat Middle Carboniferous area is comparatively undrained, and hence much wet, barren land exists upon it, and shallow peat bogs are common.

"Making Weldford station our headquarters in the first part of the season we examined the country along the Intercolonial railway to the north and south. Numerous cuttings exposed good sections of the superficial deposits, and the rock surfaces exhibited striæ in many places. Two well-defined sets of these were observed. The first set occurs along the railway to the north of Richibucto River, the striæ trending about due east, and this course was found also near the coast in the Buctouche and Cocagne districts, varying in some places to points between east and north-east. The second set was seen along the Intercolonial railway to the south of Richibucto River, the striæ

having a nearly north to south course. Good examples of the latter were discovered just south of Welford station where the rock surfaces were exposed during the construction of the railway exhibiting finely preserved striæ with a course of S. 5° W. This is upon the water-shed between the Richibucto, which flows easterly into the Straits of Northumberland, and the Salmon River, flowing southwesterly into the St. John, or rather into Grand Lake, the elevation of this water-shed not being more than 200 to 250 feet above the sea. These two sets have only been produced by two different bodies of ice, both of which, to all appearances, have been local, the east and west striæ by ice which moved towards the straits mentioned, and the north and south by ice which flowed either northwardly into the valley of the Richibucto, or southwardly towards that of the St. John River.

"Boulder clay is sparingly found in many places on the higher grounds, but the chief covering of the rocks is a coat of their own debris, in the form of gravels, sands, &c., intermixed with boulders, chiefly local, with which, however, transported ones occur in greater or less numbers. The local debris referred to is usually masked by stratified materials, the relations of the two being seen in river banks, especially below the 200 feet contour line. The whole superficial covering of the Carboniferous rocks, indeed, appears more or less stratified in the upper part, and is, generally speaking, deeper than that resting upon the other geological systems or formations of the province. It conceals the rocks from view everywhere, except along river valleys. The millstone-grit, in its decay, seems, however, to have crumbled down largely into arenaceous materials. Sandy loam is met with along river courses, and clay beds constitute the basal member of the stratified series in certain places, but are not common; hence the conditions necessary for the preservation of the shells of marine animals in the post-Tertiary deposits of this district are rare, and consequently very few of these are found in the fossil state.

"A noteworthy feature of the surface beds upon the area referred to is the presence of boulders of granite, felsite, diorite, etc., scattered broadcast over them and often embedded therein. The boulders are obviously derived from the Cambro-Silurian, Cambrian and pre-Cambrian rocks to the north-west. Near the coast and below the 200 feet contour line, however, they are sparingly intermingled, in some localities, at least, with others which are not so easily accounted for, and which appear to have been borne thither by floating ice. The direction in which the boulders on the higher parts of the district have been transported is exemplified by their greater or less abundance in the different localities as we recede from the parent beds. For example,

along the south-west Miramichi those of granite and other crystalline rocks are unusually large and abundant, and in many cases angular, being near the parent rocks; but as we proceed eastwards across the Carboniferous basin they become smaller and more scattered. These transported boulders are, however, merely the residual specimens of the vast numbers which have been borne thither. Remains of others which have crumbled to pieces are seen in the coarser gravels and sands in numerous places.

"The other superficial deposits of the district presented no new features worthy of consideration.

"The evidence regarding the Pleistocene subsidence indicates that it may have been slightly less here than in the Bay of Fundy and the Baie des Chaleurs basins. An old shore line, quite distinct, was observed at Galloway, near Kingston, at a height of 150 to 160 feet above sea level. A similar ancient shore line, at about the same elevation, occurs in the Miramichi valley.

"After Mr. Wilson joined our party on the 30th of June, he and Mr. McDonald examined the southern part of the district, following all the roads and streams. While they were thus engaged, I first visited the ship railway now under construction across the Isthmus of Chignecto, for the purpose of re-examining the formations disclosed in an excavation for docks which is now being made at its western end. This excavation is opened in the margin of the Amherst salt marsh, between the mouths of the La Planche and Missaguash rivers. The section exhibits in descending order—(1) marsh mud, (2) blue clay holding shells of *Mya arenaria*, *Macoma grœnlandica*, and the young of *Buccinum undatum?*, (3) peat or humus, (4) red clay, and (5) boulder-clay, with local boulders. The bottom of the boulder-clay is not reached, although the excavation is upwards of 60 feet in depth. Afterwards I proceeded to Grand Manan, to examine one or two doubtful points there. Striation by ice, apparently from the mainland, and a few boulders evidently belonging to rocks other than those on the island, were observed on the higher parts, 350 to 400 feet above the sea. Returning to Kent county, I then made a canoe trip along the coast and around the lagoons inside of the sand dunes, which here form barriers along the shallow shores. Many interesting facts were noted regarding the formation of the sand beaches, lagoons, peat beds, salt marshes, etc.

"On the 3rd of October I visited St. John, with the view of re-examining the boulder-clay beds at Negrotown Point and the Fern Ledges. In company with Mr. Wilson, I measured a section of them at the latter place, to enable me to make a diagram exhibiting a deposit

of stratified clay intercalated therein. From St. John I went to St. Andrews to make some further observations on the glaciation of that section, more especially of Chamcook Mountain, etc. It was found that ice had ground completely over that hill, and that the summit, 637 feet above sea level, was scored and polished in a remarkable manner.

"Regarding the soil of the district examined during the past season, it may be remarked that it is, on the whole, good, especially along the coast and river banks, and also on some of the higher grounds between the streams. But large tracts are swampy, or covered with boggy material, constituting the so-called barrens. Wherever the natural drainage is sufficient to carry off the surplus waters due to precipitation, the land is fit for cultivation. It is, however, deficient in lime, and requires frequent applications of that material to bring it up to its highest yielding capacity. Good farming districts are found along the Richibucto valley, more especially on Nicholas River and Coal Branch, also in the Kouchibouguacis valley, and in the Buctouche and Cocagne districts.

"The forests of this part of the province, formerly so dense, and consisting of a mixed growth of trees, such as pine, spruce, birch, hemlock, cedar, poplar, hacmatac, etc., are now becoming greatly depleted. Large areas have been overrun by fires, and present little else but bare trunks and a scanty second growth. The destruction of timber from this cause alone is enormous. During the summer of 1888 the fires which swept over a large portion of the area under review destroyed valuable tracts of the forest.

"The materials of economic value met with in the district are few and unimportant.

"Peat is found in extensive bogs along the coast, especially near the Kouchibouguac, the Kouchibouguacis, Aldouane, Richibucto, and in many other places. These bogs are often deep, and produce abundant crops of cranberries. In the interior, large bogs often occur upon the flat, undrained portions of the district, but they are usually shallow, and in many cases support a scrubby growth of hacmatac and black spruce. No use has yet been made of peat in this part of the country.

"Gravel and sand, suitable for ballasting, road-making, etc., were observed in nearly every locality, and clay, available for brick-making, occurs in many of the river valleys. Fine blown-sands are abundant everywhere along the coast, forming the dunes or barriers already referred to.

"In the latter part of the season I visited the deposit of so-called magnetite, near the head of Millstream, Gloucester county, specimens

of which, analysed by Prof. Donald, chemist and assayer, Montreal, are reported to have yielded upwards of 60 per cent. of metallic iron, with 10 per cent of silica, etc. Considerable portions of the ore appear to be highly pyritous. About two miles distant from this deposit there occurs a vein of pyrites and galena, the former containing traces of gold and the latter of silver, according to an assay made by Mr. Hoffmann, chemist and mineralogist to the Geological Survey Department.

"Field work closed on the 4th of November and on the 6th I reached Ottawa. Mr. W. J. Wilson rendered me good service, and has now acquired such a knowledge of surface geology as to make him an efficient and valuable coadjutor in the work."

Cost of season's explorations, $1,005.41.

Early in July, Professor Bailey was occupied in completing the work taken in previous seasons in the counties of Rimouski and Temiscouata, in the province of Quebec, and in obtaining the additional data required to complete the sections of the map illustrating this region. Respecting the work, he reports as follows :—

"Careful examinations were made of the rocks exposed along the lines of the Intercolonial and Temiscouata railways, with reference both to the succession of strata and the possible occurrence of fossils, while similar observations were extended to portions of the intervening district, between Little Métis and Rivière du Loup. The general result was to show that the greater part, if not the whole, of this district is occupied by the Sillery formation, supposed to represent an upper portion of the Cambrian system. A detailed report, with accompanying maps, is being prepared, and will be published during the year.

"About the 25th of July I proceeded, in accordance with your instructions, to the province of Nova Scotia, and entered upon the study of the geology of Queen's and Shelburne counties. Having been desired by you to give my first attention to the coast, operations upon the latter were begun at the town of Liverpool, and were continuously carried on until the entire coast, from Port Medway harbour, forming the eastern boundary of Queen's county, to Pubnico harbour, forming the western limit of Shelburne, had been examined. This work was found to be unexpectedly easy, owing to the circumstance that almost the entire shore is occupied by fishermen, and bordered by roads which give easy access to any desired point. The comparative uniformity of the rock formations, consisting chiefly of fine grained gneisses, quartzites and mica schists, together with irregular masses of granite, further facilitated their study. The general result of these observations was

to show the crystalline rocks in question, which occupy a belt along the coast of from two to fifteen miles in width, are only a more highly altered condition of the gold-bearing slates and sandstones of the interior.

"Having completed the study of the coast, attention was next given to the more accessible portions of the inland districts. Every road in the two counties was traversed and observations were made on the character and relations of their rock formation, particular attention being paid to the country embracing the gold districts of Molega Lake and Whiteburne. The several members of the gold-bearing series were clearly distinguished, and numerous facts ascertained bearing upon their succession and the plications by which they have been affected, facts of the first importance in connection with the development of the gold industries of the district. A report embodying the results of these observations is now in course of preparation, but cannot well be completed until examinations are made of the numerous lakes and streams by which the country is intersected, and for the traversing of which there was not sufficient time during the past season. One of the streams, the Port Medway, affords admirable opportunities for this purpose, forming an almost continuous rock section from the border of Annapolis county to the coast, and its careful study will supply a key to the structure of the entire region."

Mr. Fletcher left Ottawa for Nova Scotia on the 8th of July, 1890, and continued fieldwork until the second week in December, being engaged during the greater part of that time in an examination of the district lying west of that surveyed in 1889, including a portion of the counties of Colchester and Hants.

His assistants were M. H. McLeod for six months, B. A. L. Huntsman for two months and a half, and D. I. V. Eaton, who is still employed. The cost of the season's explorations, including salaries of assistants, will be $1,300.

Within the area examined, Triassic, Carboniferous limestone and Devonian rocks are well exposed.

Between the Intercolonial railway along the Salmon River and the valley of the Stewiacke River, the country is occupied chiefly by the rocks of Union and Riversdale, described in previous reports as Devonian. These, at Brookfield, are referred by Sir Wm. Dawson to the Devonian, but south of Truro, to the lowest part of the Carboniferous. Dr. Ells, who considers them Devonian, traced them in 1884 nearly to the Shubenacadie River where they are succeeded by Carboniferous limestone; but beyond this river quartzites and

slates also occupy a considerable portion of the shore of Minas Basin at Walton, Split Rock, Somerville Landing and Avonport, and are seen in most of the brooks from Maitland as far as the mouth of the Gaspereaux River. Although at a few points west of Clifton the Carboniferous limestone comes between them, they are as a rule capped on the north by Triassic strata. These occupy, in nearly horizontal attitude, a basin which extends westward from near Valley Station, one rim fringing the south side of Minas Basin, the other reaching much further inland on the north side.

South of the Devonian slates, Carboniferous limestone occupies the basin of the Stewiacke River from Eastville to its confluence with the Shubenacadie, whence it stretches from Brookfield to Gay's River; thence up Shubenacadie River to Enfield, where it rests on Cambrian rocks of the Atlantic coast gold-bearing series and down stream to Maitland and Blackrock. Outliers are also found on Minas Basin, and a broad belt lies, as already stated, along the Kennetcook River.

Between the gold-bearing rocks and the Carboniferous of Stewiacke lies a great mass of drift sand, gravel and boulders.

Good sections across the country are given by the road from Walton to Brooklyn and Newport station, by that from Noel through Kennetcook Corner to the Gore, and from the Gore to Shubenacadie station. The first crosses principally Carboniferous limestone to the contact of the gold-bearing rocks, a short distance east of Newport station. The second shows first Devonian, then Carboniferous limestone, with the small coal seams of Kennetcook, then the great band of soft micaceous and chloritic slates of various colours, which enclose the cross-leads of quartz, from which are derived the stibnite of the West Gore antimony mine and the gold of Central Rawdon. From the last named locality come the forms found at the gold mines last summer by Professor Hind, supposed by him to be *stromatopora*, but which, on examination by Mr. T. C. Weston, of the Geological Survey, proved to be only concretions of dolomite. From Shubenacadie and Elmsdale to the slates of the Gore—once quarried for roofing slate—the rocks are chiefly Carboniferous limestone.

A careful survey of the Devonian rocks and Carboniferous limestone of the East Mountain of Onslow and Penny's Mountain, in Clifford's and Farnham's brooks, has shown that the latter rest, in small patches, on the former, with the most complete and satisfactory evidence of unconformity, and unconformity scarcely less evident is seen also at Walton and Cheverie.

The Trias seems to yield no minerals of economic value, its sandstones being too crumbly for building, and its concretionary beds too impure for limestone. In the Lower Carboniferous, on the other hand, limestone quarries abound, some of which at Brookfield, Stewiacke, Shubenacadie and elsewhere, are extensively worked. The red hematite of Newton Mills is a deposit at the junction of the Carboniferous limestone, and conglomerate with the Cambrian gold-bearing series, and similar ores may be expected at other points along the line of contact. The limonite of the Brookfield iron mine is also at or near the base of the Carboniferous. It is now being vigorously worked by the New Glasgow Coal, Iron and Railway Company, who are also working their East River of Pictou iron areas, near which they are erecting a large blast furnace (see "Canadian Mining Review" for August, page 113.) At the same horizon, probably, are the manganese mines of Tenny Cape, Walton, Cheverie and East Onslow. That of Tenny Cape has continued for many years to supply a large quantity of the purest manganese di-oxide (pyrolusite).

From quarries near Windsor, Cheverie and Walton large quantities of gypsum are exported to the United States, and plaster is also worked on a smaller scale at Beaver Brook, Shubenacadie, Stewiacke and other places within the area.

In the East Brook, which flows into Stewiacke River from the south, about eight miles above the station, a seam of coal, apparently not exceeding eighteen inches in thickness, of mixed coal and carbonaceous shale, was lately opened. A boring sunk about 80 feet at Johnston Brook, not far distant, is said to have cut black gypsum, and the coal is probably about the same horizon as that of Kennetcook. The celebrated scythestone of Birch Hill, a fine gray sandstone, with sharp grains of silica, is found in the same neighbourhood. Coal was also reported to occur at Selma, but the report seems to have arisen from the presence of thin bands of dark gray shale, marked with fossil plants, among thick beds of gray flinty sandstone, which forms barrens in the neighbourhood. At the request of Mr. Robert H. Fraser, Superintendent of the Nova Scotia Central railway, a visit was paid on the 20th of October to borings made in search of coal at Spa Springs, Annapolis County. One hole had been sunk 100 feet, but nowhere in the neighbourhood were rocks seen in which coal could reasonably be expected to occur. Beneath what appears to be an overflow of coarse dolerite near the top of a steep slope lies a layer of bright greenish clay rock, underlaid by dark graphitic argillite, from a few inches to several feet thick, succeeded below by bright red rocks, presumably of Triassic age.

Great excitement was caused last summer by the reported discovery of gold in a whitish-gray flinty conglomerate consisting almost wholly of pebbles and grains of white quartz, beds of which underlie the Carboniferous limestone from the neighbourhood of Brookfield, far up the Stewiacke River on the north side. The region was proclaimed a gold district, and rights of search taken out covering many miles. The attention of prospectors was, moreover, directed to all the conglomerates in the province. That the conglomerate on Gay's River is auriferous has long been well known, and Professor Hind has proved the existence of gold, silver and copper in certain beds of that nature near Baddeck. The Brookfield conglomerate was said to have given rich returns by milling, although a somewhat close examination by panning the dirt in the beds of the streams flowing over it failed to indicate the presence of gold in appreciable quantity. Two samples were sent to Mr. Hoffmann, one from the neighbourhood of the barytes mine, the other from the brook three hundred yards above the Glenbervie mills; but neither of them yielded, on assay, a trace of either silver or gold. Tests subsequently made on a large scale at the mill of one of the gold mines emphatically confirmed the accuracy of Mr. Hoffmann's assays.

It has been shown that the rocks of the Londonderry iron mines, formerly supposed to be Devonian, and subsequently Silurian or Cambro-Silurian, everywhere contain Devonian plants; and as similar slates were stated by Mr. Scott Barlow to be largely developed in the west branch of Economy River, it was deemed advisable to re-examine these latter for comparison, and to collect specimens of the fossils with which they are crowded. In 1876, from dark shales in situ in a little brook at Farmington, in Cumberland county, a locality of slaty rocks to which also attention was directed by Mr. Barlow, and at which he obtained trilobites in 1876, several species of graptolites and other Silurian fossils were collected. In Bulmer Brook and other brooks of this vicinity, pre-Carboniferous argillites were seen in contact with traps, agglomerates, felsites and other rocks of similar origin.

The conclusion arrived at, that large areas hitherto mapped as Cambro-Silurian are no older than Devonian, led to a short re-examination of the Cambro-Silurian strata of the iron mines of the East River of Pictou. These, however, appear to be older than the rocks of Londonderry.

Mr. E. R. Faribault left Ottawa on the 11th of June, with instructions to continue the detailed surveys of previous years and study the

stratigraphical structure of the gold-bearing series of rocks of the Atlantic coast of Nova Scotia.

The district surveyed lies westward of that surveyed in 1888, and southward of that surveyed in 1889, extending along the sea shore in Halifax county from Tangier to Lawrencetown and some twenty miles inland, an area of about 375 square miles.

The auriferous Lower Cambrian rocks of the country are cut by an uninterrupted belt of granite, two to four miles wide, extending westward to within two miles of Waverly. The folds of the gold-bearing series, and more especially the anticlinal axes, were carefully examined and traced out, on account of their close relation to the richest auriferous belts.

The gold mining districts of Tangier, Lake Catcha and Head of Chezzetcook are situated in the region examined. These districts were carefully studied as to their geological structure, and found to be on the axes of anticlinals, and are the auriferous leads of Murphy's Cove and Black Point of Ship harbour, Clam Bay and English Point of Jeddore, and those on the south side of Conrod and Thomson lakes are similarly situated.

Three miles up the Musquodoboit road a few tons of loose argentiferous galena ore were taken out, along four levels tunnelled in granite debris on the face of a hill. An assay of the ore is said to have given a good showing of silver, but so far the developments made have not reached the bed rock.

Some fossil forms, taken from the gold-bearing slates at the Northup gold mines at Rawdon, and believed to be of organic origin, were found on microscopic examination by Mr. T. C. Weston to be merely concretions.

Mr. Ed. Gilpin, Inspector of Mines in Nova Scotia, has found markings on Lower Cambrian rocks near Bedford which may prove of some importance in determining more definitely the age of this series.

Mr. Faribault was assisted, as in previous years, by Messrs. A. Cameron, J. McG. Cruickshanks and P. A. Faribault.

The season's work extended until the first of November; cost $1,106.54.

MINERAL STATISTICS AND MINES.

Mr. E. D. Ingall, Mining Engineer in charge of the division of Statistics and Mines, makes the following report on the work done during the past year :—

"The early part of the year was occupied with the ordinary routine connected with preparation of statistics of mineral production, etc., during 1889. A summary of this was printed and distributed in April, and the full report was issued in November. Considerable attention has also been given to devising more complete and efficient methods for attaining the objects sought in establishing the Mining division of the Department. To this end, efforts have been made to revise and complete the Directory of producers of economic minerals and of the localities where the various minerals are worked, or occur in the Dominion: these latter are being geographically represented on maps by means of a complete system of conventional signs. In the compilation of this schedule of signs those already in use by the Survey have been taken as a basis, others invented, where necessary for the completion of the list, and the whole elaborated so as to show not only the metallic ore dealt with, but also the particular ore yielded by the deposit.

"Preliminary steps have also been taken towards the more systematic arrangement of the mining records, such as of borings, mining plans, reports, etc., and the cataloguing of the same, while effort has also been directed towards the more continuous and regular acquirement by the office of general mining information at frequent regular intervals during the year from the several mining districts.

"During the summer investigations were made by myself and by Mr. Brumell, regarding the progress and condition of the mineral industries in a number of mining districts in Ontario, Quebec and New Brunswick.

"As last summer was the first opportunity I have had to visit most of the mining districts referred to, the investigations made were more or less of a preliminary and general character, and were undertaken to familiarize myself with the aspect and leading features of the several districts, and to become better acquainted with the mine owners and managers, and thus be able to deal more intelligently with the returns and the reports sent by them to the Department.

"With this object in view the iron, mica and phosphate districts of the eastern part of the province of Ontario were visited, as also were the Madoc gold and iron centres, likewise the Sault Ste. Marie and the Sudbury mining districts. Attention was also directed to the salt, gypsum, petroleum and natural gas industries, the two latter receiving special attention from Mr. Brumell.

"In Quebec visits were made to the gold, asbestus and copper mining, and slate quarrying districts of the Eastern Townships, as well as the newly started asbestus mines and phosphate mines of Ottawa

county. In New Brunswick the coal and manganese mines were visited, and also the gypsum and granite quarries, etc.

"During the summer Mr. Brumell visited several points in Ontario where boring operations were being carried on. Notes on these were made and information relating to old borings and the occurrence of gas and oil was obtained. Mr. Brumell states:—

"In Essex county extensive drilling operations were in progress at various points, more especially in the district between Essex Centre, Harrow and Leamington. At Essex Centre the Central Gas and Oil Company of that place have finished a well 1,200 feet in depth without, however, any economic result, as neither gas nor oil were obtained. At Walker's Marsh, the Messrs. Walker and Sons, of Windsor, have finished three wells from which a very considerable flow of oil was obtained. They have also been actively carrying on operations in other parts of the county and in the adjoining county of Kent. The Citizens Gas, Oil and Piping Company, of Kingsville, during the year drilled on the road allowance, west of the well known as 'Coste No. 1,' where a daily flow of gas amounting to over 7,000,000 cubic feet per day was obtained; this gas is now being utilized in lighting the streets of Kingsville, to which town it has been piped. The drilling of this well was the cause of considerable litigation between the owners and the Ontario Natural Gas and Fuel Company, the owners of 'Coste No. 1,' the result of the suit was, however, in favour of the former company the injunction given at the instance of the latter company not being sustained. The Ontario Natural Gas and Fuel Company have, it is understood, again undertaken operations in the county, in that part between 'The Marsh' and Essex Centre, with what result, however, we are unacquainted. Various other operators have been working throughout the country, but owing to lack of time I was not enabled to ascertain the result nor the extent of their operations.

"In Kent county, in addition to the work done by Messrs. Walker & Sons, mentioned above, a certain amount of work has been carried on, notably the well sunk by the Citizen's Gas Company of Blenheim, where in a boring 900 feet deep small flows of gas were obtained at 700 and 800 feet.

"At Stratford, Perth county, a boring was undertaken by the Stratford Natural Gas Company, which at the time of my visit, on the 12th of August, had reached 900 feet without encountering gas or oil.

"In Welland county the Provincial Natural Gas and Fuel Company, have finished their series of wells to the number of fourteen, all of which are situated in the townships of Bertie and Humberstone, in the vicinity of Sherks Station on the Grand Trunk railway. Other

operators have been busy throughout the county, notably Messrs. Conmiller & White, who drilled for and obtained gas in the town of Port Colborne. John Rube struck gas a few miles west of that town, this gas is being utilized in the firing of lime-kilns owned and operated by Mr. Rube. Another lime producer, Mr. Carroll, drilled in the south-west part of Bertie township, and in the northern part of Port Colborne, Mr. Edward Wear struck a well from which a daily flow of gas of over 400,000 cubic feet is recorded.

"In Wentworth county considerable activity has been evinced in the search for gas and oil, several wells having been sunk in the vicinity of Hamilton, though with what result was not ascertained.

"Outside of the counties above mentioned, but little has been done except in the county of Lambton, where, in the oil territory of Enniskillen township, the usual amount of boring has been carried on and many new wells brought in with the usual average daily flow of oil."

A detailed report of the gas oil and salt wells in Ontario is now being prepared by Mr. Brumell.

In reference to the development of the gas and oil industry of which particulars are given above as regards Ontario, I desire to again call attention to a district in the province of Quebec, viz.: The valley of Richelieu River, north of St. Hyacinthe, on the Grand Trunk railway, as one in which there are strong probabilities of remunerative gas or oil wells being struck at depths probably not exceeding 1,500 or 2,000 feet. The whole area is underlaid by the Trenton limestone and already, further north-east, near Lake St. Peter, a considerable flow of gas was struck, but which, so far, as I can learn, has never been utilized in any way. This well was described in the Summary Report for 1887. That the discovery at St. Grégoire should not have been more energetically followed up, is probably accounted for, if, as I am informed, one company has acquired by charter an exclusive right to seek and use natural gas in and over the whole province of Quebec.

"Mr. Jas. White's time was occupied in completing surveys of the south-west corner of the map illustrating the River du Lièvre, and Templeton phosphate districts, and in making surveys of mines and workings in the Eastern Ontario phosphate, mica and iron districts, comprising the workings and pits of some 22 mines.

"Since returning from the field in the fall, the time has been occupied in the ordinary routine work of the division; collecting and preparing the material for the annual report; answering inquiries, etc., together with a continuation of the work of preparation of the Directory, and maps of mineral occurrences, etc. It is hoped, that some of these maps will be published during the coming year.

"The number of circulars sent out, together with the reminders found necessary, amounts to about 5,500, besides about 650 letters sent, and some 500 received."

Chemistry and Mineralogy.

With reference to the work carried out in this connection, Mr. Hoffmann reports as follows:—

Agreeably with the practice of former years, the work carried out in the chemical laboratory has been of an almost purely practical character; but few examinations or analyses having been made other than material which it was deemed might, not improbably prove of some importance. The work embraced:

I. Analyses of fuels.

II. Analyses of limestone and dolomites.

III. Analyses of mineral waters and brines.

IV. Analyses of iron ores.

V. Gold and silver assays.

VI. Miscellaneous examinations—under which heading are included clays, marls, saline deposits, etc., etc.

The number of mineral specimens received, brought or sent, for examination amounted to five hundred and fifty-eight. The greater number of these were brought by visitors, to whom the required information in regard to their economic value was communicated at the time of their visit. In other instances, those where a more detailed examination appeared called for, or when the specimens had been sent from a distance, the results were sent by letter. The number of letters written, the majority of which were of the nature of reports, amounted to two hundred and forty-six. The number of letters received, one hundred and forty-eight.

Mr. F. G. Wait has, as a principal work, been engaged in the analyses of some twelve samples of brine from Lake Winnipegosis, collected by Mr. J. B. Tyrrell; the inquiry having for its object the ascertaining if these brines would be suitable for the manufacture of salt.

Mr. R. A. A. Johnston has, in addition to a great variety of miscellaneous work, conducted a series of analyses of limestones and dolomites, with the view of ascertaining their relative merits, in so far as chemical composition is concerned, for structural and other purposes. He has also examined numerous samples of ore in regard to their nickel content.

In the work in connection with the minerological section of the Museum, I have been most ably and faithfully assisted by Mr. R. L. Broadbent. In addition to the work of labelling, readjusting specimens and maintaining the collection generally in an orderly condition, he has completed the rough draft of a catalogue of the economic collection of minerals, so that the manuscript of the whole catalogue for this section of the Museum will now very shortly be ready to place in the hands of the printer.

A great many of the mineral specimens have been replaced by more characteristic ones, and the collection augmented by the addition of some three hundred others. Of these the following were collected by members of the staff:—

1. Dr. G. M. Dawson:—

   Ninety specimens of gold and silver ores from British Columbia.

2. Mr. A. E. Barlow:—

   Thirty specimens of copper and nickel ore from Sudbury and vicinity.

And the undermentioned constituted presentations:—

1. Allan, W. A., Ottawa, O.:—

   Magnetite, from lot 1, range I., of the township of Torbolton, in Carleton county, O.

2. Baker, Lieut-Colonel James, M.P.P., Cranbrook, Kootanie, B.C.:—

   A sample of crude petroleum, from Sage Creek, Flathead River, East Kootanie, B.C.

3. Byrne, W. E.:—

   Galena, from mine on Mill Stream, township of Beresford, Gloucester county, N.B.

4. Campbell, A. M., Perth, O., per A. E. Barlow:—

   Martite, from the Dalhousie mine, Dalhousie township, Lancaster county, O.

5. Canadian Copper Company, Sudbury, O., per Wm. Evans, Manager:

   (*a.*) Pyrrhotite (nickeliferous), and

   (*b.*) Chalcopyrite and pyrrhotite (nickeliferous), from the Copper Cliff mine, lot 12, range II. of the township of McKim, district of Nipissing, O.

   (*c.*) Sample of foregoing ore, after roasting.

   (*d.*) Sample of matte containing 17 per cent nickel and 23 per cent copper.

(*e.*) Nickeliferous pyrrhotite and chalcopyrite, from Evans's mine, lot 1, range I. of the township of Snider, district of Algoma, O.

6. Dickson, Wm., Pakenham, O. :—
Silicified wood, from Long Lake, N.W.T.

7. Donald, J. T., Montreal, Q. :—
Scolecite, from Black Lake, township of Coleraine, Megantic county, Q.

8. Ferguson, J., Newcastle, N.B. :—
Iron ochre, from the North-west branch of the Miramichi, Northumberland county, N.B.

9. Gordon, W. H. Lockart, Toronto, O. :—
(*a.*) Apatite, from lots 13, 14, 15 and 17, range XI. of the township of Monmouth, Peterborough county, O.
(*b.*) Apatite, from lot 4, range III. of the township of Dudley, Peterborough county, O.
(*c.*) Apatite, from lot 11, range V. of the township of Dysart, Peterborough county, O.
(*d.*) Apatite, from lot 21, range XI. of the township of Harcourt, Peterborough county, O.

10. Grace, P., Gracefield, Q. :—
Mica, from lot 38, range I. of the township of Bouchette, Ottawa county, Q.

11. James, Joseph, Bridgewater, O. :—
(*a.*) Asbestus, from lot 7, range XI. of the township of Elzevir, Hastings county, O.
(*b.*) A sample of the ground asbestus.
(*c.*) Roofing cement prepared from the same.

12. McKindsey, Hon. G. C., Milton, O. :—
Seven specimens of terra-cotta ware.

13. Matthis, Bro., Ottawa, O. :—
Clay nodules, from Green's Creek, Gloucester township, Carleton county, O.

14. Murray, John, Spence's Bridge, B.C. :—
Gypsum, from vicinity of Spence's Bridge, B.C.

15. Northup, Gould, per Hugh Fletcher :—
Native gold in quartz, from the Central Rawdon gold mine, Hants county, N.S.

16. Payne, W. R., Bathurst, N.B. :—
Magnetite, from head of Mill Stream, township of Beresford, Gloucester county, N.B.

17. Poole, H. S., Stellarton, N.S. :—
Stalagmite, from the Acadia coal mine, Pictou county, N.S.

18. Robotham, Capt. J. G. C., Victoria, B.C. :—
Infusorial earth, from Quamichan, Vancouver Island, B.C.

19. Scott, J. G., Quebec, Q. :—
A six-inch cube of dressed limestone, River Mistassini, about thirty miles from Lake St. John, Q.

20. Soues, —, Clinton, B.C. :—
A nugget of native copper, from Eleven-Mile Creek, Fraser River, B.C.

21. Sperry, Francis L., Sudbury, O. :—
Sperrylite, from the Vermilion mine, lot 6, range IV. of the township of Denison, district of Algoma, O.

22. Willimott & Co., Ottawa, O. :—
(*a.*) A collection consisting of 119 specimens of Canadian cut-stones.
(*b.*) Strontianite, from Carleton county, O.

Mr. C. W. Willimott reports that during the early part of the year, he was engaged making up collections of minerals and rocks, for the following institutions :—

High School, Beamsville, Ont	113
do St. Johns, Que	113
Commercial Academy, Quebec, Que.—(Supplementary	20
Mechanics Institute, Wingham, Que	121
High School, Paris, Ont	113
Shefford Academy, Shefford, Que	113
Royal Military College, Kingston, Ont.—Supplementary	54
Collège St. Rémi, county of Napierville, Que.	106
High School, Essex Centre, Ont	109
do Parkhill, Ont	109
Separate School, Freelton, Ont	109
Collège Set. Anne de la Pocatière, Que	109
St. Francis College, Richmond, Que	109
Presqu'Ile Park Museum, Presqu'lle, Ont	109
High School, Guelph, Ont	115
Superior School, Petit Rocher, Gloucester county, N.B	13
Collegiate Institute, Hamilton, Ont	103
Total	1,648

A collection of 400 specimens of minerals and rocks was sent in for identification by the Collège St. Laurent, Montreal, these were named and returned. That during the summer, between the 11th of August and the 16th of September, several mineral localities in the townships of Hull and Wakefield were visited to obtain specimens, required for making up collections. Only those localities were examined, which it was thought would afford the best specimens. In some instances poor success was met with, either from the running out of the mineral, or from being unable to find the exact locality, owing to the dense growth of underbrush. Nevertheless ten boxes of suitable specimens were collected, including some fine examples of crystals. Considerable delay was caused by the extremely wet weather, making the search through the thick woods unpleasant and difficult.

Mr. W. F. Ferrier has been chiefly occupied in the study of collections of rocks brought from various parts of the Dominion by the field geologists and explorers of the staff.

A considerable portion of his time has also necessarily been devoted to superintending the preparation of thin sections of these and other rocks requiring identification, the arrangement of a large number of specimens collected by Dr. Lawson, Mr. Adams and others, and other routine work.

Good progress has also been made in the determination, naming and labelling of the rocks in the general stratigraphical collection exhibited in the Museum, which, when properly classified and arranged, will be invaluable as a reference collection. Numerous specimens have been handed to him from time to time, and identified by their microscopical characters and simple blowpipe tests.

A few of the building stones from British Columbia have been studied microscopically to determine their true character and durability, and further work is purposed in this direction.

The series of Archæan rocks collected by Mr. Tyrrell from Lake Winnipeg, and by Dr. Bell and Mr. Barlow from the Sudbury region, which show many striking points of resemblance are now being investigated. 121 of the specimens of rocks brought in by the field parties, have been studied in thin sections, with the microscope and reported on during the past six months.

Palæontology and Zoology.

In addition to museum work and his other official duties, Mr. Whiteaves has been engaged, during the past year, in a critical study of the fossils of the Devonian rocks of the Mackenzie River district and of

Northern Manitoba. The manuscript of the third part of the 'Contributions to Canadian Palæontology,' which consists of a report upon the collections of fossils made by Mr. McConnell in 1887-89, from the Devonian rocks of the Hay, Mackenzie and Peace rivers, was finished in September, and the four plates required for its illustration were printed. Before sending the MS. of this report to the printer, however, the receipt of an additional and important collection of fossils, made by Mr. McConnell during the summer season of 1890 from the Devonian rocks of the Athabasca River and its tributaries, induced the writer to enlarge its scope, so as to make it include not only all the raw material obtained by Mr. McConnell, but also three small collections of fossils made by Prof. Macoun, Mr. A. S. Cochrane and Dr. Bell, in 1876, 1881 and 1882, from the Devonian limestone of the Athabasca and the Clearwater. The report as thus enlarged has been rewritten, an additional plate has been prepared to illustrate it, and the whole is now ready for publication.

Considerable progress has been made in the study of the unusually extensive collections of fossils made by Mr. Tyrrell, in 1888-89, from the Devonian and Silurian rocks of lakes Manitoba and Winnipegosis. The generic and specific relations of nearly all the sponges, brachiopoda and cephalopoda, and those of most of the pelecypoda, gasteropoda, crustacea and fishes in these collections have been ascertained and a preliminary list of them prepared for publication in Mr. Tyrrell's forthcoming report on the geology of this region. Some of the more critical of the mollusca and most of the corals and polyzoa have, however, yet to be studied. At an early date it is intended to publish an illustrated report upon the whole of these fossils in the fourth and concluding part of the 'Contributions to Canadian Palæontology.' In the meantime a paper descriptive of fifteen of the most striking species of brachiopoda and mollusca in these collections has been prepared and published in the 'Transactions of the Royal Society of Canada' for 1890. It consists of eighteen pages quarto and is illustrated by seven full page plates.

In August a fortnight was spent with Dr. Ells in an examination of the fossiliferous exposures near Philipsburgh, St. Dominique and Mystic, P.Q., and several species of fossils new to that district were obtained. In September a short visit was made to Hamilton, Hagersville and Cayuga, Ont. At the first named place a number of local collections were examined and several specimens of interest secured for the museum, especially a series of jaws, vertebræ and other bones, of snakes, small rodents and insectivora from the upper part of the sand and gravel ridge at Burlington Heights. From the Corniferous lime-

stone of the neighbourhood of Hagersville a small collection of fossils was made which includes specimens of a few species not previously represented in the Museum.

The MS. of the first part of a descriptive monograph of the Vertebrata of the Tertiary and Cretaceous rocks of the North-west Territory, by Prof. E. D. Cope, has been received during the year and is now in type. It contains a description of the species from the White River beds (Older Miocene) of the Swift Current Creek region of the Cypress Hills and will consist of twenty-seven pages quarto, illustrated by fourteen full page plates.

The MS. of the third part of the 'Contributions to Canadian Micro-Palæontology,' by Prof. T. Rupert Jones, F.R.S., has also been received and is now in the printer's hands. It consists of a description of a number of Ostracoda from the Cambro-Silurian, Silurian and Devonian rocks of Canada, and will be illustrated with two full page large octavo plates.

In the Department of Zoology another large collection of the mammalia, birds, reptiles, etc., of British Columbia, has been received from Prof. Macoun. Fifteen specimens of mammals, ninety-five of birds and two of turtles have been skilfully mounted by Mr. Herring during the past year, and twenty-four bird skins have been put up by him. Among the most striking of the additions to this branch of the museum are a remarkably fine specimen of the Musk Ox (*Ovibos moschatus*), from Fort Rae, on Great Slave Lake, recently presented by Julian Camsell, Esq., Chief Factor of the Hudson Bay Company in the Mackenzie River district, and an adult male of the Woodland Caribou (*Rangifer Caribou*), from the Selkirk Ranges of British Columbia, obtained by Dr. G. M. Dawson.

For two months and seven days during the past summer the duties of Acting Director have been performed by Mr. Whiteaves, and in addition to the correspondence thereby occasioned, 220 official letters have been received during the year, and 220 written.

From the 6th of January to the 26th of June, Mr. T. C. Weston was confined to his house by severe illness. He subsequently obtained leave of absence until the first of August, and during that time and up to the 8th of September he was occupied in the examination of the rocks in the neighbourhood of Quebec city, from which he was successful in obtaining a remarkable and in some respects u nique set of fossils, which throw considerable light on the age of these rocks, which is still under discussion. From the 10th of September until the close of the year, Mr. Weston's time has been spent in museum work, in the palæontological and archæological sections, in arranging several hundreds of

new specimens in the cases, in preparing descriptive labels for them, and the like.

Mr. L. M. Lambe was engaged in the early part of the year in the study of collections of fossils from Lake Winnipegosis and the Hay River, collected by Messrs. Tyrrell, Dowling and McConnell, in assisting in their determination and preparing drawings for their illustration.

During the latter part of July and in August Mr. Lambe, with Mr. Dowling, made a collection of fossils from the Cambro-Silurian rocks of Lake Winnipeg, from Dog Head on the south to the Little Saskatchewan on the north, and then east to Beren's or Swampy Island, including all the islands off that part of the western shore of the lake. He also visited East Selkirk, Manitoba, and made a collection of fossils at that place.

After his return, Mr. Lambe assisted Mr. Whiteaves in an examination and study of some Devonian fossils from Lake Winnipegosis, and prepared plates for their illustration in the transactions of the Royal Society of Canada for 1890, and has since been engaged in the study of some fossils collected by Mr. McConnell on the Athabasca River during the summer of 1890.

During the past year Mr. H. M. Ami's time has been occupied at intervals in sorting, identifying and labelling large collections of fossils which have not been unpacked since they left Montreal. About 20,000 specimens were examined with this end in view, and all of these are now accessible and available for reference or as duplicates. In March he made a selection of about 100 specimens of fossils and Indian remains belonging to the estate of the late Sheriff Dickson, for the Museum. He also assisted in a preliminary examination of fossils recently received from the North-west Territories, and spent some time in rearranging the palæontological part of the library, with a view to making a catalogue thereof. In April Mr. Ami identified and labelled some 250 fossils for the St. Laurent College, Montreal, and some other specimens for a private collector at Hamilton in return for donations to the Museum. He also prepared systematic lists of species from various localities in Ontario, Quebec, Nova Scotia and New Brunswick, and selected several especially among the graptolidæ, monticuliporidæ and ostracoda, which require further study. With Mr. Herdt's assistance and during Mr. Weston's illness, he attended to the reception, registration and arrangement of the archæological specimens brought in by officers of the Survey or presented by them. During the month of May he arranged, classified and labelled the vertebrate remains of the Lower Miocene of the Cypress Hills upon which Professor Cope has recently reported. A collection of fossils, consist-

ing of 61 species and 184 specimens, has been prepared by Mr. Ami and sent to the Museum of Queen's College, Kingston, in July, and another, consisting of 365 specimens, was sent to the Redpath Museum, Montreal, in October. Small sets of fossils have been loaned or sent, for scientific purposes, to various specialists, especially to Professor Hall at Albany, Mr. C. D. Walcott at Washington, Professor E. D. Cope at Philadelphia, and Dr. J. G. Hinde of Croydon, England. At the end of October he visited Quebec city and collected a series of fossils from the neighbourhood and named several hundred specimens of fossils for the Laval University. In November he prepared systematic lists of fossils for Mr. Low's report on the geology of the counties of Portneuf, Quebec, Montmorency and Champlain, P.Q., and identified a few fossils from the black shales of Mr. Wissick, Lake Temiscouata, for Professor Bailey. He has also made a preliminary examination of the collections of fossils from Quebec city, made by Mr. Weston during the past summer, and of those made by Dr. Ells, Mr. Giroux and Mr. Deeks in the Eastern Townships. He has also prepared labels for a number of species of Cambrian and Carboniferous fossils which were previously unlabelled. From the 3rd May to the 1st September he was assisted by Mr. H. D. Herdt, a science student of McGill University.

The following collections have been received during the year from members of the staff:—

Dr. G. M. Dawson:—

174 specimens of fossil plants, shells, etc., from the southern interior of British Columbia. Six specimens of the fresh-water pearl mussel (*Margaritana margaritifera*) from the headwaters of the Bonaparte River, B.C. One fine specimen of the Woodland Caribou (*Rangifer Caribou*). About 200 specimens of arrowheads, jade implements, etc., from British Columbia.

J. F. Whiteaves:—

Fifty specimens of fossils from the Corniferous of Hagersville, Ont.

Dr. R. W. Ells:—

About 1,200 specimens of fossils from the Cambrian, Cambro-Silurian and Silurian rocks at numerous localities in the province of Quebec. Hairy-tailed Mole (*Scapanus Breweri*) from base of Orford Mountain, P.Q.

Hugh Fletcher:—

Fifty-four specimens of Silurian and other fossils from Economy River and River Philip, N.S. About sixty specimens of Carboniferous plants from the Pictou and Springhill coal mines of

Nova Scotia, through Messrs. H. S. Poole and William Madden.

R. G. McConnell :—

About 300 specimens of fossils from the Devonian and Cretaceous strata of the Athabasca River and its tributaries.

J. B. Tyrrell :—

500 fossils from the Assiniboine and Saskatchewan rivers and Lake Winnipeg region of Manitoba.

T. C. Weston :—

284 specimens of Cambro-Silurian fossils from the Montcalm market and Cove Field rocks of Quebec city, Que. One spear head from Hog's Back, Nepean, Ont.

H. M. Ami and H. D. Herdt :—

A number of fossils from the post-Tertiary deposits of Moose Creek, the post-Tertiary and Cambro-Silurian formations of the city of Quebec and vicinity of Ottawa. Eleven archæological specimens from Old Indian Settlement, Casselman, Ont., and an Ermine (*Putorius ermineus*) from Russell, Ont.

D. B. Dowling and L. M. Lambe :—

750 specimens from the Cambro-Silurian rocks of Lake Winnipeg, Man.

L. M. Lambe :—

Fifty specimens of fossils from East Selkirk, and a large "head" of *Cleiocrinus* from Hull, P.Q.

A. P. Low :—

One fossil from Chambord, Lake St. John, Que. One chipped quartz implement, Quebec.

N. J. Giroux :—

About 100 specimens of fossils from the Cambro-Silurian rocks of Quebec.

The additions to the palæontological, ethnological and zoological departments of the museum, by presentation, exchange or purchase, are as follows :—

By Presentation.

Julian Camsell, Chief Factor, Hudson Bay Co., Mackenzie River district :—

Fine specimen of the Musk Ox (*Ovibos moschatus*) from Fort Rae, Great Slave Lake.

James Fletcher, Ottawa :—

Male Mole Shrew (*Blarina brevicauda)* in the flesh. Six Snow-flakes (*Plectrophenix nivalis*) in the flesh. One Lapland Long-spur (*Calcarius Lapponicus*).

Dr. C. A. White, U.S. Geological Survey, Washington :—

Two specimens of an undermentioned species of *Rhynchonella* found associated with *Aucellæ* at Paskanta, California.

John C. McRae, Port Colborne, Ont. :—

Twenty-five specimens of fossils from the Corniferous Limestone near Port Colborne, two fragments of *Eurypterus* from the Water-lime group at Stonebridge, Ont., eleven specimens of fossils from the St. Louis limestone, and a *Spirifera* from the sub-Carboniferous limestone of Alabama.

Max Klotz, Preston, Ont. :—

Four specimens of *Megalomus Canadensis* from the Guelph limestone, below Preston, on the Grand River.

Donald McKay, Indian Head, N.W.T. :—

Skin of Silver-haired Bat (*Scotophilus noctivagans*) from Indian Head.

W. F. Ganong, Cambridge, Mass. :—

One Starfish (*Asterias Forbesi*) from Oak Bay, Charlotte Co., N.B., and four species of marine Mollusca from the oyster beds of Prince Edward Island.

G. R. White, Ottawa :—

Skin of Grey Gopher (*Spermophilus Richardsoni*).

Prof. H. Alleyne Nicholson, University of Aberdeen, Scotland :—

Named specimens of twenty-one species of Polyzoa from the Trenton, Corniferous and Hamilton formations of Ontario, described or identified by the donor.

H. G. Stanton :—

Specimen of *Miya truncata*, with both valves, from the post-Pliocene of River Beaudette, P.Q.

J. Deans, Victoria, V.I. :—

One specimen of *Monotis subcircularis*, two of *Arniotites Vancouverensis*, from the Trias of Vancouver Island, and phragmocone of a large Belemnite from the Cretaceous rocks of Maud Island, Q.C.I.

S. Robbins, Nanaimo, V.I. :—

Two cores from boring in the Cretaceous rocks (Nanaimo series) of Vancouver Island ; one containing specimens of *Anomia*

Vancouverensis, *Inoceramus mytilopsis*, *Entalis Cooperi* and *Haminea Hornii*.

Captain Josiah Jacques, Victoria, V.I. :—

Burrows of *Teredo* in fossil wood; four species of fossil Pelecypoda and two of Gasteropoda, from near Carmanah Point, V.I.; also one *Conchocele disjuncta* and one *Pachypoma gibberosum*, from post-Pliocene deposits, three miles E. S.-E. of Bonilla Point, V.I.

W. E. Saunders, London, Ont. ;—

One small Turtle (*Nanemys guttata*) alive, caught near London, Ont., and one fine living example of Blanding's Box Turtle (*Emys meleagris*, Shaw), from Rondeau, near Chatham.

Colonel C. C. Grant, Hamilton, Ont. :—

Specimen of *Orthis circulus*, Hall, from the Niagara group at Hamilton.

D. Herring, Toronto :—

Female Stilt Sandpiper (*Micropalama himantopus*), from Toronto Island; female Bartramian Sandpiper (*Bartramia longicauda*), shot on the Humber, near Toronto.

S. Herring, Ottawa :—

Four specimens of the Evening Grosbeak (*Coccothraustes vespertina*), shot near Toronto. In the flesh.

Col. Irvine, per Dr. G. M. Dawson :—

One large spear head from the Cypress Hills, Assiniboia.

W. Dickson, per Dr. G. M. Dawson, from the estate of the late sheriff Dickson, Pakenham, Ont. :—

Three adzes from the vicinity of Pakenham, Ont., from his own collection; one fragment of pottery from Long Lake, N.W.T.

R. Têtu, per W. McInnes :—

Two arrow heads from near the mouth of the Cabano River, Lake Temiscouata, Têtu P.O., Que.

D. J. Wing, per D. G. M. Dawson ;—

Chisel of jade, from Kamloops, B.C.

George Possie :—

An iron axe.

J. W. Mackay :—

Three black flint arrow heads, from Lillooët, B.C.; one stone scraper, from Spence's Bridge, B.C.; one skin scraper, from Kamloops, B.C.; fragments of shells, teeth and flint from Lytton, B.C.

Walter Odell, Ottawa :—

Eight specimens of sponges and Polyzoa, from the post-Pliocene clays of Odell's brick yard, Ottawa, Ont.

Walter R. Billings, Billings Bridge, Ottawa :—

Eight specimens of *Zygospira deflecta*, Hall, from the Trenton limestone of Division St., Ottawa.

Charles Giramaire, Ottawa :—

One female Short Eared owl (*Asio accipitrinus*) in the flesh.

John Vicars, Cannington, Ont. :—

Skin of a Hoary Bat (*Atalapha cinerea*) from Manitoba.

Dr. Lorenzo G. Yates, Santa Barbara, California :—

Two specimens of the rare *Cyprœa spadicea* from the Santa Barbara Channel; three specimens of *Gonostoma Yatesii* from Calaveras Co., Cal., three of *Melania Surati*, from near Cordova, Mexico, and one *Pinna Venturensis*, from the Cretaceous rocks in Ventura Co., Cal.

J. A. Doyon, Ottawa :—

Female Long tailed Duck (*Clangula hyemalis*) in fall plumage.

G. Everett, Ottawa :—

Specimen of the Deer Mouse (*Hesperomys leucopus*) in the flesh.

Dr. H. G. Griffith, Burlington, Iowa :—

Four species of corals and two of Stromatoporoids from the Hamilton shales at Rockford, Iowa.

G. P. Jones :—

Specimen of *Macoma nasuta*, Conrad, brought up on the point of a pile driven fifty feet into the bottom of the Nicomekyl River, B. C.

A. E. Walker, Hamilton, Ont. :—

Petrified specimen of *Mesodon albilabris* from cavities in the Niagara limestone of the mountain at Hamilton.

Dr. P. Jones, Hagersville, Ont. :—

Two otoliths of sheepshead (*Haploidonotus grunniens*) dug up in an Indian ossuary at Hagersville.

Isaac Moore, Ottawa :—

Young Night Heron (*Nycticroax nycticorax nœvius*) in the flesh.

By Exchange :

W. Turnbull, Hamilton, Ont. :—

Shells of three species of turtles, nine fossils from the neighbourhood of Hamilton, and one specimen of *Palœotrochus Kearneyi* from the Corniferous limestone of Hagarsville.

G. M. Leslie, Hamilton, Ont. :—

Six species of land shells from the vicinity of Hamilton. A series of vertebræ, ribs, jaws and portions of skulls of snakes, small rodents and insectivora from the upper portion of the gravel ridge at Burlington Heights.

S. W. Howard, J.P., Hagersville, Ont. :—

Seven specimens of fossils from the Corniferous limestone at Hagersville.

S. A. Morgan, B.A., Hagarsville, Ont. :—

One head of *Dalmanites anchiops*, one specimen of *Platystoma lineatum*, two specimens of *Chonetes hemisphærica* from the Corniferous limestone at Hagarsville, and two arrow heads from the same place.

By Purchase :

From John Stewart, Ottawa :—

Two hundred choice and selected specimens of fossils from the Trenton limestone, mostly from the neighbourhood of Ottawa, and from the post-Pliocene of Green's Creek, Gloucester, Ont. Among the former are about seventy remarkably fine, and in many cases unique crinoids, and two specimens representing a new genus of Blastoidea. Among the latter is the most perfect specimen known of the rare fish known as *Cottus uncinatus*, Reinhardt, and several plants not heretofore represented in the museum collection.

Henry Sproule, Ottawa :—

120 fossils from the post-Pliocene nodules of Green's Creek, Gloucester, Ont.

E. Effingham, Cooksville, Ont :—

Specimen of the Turkey Vulture (*Carthartes aura*), shot at Cooksville, Ont. In the flesh, and since mounted.

G. Hogle, Philipsburg :—

Seven specimens of fossils from the neighbourhood of Philipsburg.

Prof. Henry Ward, Rochester, N.Y. :—

A small series of exotic shells, mostly terrestrial species from the Phillipine Islands.

The entomological collections in the Department are under the care of Mr. James Fletcher. They are contained in nine cabinets, and number about 9,000 specimens. Mr. Fletcher reports :

"The cabinets have been regularly examined, and the collections therein contained are in a good state of preservation, no losses having occurred from insects, mould or accident. Several valuable additions have been made during the year. These are chiefly from the collections made by the officers of the Survey, and by donations. Valuable and extensive collections were brought in by Dr. G. M. Dawson, from the Kamloops district in British Columbia, of Coleoptera and Lepidoptera; by Prof. Macoun, from the Kootanie District in British Columbia, of Lepidoptera and Coleoptera; by Mr. W. McInnes, from the Lake Superior region, of various orders. There are in all these collections many specimens which are interesting additions for the cabinets as well as duplicates for exchange.

"Donations have been received from the following:—

Rev. C. J. S. Bethune, Port Hope, Ont., Coleoptera.

Mr. W. H. Harrington, Ottawa, Coleoptera and Hymenoptera.

Mr. W. H. Darley, Victoria, B.C., Lepidoptera.

Rev. G. W. Taylor, Victoria, B.C., various orders.

Mr. A. L. Poudrier, Victoria, B.C., Lepidoptera from the Rocky Mountains.

Mr. T. E. Bean, Laggan, N.W.T., specimens of rare Lepidoptera.

"Most of these are insects not represented in the collection, and were kindly given in response to an application by the Curator.

"Special cases have been prepared for the exhibition of a collection of native insects in the hall of the Museum, which, it is believed, will be of interest to the many visitors who frequent the Museum."

Botany, &c.

Early in the year Professor Macoun was engaged on Part V. of the Catalogue of Canadian Plants, and was also attending to Mr. Pearson's list of Canadian Hepaticæ, then passing through the press; both have since been printed and distributed. Part V. included the ferns and their allies, and an addendum that brought the whole work up to date. One hundred and fifty-five species have been added to the Canadian Flora since the addendum, printed with Part III., was issued.

As the investigation of the fauna and flora of British Columbia had hitherto extended only from the Pacific coast to the Gold Range, Professor Macoun was authorized last spring to make examinations of the Columbia and the Kootanie river valleys and lake districts, and later to make collections amongst the higher summits of the Selkirk and Rocky Mountain ranges. He reports: "This work was successfully carried out. By the first week in April a competent collector was

stationed at Revelstoke on the Columbia river. He worked there for two months, and procured 259 fine skins of rare birds. I joined him early in May and collected in the vicinity of Revelstoke for four weeks, or up to the first of June. My assistant, Jas. M. Macoun, who had remained in Ottawa reading proof and attending to arrears of office work, joined me on that date, and we then went down the Columbia to Deer Park and Sproat, where careful enumerations and collections of the fauna and flora were made. Early in July we crossed the portage from Sproat to Nelson, and spent the next three weeks at various points on Kootanie Lake. We then returned to Revelstoke, and on the 28th of July went to Roger's Pass in the Selkirk Mountains, where some of the highest surrounding peaks were ascended and a number of rare and interesting specimens were secured. Ten days were then spent at Hector, in the Rocky Mountains, and large collections were made on the higher summits around that station. We left Hector for Ottawa on the 20th of August.

To secure data to complete the enumeration of the mosses in Part VI. a three weeks' trip was made in September to the western part of Ontario. The species of that region which had not hitherto been noticed, were collected and recorded. Owen Sound, Windsor, Chatham, Sandwich, Port Dover, Leamington, Port Colborne and the vicinity of Niagara Falls were visited.

The results of the season's work were the addition of over twenty species of birds to the British Columbia Avi-fauna and the addition of many species of flowering plants, part new to science and all new to the Canadian flora. The discoveries in cryptogams, especially mosses, have been so numerous that Dr. Carl Muller, of Halle, says in a letter to Dr. Kindberg, that they constitute a new epoch in American Bryology. Up to the present writing these two gentlemen have named 200 species new to science, collected chiefly by Prof. Macoun during the last three years. About 400 specimens of birds and mammals and 20,000 specimens of plants were collected during the past season.

Since our return from the field my assistant had been engaged in examining and naming the year's collections of flowering plants, getting out the species to mount and doing the general work of the office, while I have been occupied on Part VI. of the Catalogue of Plants and on the Catalogue of Canadian Birds, which is approaching completion. All work in connection with the Herbarium has been done as in the previous year, 1889, by Mr. Jas. M. Macoun. During 1890, 3,807 sheets of specimens have been mounted and placed in the herbarium. Of these 2,316 were flowering plants and 1,491 cryptogams, principally mosses. Of the flowering plants 1,699 were Canadian, 260 from the United States, and 457 from Europe.

4,211 sheets of specimens were sent from the herbarium to private individuals and to public institutions in exchange for desiderata; of these 1,871 were cryptogams and 2,340 flowering plants. Specimens were sent to

The British Museum	200
Central Experimental Farm, Ottawa	200
Mechanics Institute, Wingham	100
St. John's College, Winnipeg	100
Department of Public Instruction, Quebec	100
McGill College, Montreal	100
National Museum, Washington	200
University of Nebraska	124
Harvard University	164
California Academy of Science	100
Shaw School of Botany, St. Louis, Missouri	170
Columbia College, New York	218
The University of Copenhagen, 100 flowers, 400 cryptogams	500
Professor Kindberg, Linkoping, Sweden	884

Since the 31st of December, 1889, in connection with the work of this division, 447 letters of sufficient importance to copy were written, and about the same number were received.

Since returning from the field the herbarium of St. Laurent College, Quebec, has been examined, and the specimens, over 2,100, named; also the herbarium of Mr. Morten, of Wingham, and Dr. White, of Toronto, besides many small collections from various parts of the Dominion.

The survey herbarium is arranged in eight large cases, but these are now so full that specimens are frequently injured by being crushed; another case will shortly be available and a better arrangement of the specimens will then be effected, and they will be much better preserved.

Considerable inconvenience is now caused by the crowded state of the small room devoted to the work of this division. It arises from the accumulation of the large collections annually brought in, and it is hoped that the alterations that have been suggested, whereby this serious inconvenience would be in a measure obviated, will be speedily carried out.

The following notices from foreign journals indicate the estimation and appreciation of the botanical work of the division under Professor Macoun:

From "Zoe," (Vol. 1-9) a biographical journal published at San Francisco—

"Catalogue of Canadian Plants, Part V. This part contains the ferns and fern allies and additions and corrections to Vol. I–IV., which are rather extensive, embracing a hundred pages and conforming to recent revisions. * * * The work in general has been carefully done and reflects credit upon the Government of Canada and the botanists concerned in its production."

From "Botanical Gazette," Vol. XVI. :—

"With the appearance of Part V., devoted to Pteridophytes, Prof. John Macoun's Catalogue of vascular Canadian Plants has been completed. It has been very handsomely done, and the painstaking care so evident through it all has made it a mine of information concerning the Canadian Flora. A large appendix brings together additions and corrections to Parts I–IV., the results of all monographic work done since the beginning of the catalogue being included. * * * The part is rounded out by a complete index to all the parts, and the five will make a very complete and compact volume."

MAPS.

Maps in course of Preparation and Published during 1890.

North-west Territory, 9 sheets, 20 to 26 inches long by 16 inches broad, showing waters followed by the members of the Yukon Expedition, 1887–88, and reaching from longitude 111° to 144° and latitude 59° to 68°, to accompany report by Mr. McConnell, will be ready for engraver in two months.....	8 miles=1 inch.	
Index map of the above now in the lithographer's hands.....	48 miles=1 inch.	
British Columbia, part of southern interior (Dr. Dawson), in draughtsman's hands, will be ready for engraver in April....	4 miles=1 inch.	6,400
British Columbia, Kootanie district (Dr. Dawson), published 1890.....	8 miles=1 inch.	11,000
British Columbia, Shuswap district (Dr. Dawson), in draughtsman's hands.....	4 miles=1 inch.	6,400
Manitoba, map taking in the whole of Lake Winnipeg (Mr. Tyrrell) in the draughtsman's hands.....	do	48,600
Northern Manitoba, in manuscript (Mr. Tyrrell).....	2 miles=1 inch.	5,000

Northern Manitoba, in engraver's hands (Mr. Tyrrell)	8 miles=1 inch.	20,000
Western Ontario, Lake of the Woods, sheet No. 2, in the engraver's hands	2 miles=1 inch.	2,000
Western Ontario, Hunters Island, sheet No. 7, (Dr. Lawson) in the engraver's hands	4 miles=1 inch.	1,450
Western Ontario, north of Hunters Island, sheet No. 6, in draughtsman's hands	do	3,456
Ontario, sheet No. 130, Sudbury Mining district (Dr. Bell), in hands of draughtsman; will be ready for engraver in a few weeks	do	3,456
Ontario, sheet No. 115, ready for draughtsman	do	3,456
Ontario, general map in progress	do	
Quebec, N.E. ¼ sheet (Eastern Townships map) in hands of engraver	do	4,500
Quebec, S.W. ¼ sheet (Eastern Townships map) in draughtsman's hands	do	4,500
Quebec, N.W. ¼ sheet (Eastern Townships map) in progress	do	4,500
Quebec, Quebec and Lake St. John district, 2¼ sheets in progress	do	6,912
Quebec, ¼ sheet, 18 S.E. and 18 N.E. (Messrs. Bailey & McInnes) in draughtsman's hands	do	3,950
Quebec, Lièvre River and Templeton Phosphate region, Ottawa county, 2 sheets (Mr. Ingall), will be ready for engraver in two months	40 chains=1 inch.	220
New Brunswick, surface geology, ¼ sheet 1 S.W., 1 S.E. and 1 N.E., 3 sheets (Mr. Chalmers), ready for engraver in a month	4 miles=1 inch.	6,650
Nova Scotia, ¼ sheet, 11 N.W. and 11 S. W. in the engraver's hands	do	
Nova Scotia, ¼ sheet, 4 N.E. and 4 S.E., (Messrs. Fletcher and Faribault) in manuscript, most part of them drawn	1 inch=1 mile.	

LIBRARY, SALES AND DISTRIBUTION OF PUBLICATIONS.

Dr. Thorburn reports that the distribution of the various publications of the Geological Survey Department with which he is charged has now attained large dimensions and is likely to increase year by year. Last year there was sent from the office, including Annual Reports, special Reports and maps, 8,936. This is exclusive of the annual Report Vol. III., 1887–88 in French, the printing of which has unfortunately been delayed. There have been distributed in Canada 6,527, the remainder, 2,409, were sent to foreign countries, to scientific and literary institutions and individuals in the various countries of Europe, India, China, Japan, Australia, the United States, etc.

There have been received as exchanges during 1890, 2,375 publications, including reports, transactions, proceedings, memoirs, periodicals, pamphlets and maps.

The books purchased during the year were 116, and 41 periodicals have been subscribed for.

The number of books bound during the same period has been 152. Now that the work of binding has been taken over by the Government, it is hoped that it will, in future, be done as promptly as is desirable, and indeed essential that it should be, to make the volumes accessible to the members of the staff who are constantly requiring them for consultation and reference.

As an evidence of the amount of work connected with matters relating to the library, and to the distribution of the Geological Survey publications, it may be stated that during the past year 1,644 letters were sent by the Librarian and 2,476 were received by him, as compared with 1,511 and 1,256 in 1889.

The number of volumes in the library is now about 8,500, and of pamphlets, 3,300.

In the Report for 1886, it was stated that a card catalogue of the library had been introduced. It has been in operation ever since and has been found to be of great service in assisting members of the staff in finding, more readily than formerly, information on the various subjects under investigation.

For several years past, the space allotted to the library has been found to be altogether insufficient, and consequently a large number of books are not readily available for reference, except at a great inconvenience of those wishing to consult them. It is to be hoped that this will be soon remedied so that a full and exhaustive classification may be made.

Sales of Survey publications for year ending 31st December, 1890, amounted to $2,366.42.

Visitors.

The number of visitors to the Museum during the year, from 1st January to the 31st December, was 17,760.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The staff at present employed is 52, viz.: professional, 34; ordinary, 18.

During the year the following changes in the permanent staff have taken place:—

Dr. A. C. Lawson, field geologist, resigned.
Mr. Amos Bowman do do
Mr. F. G. Wait, appointed assistant chemist.
Mr. L. N. Richard, appointed draughtsman.
Mr. J. B. Tyrrell, promoted from 2nd to the 1st class.
Mr. R. L. Broadbent do 3rd do 2nd do
Mr. H. M. Ami do 3rd do 2nd do

The amount available for the fiscal year ended 30th June, 1890, was:

——	Grant.	Expenditure.
	$ cts.	$ cts.
Civil list appropriation	45,750 00	
General purpose appropriation	62,100 00	
Civil list salaries		40,768 78
Wages of temporary employees		17,051 85
Exploration and survey		22,528 01
Printing and lithography		13,520 83
Boring operations, Deloraine		2,497 54
Purchase and binding of books, etc., and purchase of instruments		1,232 80
Purchase of specimens		814 57
Laboratory apparatus and chemicals		238 34
Stationery, mapping materials, and Queen's Printer		1,216 45
Incidental and other expenses		2,488 09
		102,357 26
Less—Paid in 1889		6,026 93
		96,330 33
Add—Advances to field explorers		6,534 66
		102,864 99
Unexpended balance, civil list appropriation		4,981 22
do general purpose appropriation		3 79
	107,850 00	107,850 00

The correspondence of the Department shows a total of 11,159 letters sent and 6,016 received.

I have the honour to be sir,

Your obedient servant,

ALFRED R. C. SELWYN,

Deputy-Head and Director.

GEOLOGICAL SURVEY DEPARTMENT
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

SUMMARY REPORTS

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1891

BY

THE DIRECTOR

PUBLISHED BY AUTHORITY OF PARLIAMENT

OTTAWA:
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S
MOST EXCELLENT MAJESTY
1892

SUMMARY REPORTS

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1891

GEOLOGICAL SURVEY DEPARTMENT,
OTTAWA, December, 1891.

The Hon. EDGAR DEWDNEY,
Minister of the Interior.

SIR,—In presenting the Summary Report of the proceedings and work of the Department, as required by section 6 of the Act 53 Victoria, chap. XI, it is gratifying to be able to again record the substantial and satisfactory progress that has been achieved during the year now closed, and it is even more so, to be able to ascribe it largely to the increasing interest in the work, evinced by the members of the staff, as shown by the painstaking perseverance with which they are devoting their best energies to investigating, often under very adverse circumstances, depicting and describing the diverse and often intricate geological phenomena presented throughout the Dominion, and more especially in endeavouring to decipher what the bearing of these phenomena is and what they teach, in reference to the profitable development of the mines and mining industries of the country. Thus one or other of the members of the field staff of the Department is in a position to give intending investors and the public the most reliable, authentic and entirely disinterested information respecting mines and minerals in all parts of Canada. Notwithstanding these facts, however, we find that in most cases the opinion of some so-called, often self-styled "mining expert" or "practical miner" from Europe or the United States, is sought and acted upon in preference to that of a member of the geological corps who is thoroughly acquainted with the geological structure of the district in which the information is desired. These "expert" and "practical" opinions rarely prove correct, and their first cost, often considerable, is by no means the greatest. Not a year passes unmarked by such cases and the past season is no exception.

The boring for gas at Stewarton in 1889; for water at Morden in 1890; for gas at Belleville in 1891; and for oil near Pincher Creek the past summer, are some of the instances of such useless expenditures, all of which might have been saved had the advice of the Department been sought and followed, instead of that of "expert" opinion.

In this connection and as showing the proper functions, not generally understood, of a geological survey and an associated museum, I may be permitted to quote the following remarks from "Science," No. 464, December, 1891:—

"A geological survey, if properly organized, is composed of professional men of scientific attainments and of undoubted integrity; it is an official organization, and its examinations are made disinterestedly, and on the truthfulness of its results depends the reputation of its members. Its publications are widely circulated; they are designed to be used by the professional man and also by the layman; being official, and coming from such a disinterested source, the results are accepted generally without hesitation by the capitalists or manufacturers. Such influence and acceptance could never be reached by reports emanating from owners of property or other interested parties, nor would the judgment of such concerning theories of distribution or quality command respect unless emanating from well-known expert sources; thus the capital and enterprise necessary for the inception of such undertakings would be slow to follow such guidance. Hence, a good geological survey constitutes the best of advertising mediums, if you choose to call it such; advertising what is genuine and good, but never stooping to indiscriminate booming.

"But another means of disseminating information exists, over and above that of publications. Some people are not reached by reports, either because they are not given much to reading, or for lack of access to the publications. They may come to the state, or even be in the state, knowing little or nothing of its natural features and products. In such cases, a State Museum is the most effective means of conveying information; a museum which shall contain not only specimens of materials, but maps, models, views, diagrams and reports concerning all that is of interest in this connection; the materials in which shall be so arranged as to convey clear ideas, not only of what is in the state, but where it is, how it occurs, and how much there is of it; which shall be supplemented by the presence of trained men, familiar with the state, who can guide the stranger in the right direction.

"In conclusion, I would say a few words concerning the educating influences of a geological survey among the citizens of the area in

which it operates. Through its publications, through the intercourse with its members, and in other ways, a vast amount of information is absorbed by the people concerning the land they live in and its products. This information they apply unconsciously in their various operations. It prevents them from being led into hopeless enterprises, it leads them to discountenance extravagant expectations and to recognize charlatanry, it brings them to appreciate the truly useful and valuable, and it supplies them with a source of advice which many are otherwise destitute of."

The foregoing description of the proper functions, educating influences and general usefulness of such an institution, is worthy of the attention and careful consideration of the public and especially of those in whose hands it rests to find the means for its establishment and support.

The early part of the year was as usual fully occupied by the members of the survey in the preparation of maps and reports and in the critical examination and classification of the numerous specimens—rocks, minerals, fossils, plants and insects—collected in the field. In the divisions of lithology, palæontology, botany and entomology valuable, gratuitous assistance has been rendered the survey by the following United States and European scientists :—

Professor G. H. Williams, of Baltimore, O.
Professor Cope, of Philadelphia, Pa.
Mr. S. H. Scudder, of Cambridge, Mass.
Professor T. Rupert Jones, London, England.
Professor H. Alleyne Nicholson, Aberdeen, Scotland.
Dr. N. C. Kindberg, Sweden.
Dr. Carl Müeller, Germany.
Mr. C. Warnstorf, Germany.
Mr. C. Lyman, of Montreal.

To all of these gentlemen the best thanks of the Geological Survey of Canada are due and I have much pleasure in thus officially tendering the same.

Mr. James Fletcher has also added to his already onerous duties in connection with the experimental farm, the honorary curatorship of the entomological collection in the museum of the Geological Survey, and has devoted no little time to its arrangement and care.

In my last Summary Report, page 7, I referred to the annual report Vol. IV and mentioned seven of the parts then issued. The volume has since been issued. It contains ten separate reports, which with illustrations and maps, table of contents and index, constitutes a work of some 1082 pages R. 8vo. The detailed reports which will form

Vol. V of the annual reports are well advanced and the volume will probably be issued before the close of the present year.

As in previous years the geological investigations were carried on in all the provinces of the Dominion, either in the direction of revising and adding to the details of portions of districts that had already been examined and reported on, or in exploring and mapping districts in which no detail had hitherto been secured.

The working parties, 20 in number, were distributed as follows :—

British Columbia.....	1	Quebec	5
Alberta	1	New Brunswick.....	1
Manitoba	2	Nova Scotia.....	3
Ontario	7		

In addition to these, explorations were made by Professor Macoun and by Messrs. Ami, Weston and Willimott for collecting in Botany and Zoology, Palæontology and Mineralogy.

From the summary statements herewith presented, it will be seen that Professors Bailey, Adams and Laflamme were only a short time in the field, during vacation, and Mr. McConnell only during the month of June, while nearly the whole of Dr. G. M. Dawson's time had to be devoted to work in connection with the Behring Sea Commission.

A large part of my own time during the year has, as usual, been occupied in editing reports, in correspondence and in attending to the executive details of the Department, including those of the Survey and the Museum.

On the 11th of March I received a communication from Mr. Beauchemin, of St. Hyacinthe, informing me of the discovery of natural gas in that vicinity. On page 34A of my Summary Report for 1887, referring to this subject, I wrote : " While for reasons connected with this —the geological structure—I have never had any faith in their occurrence on the north side of the St. Lawrence, I consider that the probability of such reservoirs existing on the south side, in the country between Lake St. Peter and St. Hyacinthe, is very great."

In reply to Mr. Beauchemin's letter, I communicated the above to him, and that I would take an early opportunity to visit the locality. I was unable, however, to do so till the 7th of July, when I proceeded to St. Hyacinthe, and accompanied by Mr. Beauchemin and Mr. Desaulier, I visited the several sites where gas was reported. The first examined was on the farm of Antoine Laplante, about six miles north of St. Hyacinthe, on the concession St. Amable, two miles south-west of the village of St. Barnabé, and the same distance west of the Richelieu river. Here Laplante had recently, with the aid of a small

hand-boring tool, succeeded in reaching the rock at a depth of 90 feet, a continuous, though not large, flow of gas being the result. The material penetrated consisted entirely of clay, with some small stones near the bottom. This boulder clay covers and almost entirely conceals the older rocks, and forms the level surface of the great plain of the Richelieu and Yamaska rivers. A pipe $1\frac{1}{2}$ inch diameter had been inserted in the hole, and a continuous, though not powerful, flow of gas was coming from it. On inquiry, I found that within a radius of 400 yards from this well, there were four places, sites of old wells, where gas is escaping. One of these was sunk 45 years ago, and the gas has been escaping ever since. The others are more or less recent trials for water, and have penetrated to rock through from 85 to 100 feet of clay, and in all gas comes from the bottom. In three, an inch and a-half pipe has been inserted, and the escaping gas ignites readily and burns steadily, but the pressure is light. On lot No. 18, parish of St. Hyacinthe, range St. Francis, on the farm of Emile Lorquet, close on the east side of the railway to Farnham, I also found gas escaping in a similar manner from a small pit sunk about two feet into the black soil. Near this two wells had been sunk, one 150 yards east, 106 feet deep, the other about 500 yards north, 110 feet deep, and in both, I was informed, gas had been encountered at the bottom. The sinking was through clay, like that in the bore holes on the St. Amable concession, which lies about eleven miles nearly due north, and on the other, or west, side of the Yamaska river.

These facts, in connection with what I wrote in my summary report for 1887, above referred to, are certainly interesting, but by no means sufficient to warrant any positive assertion respecting the success or otherwise of an attempt to find extensive gas or oil reservoirs in the Trenton or other Cambro-Silurian formations, which underlie the great plain of the Richelieu and Yamaska rivers, between Sorel and St. Hyacinthe. There are no surface indications in the area which would indicate any particular site as the most favourable. Under these circumstances the vicinity of, or on, the St. Amable concession is the locality I would suggest as that where a trial should be made. If successful, the cost of piping the gas to St. Hyacinthe would be a trifle in comparison with its value for heating and lighting purposes.

On Friday, the 10th of April, I left Montreal for Deloraine, Manitoba, to make arrangements with the contractor there, to continue the boring. On arriving at Deloraine, on the 17th of April, I found the boring had attained the depth of 1,740 feet, without any material change in the character of the strata from that stated page 9 of my Summary Report for 1890.

After discussing the situation with the local boring committee and the contractor it was arranged to continue the work. Various unexpected and unavoidable delays and difficulties have, however, since arisen, notwithstanding every effort on the part of the contractor, so that on the 31st of December a depth of only 1,808 feet had been There is, however, still every reason to believe that a successful result will be attained so soon as the base of the impermeable clay shales is reached.

Since the date of my last report the expenditure has been $6,846.18, making a total to 31st December, 1891, of $15,494.80.

The undertaking is of national importance and should certainly be prosecuted in spite of the unfortunate accidents and delays that have occurred, until either a negative or affirmative result is attained.

I left Deloraine on the 20th of April, the 22nd was spent at Schreiber in an examination of the cuttings, in the forenoon, four miles west, and in the afternoon, two miles and a half east, and to the openings lately made on a deposit of pyrrhotite precisely like those of Sudbury and occurring on the border of a mass of diabase, associated, as at Sudbury, with schists breccias and some white granite rock, this latter being well seen near both ends of the first trestle east of Schreiber. The analysis of the samples of the ore that were collected gave only ·003 per cent of nickel, but as in all these deposits the nickel is very unevenly distributed an analysis of a few small samples is of little value as an index of the contents of the whole body. At the date of my visit the snow was still thick in the woods, and I was not able to do more than ascertain that the area over which the pyrrhotite occurred was more than sufficient to constitute a good mine, and was very favourably situated for working. The deposit was, I believe, opened by Messrs. Marks, of Port Arthur, towards the close of 1890. I cannot learn that any work has been done on it since the date of my visit in April last.

The northern limit of the area of Huronian rocks, which extends from about four miles west of Schreiber, eastward, for about sixty or seventy miles, has not yet been traced out, nor has that other large area crossed by the Canadian Pacific railway between White River and Dalton stations.

It is important that this should be done so as to be able to indicate those portions of it which should be carefully explored for valuable economic minerals. With a view to comparing the rocks of these areas with those of Sudbury, I devoted several days, from the 5th to the 11th of September, to an examination of the cuttings on the line of the railway from east of the Pic River bridge to near Schreiber.

Much of it is occupied by massive gabbro, diabase and red quartz syenite, and it is in and around the borders of these crystalline rocks, especially the former, that the nickeliferous deposits should be looked for. The fine samples of zinc ore that were exhibited at the Colonial and Indian Exhibition in 1886, were derived from one of these diorite masses which lies about twelve miles north, a little east, from Rossport station, and which may be connected with the Schreiber Huronian area.

On the 13th of July I left Ottawa for Pincher Creek, Southern Alberta, and arrived there on the 19th *viâ* Lethbridge and Macleod. My object was to visit and examine the reported discoveries of petroleum in that vicinity and in the South Kootenay pass, as well as the coal seams discovered in the Crow's Nest pass. The petroleum discovery was incorrectly referred to on page 13 of my last Summary Report as being in the Crow's Nest pass, and it was stated that circumstances had then prevented me from carrying out my intention of visiting the locality. On the present occasion all necessary arrangements had been made for men and horses to meet me at Pincher Creek, and these arrived there from the west the same afternoon.

I found considerable excitement existed in the village, in fact, a decided "boom" in petroleum claims, and that a company had been formed to put down a boring, the site selected for the experiment being on sec. 21, township 3, range 29, some 18 miles south, a little east, of Pincher Creek village.

On Monday the 20th of July I proceeded to the locality named, accompanied by several gentlemen interested in the work. The country traversed is fine farming land, a richly grassed undulating prairie well watered by numerous small tributaries of Pincher creek and the Waterton river, all of which eventually find their way to the Saskatchewan. The site of the proposed boring was on a small flat on the left bank of one of the tributaries of Waterton river. A gang of men were at work erecting a derrick and preparing to put an engine and boiler, already on the ground, in place.

The evening of the 20th of July and the whole of the following day was devoted to an examination of the rocks that were exposed in the creek both below and above the site selected for boring. They were ordinary varieties of sandstone and sandy shales of the Cretaceous, with irregular dips from 15° to 20.° The last exposure of these rocks up the creek, was about three miles and a quarter, then, for about three miles further there were no exposures up to where the creek emerges from a rocky gorge, all along which there are good exposures of hard flinty red, green and grey shales and sandstones often gritty and

quartzose and dipping to south-south-west at 25° to 30.° These are the Cambrian rocks which here form the base of the eastern spurs and ridges of the Rocky mountains. It was stated that both in this gorge and at several places in pools on the prairie to the eastward petroleum had been seen, but no one at the boring camp could show me any of these places.

The whole country for many miles around and up into the entrance of the South Kootenay pass, nine miles to the south, was marked off with the stakes of the oil claims. On inquiry, I was informed that an "expert" named Baring had been there and had expressed a favourable opinion as to boring where operations were being commenced. I was unable to learn any other reason for fixing on the site. The note I made under date 21st of July reads: "There is nothing whatever to indicate the existence of petroleum in this vicinity. It seems highly improbable that it should be found here, though, of course, not impossible." I subsequently heard that a copious flow of water had been struck and the boring abandoned. The cost of this very absurd and useless operation must have been considerable.

On the 22nd of July, I left the boring camp and proceeded about eight miles in a southerly direction, gradually approaching the foot of the mountains, till we struck the Kootenay branch of the Waterton river, which here leaves the South Kootenay or Boundary pass. This stream was then followed up about two miles and a-half, where we camped on the left bank, opposite a depression in the high range which here borders the pass on its southern side, and divides the waters of the Kootenay branch from those of "Cameron Falls" creek. An ascent of about two miles by a somewhat rough trail mostly over grey and white heavy bedded dolomites brought us to the summit of this depression. We then descended into the valley of Cameron Falls creek. This creek takes its rise in a small lake near Camp Akamina of the boundary survey and flows north-east about seven miles to where we struck it, and where it makes an almost right angle bend and flows south-east into Waterton lake.

Camp Akamina is thus described by Dr. G. M. Dawson: "The spot known as Camp Akamina, the eastern terminal station of the old North-West boundary commission, is situated at the head of the valley just described. It has an elevation of about 6,000 feet above the sea, and is a sheltered hollow characterized by thick spruce woods of fine growth. The boundary cairn is placed on the watershed about a mile from the camp, and though built thirteen years ago was found in perfect preservation. It is important as marking not only the forty-ninth parallel or boundary between British North America and the

United States, but as lying at the adjacent angles of British Columbia, and the as yet unorganized North-West Territory."*

A full description is also given in the same chapter of the character of the rocks and the appearance of the country.

Cameron Falls brook is a rapid mountain stream, eight or ten yards wide. After following it up about a mile and a-half on the left bank, Mr. Fernie, my guide, remarked that we must be close to where the oil had been found. He had scarcely spoken when, while still in the saddle and on the trail eight or nine feet above the brook, I noticed a powerful odour of petroleum. Descending to the edge of the water and stirring the stones and gravel in the bed of the stream, considerable quantities of oil at once rose to the surface and floated away. Crossing to the right bank it was again seen coming out of the bank, some inches above the then level of the stream. Here, skimming it off the surface of a shallow pool, a wine bottle full was soon collected. This can now be seen in the Geological Survey Museum. Sixty or seventy yards below where the oil was seen, a rocky reef of grey siliceous dolomite crosses the creek and rises into a steep bluff on the left bank; on the right bank, seven or eight feet above the creek, a broad thickly timbered flat extends for 150 yards to the base of the bordering mountains which culminate six miles to the south-west at the boundary monument, 6,000 feet above sea level.

No work whatever had been done to test the nature of the oil sources. A comparatively small outlay for some shallow sinking or boring on the flat above described would do this.

On the 23rd, we proceeded through the pass, crossing the summit and camping on Akamina brook about six miles down on the western slope in British Columbia. On the 24th we proceeded down the valley and at about four miles north of the 49th parallel the trail came down to the level of the brook, and here on the edge of a beaver dam pool there were ledges of hard dark blue shale dipping E. 30° N. 12°. Lifting layers of this at and below the water a quantity of dark green circular patches of oil rose to the surface, and a precisely similar result followed by stirring up the mud in the bottom of the pool. This place is about fifteen miles in a direct line, west 10° south, from the occurrence on Cameron Falls creek, the main watershed of the Rocky Mountains and Mounts Kirby, Spence, and Yarrell intervening. Oil is said, by the Indians (the Stoneys) who frequent this region, to occur at other points, in the Akamina Brook valley, both above and below that recorded. The Akamina joins the Flathead river in Montana,

*Report on the Geology and Resources of the region in the vicinity of the Forty-ninth Parallel, Chap. III.

about four miles south of the international boundary. The Beaver dam oil is of a dark greenish black and does not apparenty differ much from that of Cameron Falls creek. Preliminary tests might be made here by sinking a shallow shaft in the shales at the Beaver dam pool, and by a boring on the sandy and gravelly flat country about two miles and a-half north of the boundary line.

On the 24th of July we camped in Montana on the left bank of the Flathead river, about two miles above the mouth of the Akamina or Kish-e-ne-nah creek.

On the 25th we proceeded up the Flathead valley, the trail passing for the most part along high terraces of sand, clay and gravel. At 8 a.m. we recrossed the boundary on one of these terraces and then again descended to the river where we off saddled and waited for the pack train. It arrived at 10.30; and we then ascended again to the high level terrace and turning north crossed a number of ridges and gullies into the valley of Sage creek camping on the right bank at about nine miles above its mouth.

At about a mile and a-half higher up, the creek leaves the high mountains which border its upper course in a north-easterly direction up to the main watershed some twelve or fourteen miles distant, and here at the edge of the water, on the left bank, I found hard dark flinty shales like those at the Beaver dam pool on the Akamina dipping S. 25°—30° W. $<$ 25°. Directly the layers of this rock are raised the oil rises and spreads over the surface of the water in such abundance that a short time suffices with the aid of a tin cup to collect a bottle full. Here, also a considerable quantity of gas escapes from the cracks and joints in the rock and ignites freely on the application of a match.

Less than half a mile higher up, on the right bank and on the opposite or west side of the valley, oil was again found issuing from the base of a bank of drift which has here filled the valley and caused the stream to make a sharp bend eastward to the base of the opposite mountain. No rock was exposed here, but every stone in the bed of the creek, especially on being broken or rubbed, gave out a strong odour of petroleum. The oil collected here, a sample of which can be seen in the museum, differs entirely in appearance from those of Cameron Falls creek and Akamina or Kish-e-ne-nah creek.

Some of it was of a light lemon yellow, but most of it nearly the colour of pale brandy and with a very powerful petroleum odour.

The general geological structure, the character of the rocks and the physical aspect of the country in the South Kootenay, the North Kootenay and the Crow's Nest and other passes of the Rocky moun-

tains have been admirably described by Dr. G. M. Dawson,* and the South Kootenay pass is also described in his Report on the Geology and Resources of the Forty-ninth Parallel, 1875. For details on the subjects named these works can be referred to. The present is, however, I believe the first recorded instance of the occurrence of petroleum in this region, as well as of its occurrence in Cambrian rocks. Whether the reference of the rocks to this age is correct, is not quite certain; that it is so as regards the somewhat similar siliceous dolomites and quartzose strata of the Kicking Horse pass has been proved by the discovery of a Cambrian fauna and there seems no reason to doubt that the petroleum-bearing beds of the South Kootenay pass are of the same age. At present, however, except on the traverses made by Dr. Dawson, little or nothing is known respecting the distribution of the formations in the great block of mountainous country which lies between the 49th and 51st parallels of latitude and the 115th and 117th degrees of longitude, and which comprises the Purcell, Hughes, Macdonald and Galton ranges and covers an area of about 9,600 square miles, much of it densely wooded and with peaks ranging to eight and nine thousand feet.

Leaving Sage creek we followed up the Flathead valley crossing and recrossing the river and its numerous channels so frequently that we travelled almost as much in the water as on the land. On Tuesday, the 28th of July, we travelled in this manner for ten hours without a halt, and at 6 p.m. camped on a fine grassy flat, surrounded by timber, at the foot of the abrupt ascent from the Flathead valley to the eastern summit of the North Kootenay pass.†

On the 30th of July, we camped at Lee's lake on the Crow's Nest pass trail. On the 31st Col. Baker joined me here, and on the following day we camped at the east end of Crow's Nest lake, and on the next day, 2nd of August, we reached the coal prospecting camp situated about 1,200 feet above the trail, on the ridge which runs in a north easterly direction between Marten creek and Michel creek and forms the west side of the valley of the west branch of Michel creek. From this ridge a number of spurs with steep intervening gullies descend abruptly to the trail; in these and on the intervening ridges a wonderful series of coal seams is disclosed, one above the other from near the level of the trail to the summit of the ridge.

No exact measurements were taken and it may be that some of the lower cannel seams are the upper ones repeated by faulting. The out-

*Annual Report Geological Survey, 1885.

†Annual Report Geological Survey, 1865, p. 61 B *et seq.*

crops which can all be seen on the ground are as follows, twenty seams in all, showing a total thickness of 132 feet of coal:

	Feet.	
No. 1	5	No. 1 to 10 inclusive are cannel coals.
2	3	
3	4	
4	2	
5	4	
6	3	
7	2	
8	4	
9	5	
10	6	
11	4	
12 (Peter seam)	15	
13	7	
14 (Selwyn seam)	6	So named by Col. Baker.
15 (Jubilee do)	30	
16 (Williams seam)	20	
17	5	These four are cannel coal.
18	3	
19	2	
20	2	
	132	

The number and thickness of these seams in the above table are as supplied me by Mr. Fernie, who has superintended all the exploratory work that has been done on the seams. Between the most eastern outcrops I examined, and the western ones close to the junction of Marten creek and the west branch of Michel creek, is a distance of about two miles along the steep mountain side, to the north of the trail. Within this distance the outcrops were seen of nearly all these seams, either on the ridges or in the sides of the ravines which score the face of the mountain. The few hours I was able to spend on the ground, while not sufficient to enable me to affirm the absolute correctness of the details of the table, were, however, ample to enable me to see that there is in the Crow's Nest pass, between the eastern summit, 4,330 feet above tide, and the valley of Elk river, in British Columbia, an area of not less than 144 square miles, that is destined to be one of the most valuable and most productive coal fields in Canada. A rough calculation would give about 49,952,000 tons per square mile. If one-half of this is available there are in each square mile 24,976,000 tons. The average elevation of the field is about the same as that of Canmore and Banff, or between 4,000 and 5,000 feet. From Pincher Creek westward to Elk river, the pass presents no difficulties for railway construction. The eastern entrance to the pass in Alberta is

3,800 feet, and where it comes out on the Elk river is 3,300 feet; the highest intervening summit being 5,500 feet. A better route to the Elk river, however, than that of the present trail, would be to follow down Michel creek, from near the eastern summit and thus avoid the western and higher summit, and reach Elk river about ten miles above the mouth of Coal creek. The distance through the pass from Lee's lake, Alberta, to the Elk river, is about thirty-seven miles.

On the 4th of August, after devoting the forenoon to a further examination of the Marten creek seams, we proceeded through the pass and reached Elk river at 6 p.m. No coal seams were seen till about four miles above the mouth of Coal creek; here at the mouth of a steep rocky gulley, about 200 yards to the right of the trail, a fine seam of coal, 7 feet thick, had been cut into. The section exposed showed in descending order:

Shale	10 feet.
Hard ferruginous band	1·
Coal	1·6
Shale	7·6
Coal	7·6

Cherty conglomerate and massive gritty sandstones are seen both above and below; the dip is about E. 10° N. 15°—20°. A close search along the mountain side, between here and the water-shed at the head of Coal creek, would almost certainly disclose the outcrops of many more of the Marten creek seams.

On the 5th of August, we descended the Elk river valley, about seven miles, then turning to the left ascended the mountain, a steep climb of 1,500 feet. Here on top of a broken-down cliff of massive sandstone, about 50 feet thick, we came to the first of a series of coal seams; the dip being E. 20° N. 35° and the seam 25 to 30 feet thick, with a shale parting about 2 feet; bar. 24·93. Ascending 130 feet over shales and brown thick bedded sandstone forming a similar broken-down cliff of about 50 feet, a second seam of coal was reached, also 30 feet thick; bar. 24·80. Above this four more seams were examined:

No. 3	15 feet,	bar.	24·57
4	4 do	do	24·50
5	7 do	do	24·42
6	30 do	do	24·35

Above No. 6 there are six more seams which were not visited, but the particulars of which given me by Mr. Fernie are as follows:—

No. 7	10 feet—	100 feet	from No. 6
8	4 do	100 do	7
9	7 do	100 do	8

No. 10	2 feet	—	100 feet	from	No. 9
11	7 do		100	do	10
12	4 do		200	do	11

The distances are approximate only, they have not been measured.

The above gives a total thickness of 148 feet of coal against 132 feet in the Marten creek area on the eastern side of the basin, while in other respects the seams correspond so closely as to make it almost certain that, except where cut out in the valleys, they are continuous beneath the whole intervening area. For much detailed information respecting the Crow's Nest pass the Annual Report of the Geological Survey, Vol. 1, part B, 1885, already cited, and the accompanying map, can be referred to.

Many of the seams are first-class coking coals and others are good gas coals, but none of them are anthracites. For analyses of those of the Jubilee and Peter seams, Marten Creek, See Annual Report Geological Survey, Vol. III, Part II, pp. 12 s. to 15 s., and for those of the "cannel" seams, Vol. IV, pp. 7 R. and 8 R.

On the 6th of August I reached Pincher Creek, and Ottawa on the 14th.

Dr. G. M. Dawson was employed during the earlier part of the present year in working up and preparing for publication the information intended to be included in the Kamloops sheet of the geological map of British Columbia and had made preparations to undertake some special examinations in the foot-hills of the Rocky Mountains and to continue the field work already begun in the adjacent Shuswap sheet during the summer. Before leaving for this work, however, he was appointed as one of the British Behring sea commissioners, and arrangements had consequently to be made such as to enable Mr. McEvoy to continue the work on the Shuswap sheet on the general plan already adopted, while Dr. Dawson was left free to devote himself for the time to the special enquiry just referred to. The completion of the Kamloops sheet and report has consequently been unavoidably delayed, but it is hoped that both may be ready in time to form a part of the next Annual Volume of the Geological Survey.

Mr. James McEvoy left Ottawa on the 20th of June for field work in the interior of British Columbia, and returned on the 6th of November.

He reports as follows on the special work entrusted to him, as above explained :—

The season was chiefly spent in continuing the work within the area of the Shuswap sheet of the geological map. This sheet is referred

to in the report of Dr. G. M. Dawson's work in the Summary Report for 1890. It embraces the country immediately to the east of that covered by the Kamloops sheet and like it is laid out with sides eighty miles in length, thus covering an area of 6,400 square miles.

The first ten days of the season were occupied by a short trip into the northern part of the area covered by the Kamloops sheet to secure some additional information of the country between Loon lake and Deadman river, necessary for the completion of that sheet. While in this vicinity a number of specimens of the hyalite discovered in 1889 were collected.

After the completion of this trip the country between Chapron lake and Okanagan lake was visited. As there were no trails progress was necessarily slow ; two traverses were, however, made across it, besides several shorter ones, and three mountain summits were occupied for topographical sketches. Here, and generally throughout the western and southern portions of the area of the Shuswap sheet, the Tertiary volcanic rocks are more extensively developed than was formerly supposed. At a rough estimate they cover about a-fourth of the whole area of the sheet.

During the season Shuswap, Long, Mabel and Sugar lakes and a part of Okanagan lake were surveyed with a patent floating log and prismatic compass. Observations for latitude were taken with a seven-inch sextant to fix places not otherwise determined.

Neither Mabel nor Sugar lakes had ever been surveyed and were only very roughly indicated on existing maps. They are situated in the foot-hills of the Gold range on the Shuswap river and are about 35 miles apart by the river route. Their shores are rocky, being composed of gneiss and mica-schists of the Shuswap series, with large masses of pegmatite and graphic granite included. At the head of Sugar lake grey granite replaces the gneiss entirely, holding in many places angular fragments of mica-schist.

To the north-east of Enderby, and south of the Canadian Pacific railway, the mountains were ascended and two transit stations were established at an elevation of more than 6,000 feet. These mountains are almost bare of trees, and, where not too rugged, travelling is easy. Bear, caribou and deer are abundant.

Another transit station was made on the mountains north-east of Sugar lake on the eastern boundary of the sheet. These and several compass stations on either side of White valley, together with the points occupied in 1890, will afford sufficient data for the construction of an approximately accurate topographical map.

Southward and easterly from Salmon Arm, along Canoe creek and Deep creek, there is an extensive area of flat land, with grey silty soil, very suitable for farming. Generally this area is lightly timbered, while much of it having been burnt over would be easily cleared for cultivation.

About half way between Lansdowne, on the Shuswap and Okanagan railway, and the first crossing of the Salmon river by the waggon road to Grande Prairie, specimens of garnet were discovered. The crystals are nearly equal in size to the Stikine garnets and are enclosed in a light grey mica-schist and in places form at least half of the rock mass.

Though not included within the area of the Shuswap sheet, it may be mentioned that the numerous discoveries of silver-bearing galena and zinc blende on the North Thompson river at Mosquito Flat and above the Clearwater, are attracting a good deal of attention. These localities are situated about 50 miles and 75 miles respectively from Kamloops. The ores are said to give rich assays.

The following specimens from Mosquito Flat were assayed in the laboratory of this Department:—

1. Zinc blende with a little galena: gold, none; silver, 11·666 ounces per ton.

2. Galena and zinc blende in quartz: gold, none; silver, 48·125 ounces per ton.

During the season 330 miles of patent log surveys and 540 miles of track surveys were made.

Mr. McEvoy was assisted by Mr. J. McGregor, B.A.

The total cost of the exploration was $1,459.73.

Mr. R. G. McConnell obtained leave of absence last summer for the purpose of visiting the European Alps and studying their structure as an aid to further work in the Rocky Mountains of Canada, and the field work done by him last summer was limited to an examination of part of the Bow River valley, in Alberta.

Mr. McConnell supplies the following statement respecting this examination: "This work was carried out during the month of June and was undertaken with a view of ascertaining whether the coal-bearing Cretaceous rocks of the Cascade basin recur east of the mountains. The section along the Bow proved to be too complicated and was intercepted by too many concealed intervals to trace the sequence of the formations definitely throughout, but sufficient evidence was collected to show that in all probability the conglomeritic beds exposed at the Kananaskis Falls are the equivalents of those overlying Marsh's

mine, south of the Gap siding in the Cascade basin, and that the underlying dark shales consequently represent the coal-bearing formation. East of the mouth of the Kananaskis the conglomerates and underlying shales fold over a light anticlinal, and several hundred feet of the latter are exposed without any coal seams being seen. The summit of this anticlinal, which occurs three-quarters of a mile east of the mouth of the Kananaskis river, offers the most favourable site for testing by means of a bore hole for the presence of coal. The coal horizon of Marsh's mine, assuming the identification of the conglomerates to be correct, lies at this point at a depth of 1,300 feet below the surface. There is, however, no absolute certainty that even if this depth was reached coal would be obtained, owing to the lack of persistence of the Cretaceous coal seams, and on the other hand workable seams might be struck at a much less depth. The rocks near the mouth of the Kananaskis river are comparatively undisturbed, and coal, if present, would be much less crushed and also more easily worked than is the case with many of the seams enclosed between the more highly inclined beds of the Cascade basin, and on this account a bore hole to test its presence would be desirable.

"In returning east I descended the Bow in a boat as far as Gleichen, for the purpose of studying the mode of junction between the eastern and western drift, and on the way collected a number of interesting facts bearing on this subject which will be published later on. Cost of exploration, $324.85."

During the past summer Mr. J. B. Tyrrell, and Mr. D. B. Dowling, with Mr. J. C. Gwillim as assistant, completed the geological examination and mapping of Lake Winnipeg, and made reconnaissance surveys of many of the streams flowing into both the eastern and western sides of this extensive body of water. Mr. Tyrrell reports as follows: "The two small sail-boats that had been stored at Selkirk at the end of the season 1890 were repainted and again placed in the water. Supplies for a month were procured from Capt. Wm. Robinson, and arrangements were made with him to have provisions shipped from time to time to various places around Lake Winnipeg, where they could be obtained, in passing, without unnecessary delay. Two canoes had been ordered from Peterboro' for the examination of the streams flowing into the lake, but they did not arrive till later in the summer.

"On the 5th of July, after having been delayed in Selkirk for several days by wet and stormy weather, we started northward in tow of the steamer *Sultana*, and early on the morning of the following day

reached the harbour at Swampy island, whence we sailed eastward to the mouth of Beren's river.

"Having determined to divide the party in order to accomplish a wider range of exploration during the season, Mr. Dowling was sent northward with the larger sail-boat to examine St. George and Sandy islands, to take levels on the Saskatchewan river, to follow the west shore of the lake from Limestone bay southward to the mouth of Red river, and to explore the streams emptying into that side of the lake. This work he has successfully performed, as is shown by his report appended hereto.

"From Beren's river I turned southward and devoted the summer to a close examination of the eastern shore of the lake up to the mouth of Red river, and an exploration and survey of the principal streams discharging into that portion of the lake lying north of the straits at Dog Head, including Loon, Wepiscow, Wanipigow, Manigotagan, Sand, Black, Winnipeg and Brokenhead rivers, and thus it has been possible to outline with some degree of accuracy the extent of country underlain respectively by comparatively barren granites and gneisses and by Keewatin schists and quartzites which might be profitably examined for the presence of the ores of the richer metals.

"The investigations of Mr. Low, in 1886, had shown that Beren's river, throughout the whole of the course followed on his journey to Hudson's bay, flowed through country composed of Laurentian granites and gneisses, and from the mouth of this river up to Dog Head straits the shore of Lake Winnipeg is composed of similar rocks. At this latter point these gneisses begin to assume a very regularly banded arrangement parallel to the lake, and a few miles further south dykes of dark green trap begin to make their appearance, running in the same direction. Then irruptive rocks continue close to the east shore as far south as Wanipigow or Hole river, where they merge into an extensive area of eruptive volcanic rocks and agglomerates that form the base of the Keewatin series. On ascending the streams that flow into this portion of the lake, namely, the Loon, and Wepiscow or Rice rivers, the gneiss is seen to be very regularly and evenly banded near the erruptive rocks, while further east it changes imperceptibly into the coarse grey irregularly foliated Laurentian gneiss typical of that whole region. Punk island and the many small islands between it and Black island and the main shore were examined, and while the former at its eastern end was found to be composed chiefly of St. Peter's sandstone, the latter consists of altered conglomerates quartzose sandstones, agglomerates, chloritic and sericitic schists, &c., similar to those found in the typical Keewatin in the Huronian districts elsewhere. The

quartzites and conglomerates are somewhat more easily eroded than the adjoining volcanic rocks, and they therefore lie in a hollow which is flanked on one side by Black island, and on the other by the west shore, the beds standing generally at a high angle and striking parallel to the general curving trend of the shore.

"After these islands had been examined, Wanipigow or Hole river was ascended to the lake; a survey was made of the lake, and the river was also examined and surveyed to the first heavy rapid above the lake, beyond which we were unable to proceed on account of the lowness of the water. At its mouth the river breaks through a belt of evenly banded gneisses, above which it flows for ten or twelve miles through a rich alluvial plain wooded with poplar and white spruce, the banks on either side rising to a height of from fifteen to twenty feet above the water. Very little rock is to be seen, but any exposures that do outcrop from beneath the till and alluvial deposits consist of massive coarse amphibolites and green chloritic schists. On Wanipigow lake the rocks are also almost entirely of the same character, though on some places on the north shore the gneiss approaches close to the water, and the contact of the green Keewatin schists and the Laurentian gneiss is well shown. Speaking generally, the lake and valley of the river lie in a trough of Keewatin schists, the north side of which is bounded by ridges of Laurentian granites and gneisses, while the south side rises in hills of more compact green schist the contact of which with the Laurentian was not here observed.

"A stream called English river, a tributary of Wanipigow river, and the lake into which it expands in the middle of its course, were likewise surveyed. This river in its lower portion also flows over Keewatin schists, but the lowest rapid occurs at the contact of the schist and gneisses, and above this its course is through rugged country composed of high barren hills of grey gneiss thinly wooded with a stunted growth of small Banksian pine. Specimens of galena and chalcopyrite, stated to have been found on the north shore of Wanipigow Lake, were shown to the writer, and the occur rence of these minerals is not improbable along the above-mentioned contact line.

"From the mouth of the Wanipigow river to Manigotagan or Badthroat bay the shore is composed of greenish grey evenly banded gneisses with schists and altered traps of the Keewatin series, while near Clement point these are overlain by St. Peter sand-stone (Chazy,) this being the most northerly point at which Palæozoic rocks have been recognized on the east side of the lake.

"Manigotagan or Badthroat river was then ascended to Rat Portage lake, a track survey was made of this lake, and the river was

ascended for a short distance above it. The river is remarkably picturesque throughout, consisting of long quiet stretches of clear brown water, separated by rocky rapids or high abrupt falls which are passed on portages of an average length of from one to two hundred yards, twenty-three of which must be ascended on the way from Lake Winnipeg to Rat Portage lake.

"At the mouth of the river and up to the second portage, the rock is a thin and evenly banded hornblende schist, while throughout the rest of the distance to the latter lake it consists entirely of Laurentian granites and gneisses, rising in places in hills of from one to two hundred feet in height, the summits of which present a wintry bareness throughout the year.

"From the mouth of Manigotagan river to Pt. Metasse, north of the mouth of Winnipeg river, granites and gneisses everywhere compose the points on the shore, and these points are usually connected by gently curved sandy beaches in front of low-lying alluvial land.

"Sand river was ascended through this alluvial plain to the first rapid where it was found to be too small for further ascent with our large Peterborough canoe, but the rock, where seen, was similar to that on the shore.

"Black river was also ascended past thirty-three portages to a point south of Rat Portage lake, where a portage a mile and a-half in length strikes off to the northward. The stream is shallow and much obstructed by boulders and sandbars throughout, and the rocks on either side are everywhere Laurentian granites and gneisses.

"Winnipeg river was ascended to the mouth of the Whitemouth, and on the return a track survey was made of Lac du Bonnet.

"The rocks on the main stream are all granites and gneisses, but towards the east end of Lac du Bonnet, and around the mouth of L'Oiseau river, thin-bedded green schists and altered traps, doubtless of Keewatin age, make their appearance, striking up the valley of the latter stream.

"Above Lac du Bonnet the banks of the river, as faras examined, were chiefly composed of till, with many limestone boulders, and the rocks are scored in a S. S. E.'ly as well as in a S. W.'ly direction, showing that the earlier glacier moving south-eastward over the Palæozoic Lake Winnipeg basin had extended at least this far eastward, though there is no sign of limestone drift on the main portion of Lac du Bonnet itself or on the lower part of Winnipeg river.

"From the mouth of Winnipeg river the shore of Lake Winnipeg was explored to the mouth of Red river, and a short trip was made

up the Brokenhead river to the first rapid. A paced survey was also made of Elk island, and excellent sections of St. Peter's sandstone were found, both on this island and on the long point of land opposite. In this vicinity were also found many interesting sections of the drift deposits, some of which show the alluvial clay of the east shore of the lake interbedded with glacial till, proving clearly that this clay was deposited close to the oscillating front of the glacier descending from the highlands to the east.

"As the stormy autumn weather had now set in, the boats and supplies were stored with Capt. Wm. Robinson at West Selkirk, and Lake Winnipeg was left for the season. On the way east a short time was spent at Bird's Hill to examine the remarkable ridge of gravel that there rises through the surrounding hard boulder-clay, and again at East Selkirk to see the section of Trenton limestone exposed there in a quarry north of the railway. The exposure is an interesting one, as it shows a hill of limestone, the top of which has been broken up and shoved along by the glacier of the Winnipeg basin, leaving what is known as a *tail* deposit of loose material behind a protecting *crag*. It is chiefly from this broken *tail* material that the blocks of limestone used in Winnipeg for building purposes are quarried.

"I also remained for two days at Sudbury for the purpose of comparing the rocks that are there so rich in copper and nickel with those found on the east side of Lake Winnipeg, and it was very gratifying to see the remarkably close similarity between the two sets of rocks.

"During the season forty-four large and eighty-eight small photographs were taken of characteristic sections and surfaces of rock, and of particularly interesting features of the landscape.

"The following is Mr. Dowling's account of the work accomplished by him during the summer:—

'I left Beren's river on the 8th of July, after having secured the services of a competent sailor. Our first halt was at George's island, where I made a paced survey of its shores. We then called at Little George's and the Sandy island. After stopping at Poplar Point to take observations, our next halt was at Selkirk island, the shores of which were examined, and a traverse made with compass and boat log. There are here several small exposures of a hard mottled dolomitic limestone, somewhat similar to that on the mainland west of this island. We went from here to the Grand Rapids, where I levelled across to the head of the tramway with the transit, making a section on the tramway. This road is about three miles and a half long, and rises at its highest point to 128 feet above the lake, having a total rise of 71 feet between its upper and its lower end.

'Four well-marked lake beaches are crossed at elevations of 78, 91, 95 and 118 feet above present lake level. The lower one was followed about two miles north, and its crest was found to vary in elevation from 78 to 80 feet. With an Indian and his canoe we ascended the Saskatchewan and crossed Cedar lake to the "Mossy portage," an old portage road between Cedar lake and Lake Winnipegosis, to determine the heights of several gravel ridges. The difference in the level of the two lakes was then only nine inches, Lake Winnipegosis being the higher. After returning, a trip was made along the west shore towards Limestone bay with a Peterborough canoe that had just arrived. From Grand rapids I sent the sail-boat to Reindeer island and with the canoe went along the shore south to near Clark's point, crossed over to St. Martin islands and thence north joining the boat at Reindeer harbour. We then sailed along the west shore to Little Saskatchewan, where the boat was left for another canoe trip. We went up the Little Saskatchewan river, to the elbow, portaged over to the South Branch of the War Path river and descended this stream to its mouth; at the time of our trip this stream was very shallow and we found it slow work getting down. The country through which it runs is sloping gently to the north-east and is wooded principally with poplar and tamarack and a few spruce. From the mouth of the Little Saskatchewan we ran along the shore with the large boat and examined the cliffs of yellow dolomite west from Cat Head.

'From Kinwow bay to Fisher river the shore is rather low, the land behind being very little above the lake, with the exception of a few ridges of drift material that seem to trend in a north and south direction and where extending into the lake form boulder bars and boulder-strewn points.

'At Fisher river there is a large Indian reserve having good farming land a short distance from the mouth of the river, the lower part near the lake being all splendid hay flats. The Indians seem to be very comfortable and have several good fields of grain and many fine looking cattle. The river for about twenty miles is a sluggish stream with a few shallow parts with some current. The greatest fall is at the Big Rapids and is about four feet, but in the whole length of the river to The Forks there is only about twenty feet fall. The country passed through is quite level, wooded for the most part with poplar; but a considerable portion has been fire-killed and almost reduced to prairie. Between the patches of timber open hay land was seen and swamps are reported rare, so this should make excellent land for settlement.

'From Dog Head to Bull Head the exposures are of Trenton limestone and were examined and measured. From Bull Head to Big island the underlying St. Peter's sandstone is frequently exposed in the same cliff with the limestone. The east side of Big island is seen to be underlain by limestone which is exposed in sections of from 10 to 20 feet extending from the north end to about the middle of the island. The southern part is covered principally with drift material causing the shore at its southern extremity to be boulder strewn and the water shallow. On the 29th of September I returned to Selkirk and stored the outfit; leaving the boat in the care of Mr. Muckle, Indian agent at Clandeboye.

'I was about starting for Ottawa when Mr. Tyrrell returned from the lake and commissioned me to examine the rock exposures at Stonewall, Stony mountain and lower Fort Garry. At Stonewall I observed two sets of glacial grooves on the surface of the rock, the striæ running S. 25° E. and S. 10° W., the latter evidently the newer.

'The present season's work enables us to complete the section of the Cambro-Silurian formations, which rest unconformably on the Archæan rocks of the east side of Lake Winnipeg and seem to underlie conformably the Silurian which was observed at Grand rapids by Mr. Tyrrell.

'Typical examples of the lower division consisting of beds of friable sandstone and shales may be seen at Grindstone point and Deer island.

'The middle division is represented by mottled yellow limestones at Selkirk, Dog Head and Beren's island, while the upper division consists of impure limestones and shales as at Stony mountain and Clark's point, Lake Winnipeg.

'About forty photographs of the various rock exposures were taken. Mr. Dowling left for Ottawa on the 11th of October.'

"Cost of season's exploration $2,059.29."

Mr. McInnes left Ottawa on the 17th of July, with instructions to continue the work of 1890 in western Ontario, between the Lake of the Woods and Thunder bay, Lake Superior, and arrived at Port Arthur on the 20th. Provisions and men were obtained there for the season's work, and Mr. Chas. Marks, of Port Arthur, was engaged as assistant for the season. Mr. McInnes reports as follows:—

"On the 25th a start was made southward from Savanne by canoes, and the interval between this date and the 16th of August was spent in an examination of the country lying on either side of Kashabowie lake

"The streams flowing into the lake were first ascended and the lakes along their course were surveyed by prismatic compass and boat log. A survey of the same character was made of Trout lake, which lies to the east of the north end of Kashabowie lake.

"The main body of this lake, which is about six miles in length and a mile and a-half in width, lies entirely within the gneiss area which occupies the greater part of the shores of Lac des Mille Lacs. This gneiss was found to extend continuously northward from Troutlake and to occupy the whole of the country northward to the Savanne river and the Canadian Pacific railway track. The country about the height of land here is an immense swamp which divides the water of Lake Superior and Lake Winnipeg, sparsely wooded with tamarack and stunted spruce, and with here and there low ridges of granitoid gneiss rising from the general level.

"After completing the survey of Trout lake, Asagesh or Crayfish river was next ascended, and a track survey made of it and a log survey of the lakes along its course. About a week was spent in surveying the lakes at the heads of its two branches and in fixing the southern limit of the Kashabowie belt of gneiss, at different points in the neighbourhood. The country about Round and Jackfish lakes was next visited, and a week was spent in tracing geological boundaries in that district. At the Huronian mine which has not been worked since 1885, the buildings, ten-stamp mill and vanners, &c., boarding house, shaft house, store houses, &c., were found in a good state of repair; the shaft was however filled with water and the vein could be seen only in the extension to the south-west at the Highland mine opening, where it is clearly defined and highly mineralized with iron and copper pyrites. There seems good reason to hope that with possible future railway extension in that direction, and the consequent improvement in means of transport, the properties on this vein may be profitably worked.

"Returning to Lake Shebandowan a survey was made of a series of lakes and streams extending northward to a point near the Canadian Pacific railway at Nordland station. The granite-gneiss was found to extend from a point near the Muskeg river which enters Lake Shebandowan from the north near its outlet northward to the railroad track, the belt of Keewatin rocks which has a considerable width on Lac des Mille Lacs having given place to the gneisses a short distance to the east of the lake.

"The remainder of the canoeing season was occupied in an exploration of the country lying to the south of Lake Shebandowan. A canoe route was followed leading southwards to Kekekuab river, a branch

of the Mattawin, and returning by a chain of small lakes leading across to Greenwater lake. With the exception of one small lens-shaped area of gneiss which lies about three miles to the south of Lake Shebandowan, Keewatin diorites and schists were found to extend over the whole area southward, as far as Kekekuab lake, where the northern edge of the broad belt of gneiss of Northern Light and Seiganagah lakes is struck. A number of bands, 20 feet or thereabout in width, of magnetite interstratified with schistose layers of hornblende, quartz, &c., were noticed in the dioritic areas of the Keewatin in this district. The magnetite occurs in narrow bands a quarter of an inch in thickness with thin layers of about the same thickness of the schistose material interstratified, the whole often highly contorted and twisted locally, though preserving a general trend parallel with the enclosing diorites and schists. Specimens of this ore collected from near the eastern side of Greenwater lake were submitted to Mr. Hoffmann, the chemist of the department, who describes it as 'a very fine-grained, almost compact, schistose magnetite from Greenwater lake, district of Thunder Bay, Ont.,—collected by Mr. McInnes, 4th October, 1891,—has been examined by Mr. F. G. Wait, and found to contain :-

Metallic iron	52·82 per cent.
Insoluble matter	22·31 do
Titanic acid	none

a good iron ore.'

"This, it will be seen, is a most encouraging report, both in the high percentage of metallic iron and in the absence of titanic acid, and gives good reason for the hope that a thorough exploration of the region will reveal valuable deposits of this ore. A number of locations have already been taken up in the vicinity of the Mattawin river and during the past summer considerable work was done towards testing some of these properties, the result of which has not however been learned.

"In the district further west very commendable enterprise has been shown by the Marks Company in thoroughly testing their iron properties on the Atikokan by the diamond drill. It is stated that the results have been satisfactory. Mr. Smith who makes a separate report will deal with this region in detail.

"In the whole region explored during the summer, the areas of land adapted for cultivation are few and very limited in extent. As pasture much of it might be greatly improved. This is well shown by the luxuriant growth of red and white clover and timothy grass where seed had been scattered around the old construction camps along the line of the Canadian Pacific railway. But doubtless the future of the district will depend largely upon its contained minerals and it is

to be hoped that the present very promising discoveries of extensive deposits of iron ore may be found to warrant the building of the necessary works for smelting the ores somewhere in the neighbourhood."

Mr. McInnes returned to Ottawa on the 30th of October.

The total cost of the season's explorations was $994.71.

Mr. Smith left Ottawa on the 16th of June, and was joined in Toronto by his assistant, Mr. William Lawson, whence they proceeded at once to Port Arthur.

After securing men and purchasing supplies, Mr. Lawson left English river on the 25th of June to make a compass and log survey of the chain of lakes running southwesterly from there, which it was thought might be partly within the area of the Seine river sheet. On the completion of this survey as far as the north-eastern arm of Turtle or Crow Rock lake, he travelled to Fort Frances.

Mr. Smith went through the chain of lakes and streams comprising a hitherto unknown route from Ignace to the headwaters of the Big Turtle river. He passed down this river, surveying on the way Pekagoning lake, which encroached on the northern limit of the Seine river sheet; and from thence he proceeded to Fort Frances to rejoin Mr. Lawson and obtain supplies.

The united parties left Fort Frances on the 18th of July and ascended by the Manitou canoe route to the northern limit of the area included in the Rainy lake sheet, No. 3, already published. Work was commenced here, in accordance with instructions, on the area to be included in the sheet No. 4, north of No. 3. A micrometer and compass survey of the east side of Manitou lake was made, also of a smaller lake to the west of it; and the survey commenced in 1885 of the smaller lakes on this route, between Manitou and Little Wabigoon lakes, was completed.

From Wabigoon Messrs. Smith and Lawson surveyed a route to the headwaters of the Big Turtle river, securing another tie line connecting the surveys of 1890 with the line of the Canadian Pacific railway. From the headwaters of the Big Turtle river Mr. Smith proceeded to Martin lake to verify the existence of a band of Keewatin schists supposed to occur south of this lake; this supposition was proved to be correct. Mr. Lawson at the same time examined some small lakes shown on the timber limit surveys in the vicinity of Clear and Clearwater lakes. On their reunion they proceeded to English river.

After obtaining more supplies, they endeavoured to discover a route south-westerly from English river to the Seine river, but failed to get

more than 16 miles. Then the party descended by the route traversed by Mr. Lawson in July, from the English river to Long lake, where the party again separated, Mr. Smith pushing through a hitherto unknown route to the Seine river, which resulted in the addition of six small lakes to the topography of the Seine river sheet.

Thence he proceeded to Steep Rock lake to rejoin Mr. Lawson who had descended by the Eye river to the Seine river, and thence up it to Steep Rock lake, making some geological observations needed to complete the work of 1890.

In Steep Rock lake five days were employed in investigating an apparently unconformable series of rocks found here, and which it is hoped will afford a further clue to the elucidation of the Archæan structural geology of the district.

From Steep Rock lake Mr. Smith ascended the Atikokan river to mining locations R. 400 and R. 401 where three days were spent in obtaining a section of the iron-bearing rocks, the relative age of which is not yet determined, and in examining the iron ore deposits of these locations. From here he proceeded to Savanne, arriving there on the 1st of October.

From Steep Rock lake Mr. Lawson descended the Seine river and crossed into Beaver lake which he surveyed, and after obtaining a section from Steep Rock lake to Clearwater lake he proceeded to Savanne, where he arrived on the 3rd of October, and closed the season's work.

The topography of the Seine river sheet is now complete, several lakes unknown last season having been added, but the geological problems involved in this area are so important that a few weeks more will be required to further investigate them. A brief sketch of the geology of this field was given in the Summary Report for 1890, p. 28.

Mr. Smith discovered excellent indications of a broad zone of magnetic iron ore, on the west side of a lake on the Big Turtle river called "The Lake where the River Bends." The ore is associated and interbanded with micaceous schists. The bands vary from fractions of an inch to three feet or more in thickness, and this interbanded occurrence of ore and schist in its broadest development appears to be from 150 to 200 feet wide. To the south-east near the southern end of the lake this band appears to be cut off by a fault and from this fault northward the iron ore could not be traced for more than a mile and a-half, the rocks being so thickly covered with vegetable mould that exploration in this direction was difficult and uncertain. The rocks here strike north-west and south-east and dip from 45° to 55° to the south-west. They are very evenly stratiform in appearance and seem

to constitute a tapering band trending eastward, then south-eastward, from the broad band of Keewatin schists so largely developed in Manitou and Little Wabigoon lakes, and from certain ferruginous angular fragments found in the north-eastern arm of Manitou lake, Mr. Smith is inclined to think that more ores may be found in this vicinity, in the same geological horizon as the above, in the near neighbourhood of the granites.

An analysis of these ores made by Mr. G. C. Hoffmann, chemist to this department, shows them to be very siliceous, yielding 40·17 per cent metallic iron and 37·21 per cent of insoluble matter, but no titanic acid.

The locality is about 19 miles south-west by south of Raleigh station on the Canadian Pacific railway. It could be reached by about 21 miles of railway through a comparatively level country. It would be possible, with light expense involved in building short tramways, to carry light ore trucks over the portages, four in number and aggregating one mile and a-half in length, to reach the Canadian Pacific railway by 40 miles of navigable water-way *vid* Snake lake and Snake and Wabigoon rivers.

The ore is in such a position as to be easily mined, and considerable water power is afforded at the outlet and inlet of the Big Turtle river. Unless the ore is found, as usual in this country, to be much richer in the actual ore bodies than in the surface indications, it will, of course, be of no commercial value in competition with the rich ores of the Lake Superior district on both sides of the international boundary.

The gold locations on the lake west of Manitou lake were visited during the summer and some specimens from the veins collected. The field appearance is very encouraging. One vein in particular seems to be a very strong one and in some places is as wide as ten feet of promising looking quartz associated with soft soapy talc schist in soft chlorite schist.

The iron ores of the Atikokan river have in two locations been carefully tested this summer with very gratifying results, but the details of the diamond drill borings are not yet made public. On the completion of the Atikokan Iron Range railway it is hoped actual mining will be engaged in here. The ores are very rich and pure, running as high as 60 and 70 per cent of metallic iron.

Very little prospecting has been done in the Thunder bay and Rainy river districts this summer, said to be the result of the change in the Ontario mining laws.

The season's work was mainly geological in character, but some 150 miles of compass and micrometer lines, 100 miles of log and compass

lines, and 50 miles of time traverse were run, serving as bases for the compass triangulation of islands and intermediate points.

Mr. Smith returned to Ottawa on the 10th of October.

Cost of exploration, including salary of assistant, $1,234.

Dr. Bell was requested to complete during the summer, if possible, the geological survey of the area embraced in sheet 125 of the Ontario series which adjoins the Sudbury district sheet on the south. Mr. A. E. Barlow, M.A., was to assist Dr. Bell as during the four preceding years. With the approval of the Minister, the party was to include the following gentlemen: Messrs. A. M. Campbell, H. H. Walker, B.A.Sc., H. G. Skill, A. C. Robertson, W. G. Miller, B.A., and R. W. Brock. Mr. Barlow left Ottawa for the field on the 10th of July, and returned to this city on the 1st of October. Dr. Bell left on the 23rd of July, and returned on the 6th of October.

On the work of the party Dr. Bell reports as follows:—

"Mr. Barlow worked principally in the north-western part of the sheet, in the neighbourhood of Lake Panache, and between Collin's inlet, and the lower part of the Wahnapitæ river. He also visited some localities in the Sudbury district, near the line of the Canadian Pacific railway, for the purpose of obtaining mineral specimens. The details of his work are given in his own words herewith: 'I have to express my entire satisfaction with the manner in which all the above-named gentlemen performed the duties allotted to them.

"'The central and southern part of sheet 125, amounting to about one-half its area, is occupied by the waters of Georgian bay, while many channels and inland lakes diminish considerably the area of dry land in the remaining half.

"'The north-east corner of the sheet is at the western extremity of Lake Nipissing, the north-west in the township of Hallam, the south-east in that of Shawenaga, while the south-west is near the south-e astern extremity of Grand Manitoulin island. Most of the topography of the sheet could have been represented pretty well by compiling the hydrographic surveys of Commander Boulton, R.N., the river and lake surveys of the late Mr. Murray, of the Geological Survey, and the lines run for the subdivision of the land by the Crown Lands Department. Still some parts were either entirely unsurveyed, or were too poorly defined for our purposes, and we were obliged to survey them ourselves.' The portions executed by Mr. Barlow are described by himself in the statement above referred to.

"My own topographical work embraced the following: A micrometer and compass survey of the shores and islands of the large bay between Great Cloche island and the north shore of Lake Huron. The islands in this bay are exceedingly numerous, amounting probably to a thousand or more, and as the bay has heretofore been without a name, I called it Bay of Islands, with the approval of Captain Boulton and the inhabitants and lumbermen of the neighbourhood. Cloche channel and peninsula, and the peninsula between Bay of Islands and McGregor bay were next surveyed in the same manner, and finally the latter bay, including a very large number of islands, and also the channels in its northern part, and those lying still further north. This work was begun on the 28th of July, and completed on the 29th of August. In its performance I was assisted by Messrs. Miller and Brock.

"Track surveys were made of a lake five miles in length in the interior of Great Cloche island, and of the five principal lakes lying between Killarney bay and the Mazinhozin river, which discharges into Collin's inlet, namely, George, Trout, Sturgeon, Ka-ko-kis and West lakes with their connecting streams. A number of smaller lakes in this district were also located. In this work I was assisted by Mr. H. G. Skill and Mr. Myles Tyson, the latter of whom had a good knowledge of the local topography which proved of much service in economising our time. Being favoured with very fine weather we were enabled to accomplish this part of the work between the 5th and the 11th of September.

"On the 13th of September we proceeded by steamer from Killarney to the French river region in order to add to the geological information which had been already obtained there by the late Mr. Alexander Murray and myself and to survey and locate some topographical features not previously indicated upon any map. Careful track-surveys were made of a long narrow channel running north-westward from the expansion of the river where the North Channel West is joined by the South Channel East; of a canoe-route from the head of this channel to Trout lake, of this lake itself (which is twelve miles long) and of a canoe-route by way of Ka-was-ki-gama, or Crooked lake, to the rocky delta of the middle group of outlets of French river. Numerous minor additions were likewise made to our knowledge of the topography of this region and also some corrections of the topography already laid down upon the maps.

"The part of Grand Manitoulin island which comes within the sheet, and consists principally of its eastern peninsula, had been examined by myself in 1859, 1865, 1876 and 1886 and the boundaries of the various formations traced out and represented upon the geological

maps; but for the sake of attaining greater accuracy in some localities I sent Mr. Miller with three men to go over part of the ground during the first half of September, and my own time and that of Mr. Miller and Mr. Brock for the last week of the season was devoted to the same work, so that the geological lines in this part of the sheet can now be represented in accurate detail. Mr. Skill was employed from the 19th of September to the end of that month in tracing the details of the boundary between the Laurentian and Huronian rocks, from Killarney bay north-eastward to the lakes we had surveyed behind Collin's inlet.

"In regard to the geology of the sheet, we were enabled to fill in all that was required to complete it for publication. The area of dry land is only about half that represented upon the Sudbury sheet and the distribution of the rock-formations was more easily worked out than upon the latter, as the region was more accessible and as the greater part of its area consists of Laurentian gneiss and nearly horizontal Silurian formations. We had also the advantage of the previous geological work of Mr. Murray and myself in the district. Besides these two systems the Huronian is represented by a small area in the north-western corner of the sheet.

"The Laurentian rocks which come within the sheet probably belong to the upper division of the system and consist of grey and red gneisses, generally in distinct beds, which run comparatively straight for considerable distances. The grey varieties are generally coarser than the red and their foliation is often indicated by the parallelism of the larger diameters of the grains rather than by distinct bedding or bands of colour, although these are also often present. But both the grey and red varieties become schistose in many places, and they sometimes enclose regular belts of hornblende and mica-schists, the latter always holding garnets.

"On the coast of Georgian bay, from the township of Carlyle to the eastern mouth of French river, the strike is uniformly to the north-eastward and the dip generally to the south-eastward at tolerably high angles, but in the central part of the course of French river it is mostly north-westward and westward, but with many local variations. From the eastern mouth of French river to Shawenaga bay the strike varies from north-west to south-west.

"The boundary line between the Laurentian and Huronian leaves the head of Killarney bay and runs north-eastward with a curve to the south-east and reaches the northern edge of the sheet in township 68 a short distance east of Lake Panache. From this line south-eastward as far as Collin's inlet, the rock is massive or shows only slight or local foliation and most of it might be called red hornblende-granite. A

similar rock, described by Mr. Murray as (quartz) syenite, occurs for a breadth of two miles between the Western and Middle mouths of French river.

"The Huronian rocks of the north-west corner of the sheet consist principally of quartzite, but greenstones sometimes occur among them, and they are occasionally interstratified with greywackes, clay slates, crystalline schists and other rocks in smaller quantities. Among the latter is the band of dolomite described in my report for 1876, page 209. The greenstones form a much less prominent feature among the quartzites and greywackes than further inland. They consist of several narrow belts in the neighbourhood of Lake Panache and among the islands near the north shore of Lake Huron, where they are traceable for from one mile to three, and correspond in most cases with the general direction of the strike. Much smaller masses of greenstone of various forms and lying at every angle with the strike are enclosed among the quartzites in all parts of their distribution within the sheet. Along the contact between the two systems the granite and the quartzite are a good deal intermingled; large isolated pieces of the one being incorporated in the other.

"The quartzites form the La Cloche mountains and the long and high points jutting south-westward into Lake Huron between McGregor and Killarney bays, as well as Badgeley, Centre and Heyword islands. Our surveys appear to confirm my previous opinion that the several belts of quartzite forming the La Cloche mountains are repeated in these high points and islands which represent the opposite side of a syncline or possibly an anticline.

"In the La Cloche mountains, which rise from 400 to 750 feet above Lake Huron, and also around Bay of Islands and McGregor, the strike is nearly east and west with high or almost vertical dips, mostly to the north; but further south it follows the axes of the points and islands just mentioned.

"A belt of sericite schist was traced on the north sides of Bay of Islands and of McGregor bay and on the isthmus between them and another belt of the same rock through the islands of these bays at a distance of a mile and a quarter south of the first. The greenstones above referred to were found principally towards the south side of Bay of Islands, but in the area covered by McGregor bay and in the channels to the north of it they occur in various parts, but are most abundant in the central and western portions. Clay slates were found in some abundance in the northern part of the township of McKinnon.

"The rocks of the whole district covered by the sheet have been everywhere glaciated. A number of photographs illustrating glacial

action were obtained and much interesting information was collected in reference to the phenomena of the drift."

Expended on field work by Dr. Bell, $950, by Mr. Barlow, $1,080.

Dr. Ells left Ottawa for field work on the 8th of June with instructions to complete the revision of the geological boundaries as laid down on the Montreal or south-west quarter sheet of the map of the Eastern Townships and then to continue the work westwards up the valley of the Ottawa and its northern tributaries. In carrying out the first part of this work which was completed on the 20th June, Dr. Ells reports that a "number of fossils were collected by Mr. W. E. Deeks, B.A., from places on the Calciferous, Chazy, Trenton and Hudson River formations, where fossils had not previously been collected by the officers of the survey. On the 22nd of June Dr. Ells, accompanied by Mr. F. D. Adams, of McGill College, started from Grenville for Iroquois Chute on the River Rouge near Trembling lake, with a view to re-examine the character and relations of the limestone and gneiss bands of the Trembling lake and mountain, and also to trace out the western boundary of the great anorthosite area of Wolfe and Grandison.

"The country around Trembling lake was examined, then the Macaza river was ascended to its head, thence crossing to a lake on the west branch of the Devil's river. This lake is not laid down on the Provinces map, and of which we made a track survey from Devil's to its junction with the outlet of Trembling lake, there fixing the western limit of the anorthosite in this direction.

"The first part of the season to the 20th of June, was spent in the examination of the country to the south and south-west of Montreal, necessary for the completion of the south-west quarter-sheet of the Eastern Township map. Valuable collections of fossils were made from the Calciferous, Chazy, Trenton and Hudson River formations by Mr. W. E. Deeks, B.A., many of which are from places not previously examined by the officers of the survey. A very large portion of this area is covered by a deep deposit of drift, and rock outcrops are, as a consequence, rarely seen. The geological boundaries laid down on the map of 1866 were carefully followed, in so far as the drift would permit, but in such an area these must of necessity be largely conjectural.

"Accompanied by Mr. F. D. Adams, of McGill College, I started on the 22nd of June, with four canoemen, from Grenville to Iroquois Chute, on the River Rouge, near Trembling lake. This point is forty-four miles in a direct line nearly magnetic north from the former

place, but by road is not far from sixty-five miles. This distance we traversed by teams, having arranged beforehand to secure our canoes at the Chute. Our object was to ascertain the characteristics and the relations of the lowest gneiss of Trembling mountain to the gneisses and limestone bands of Trembling lake; as well as to trace out the western boundary of the great anorthosite area of Wolfe, Grandison and Archambault and its extension through the area north-west of the latter township. In the examination of the Trembling lake area all the streams and lakes in the vicinity, to a distance of six to eight miles on all sides, were visited. Trembling mountain itself was ascended and its elevation above the surface of the lake at its front found by aneroids to be 1,720 feet, or within three feet of the elevation, as determined by Sir William Logan in 1858 by triangulation. This added to the elevation of the upper terrace at Iroquois Chute, taken from the railway survey to this point from St. Jerome which is here stated to be 875 feet above Lake St. Peter, and which is approximately the same as the surface of Trembling lake, would give for the summit of this mountain a height of about 2,585 feet above the sea. From the Iroquois Chute we ascended the Macaza river, and thence up that stream and its branches to the height of land between there and the lakes at the head of the west branch of the Devil's river. Thence by portage we reached Lac des Baies and ascended the west branch of the Devil's river to its junction with the north branch, a short distance from Devil's lake. This stream is not laid down on any map, and, in fact, this section of the country is entirely unknown to any except a few hunters who occasionally cross by this route to the waters of the Mattawin. The surface is largely drift-covered and ledges are rarely seen even around the lake shores. From the Devil's lake the main stream (Devil's river) was descended to its junction with the outlet of Trembling lake; a track survey being made for about thirty-five miles. The stream is in places very rough and presents huge cliffs of gabbro at several points. By this survey the western limits of the anorthosite area above referred to can be fixed. Finding, however, that the relations of the limestones to the associated and generally underlying gneiss could not be so satisfactorily determined in this area as in that further south, owing to the prevalence of the drift, and there being no further funds at our immediate disposal, the canoe men were brought back to Grenville by team as being the cheapest and most expeditious way and there paid off. In consequence of there being no map of the country north of the Ottawa river, in the counties of Argenteuil and Ottawa, on which the roads were laid down with any approach to accuracy, the survey of this area was taken up in company with Mr.

Deeks, who had already surveyed most of the roads in the flat country between Lachute and the Ottawa and extending west to Calumet. The greater part of the roads in the counties just mentioned, as far west as Thurso and north for ten miles beyond the Iroquois Chute on Rouge river, have now been surveyed, partly by pacing and partly by wheel survey, and from these a skeleton map of this district is now being constructed on which the distribution of the limestone bands will be shown at many points, but another season's work, devoted to the examination of the many lakes which are scattered throughout the district, will be required before the exact relations of the gneiss and limestone bands can be determined. All the roads between Point Fortune and the province boundary, on the east, and the South Nation river on the west, were surveyed to a distance of ten to twelve miles south of the Ottawa river, and the boundaries of the Calciferous, Chazy and Trenton finally revised. Much of this area is also largely drift-covered, but where rock exposures are seen they are generally highly fossiliferous, so that the determination of the formations named is comparatively easy. Good collections of fossils were obtained from various points near L'Orignal and Little Rideau, at both of which places Mr. Deeks found extensive quarries had been opened.

"The eastern outcrop of the anorthosite area through Wolfe, Beresford and further north and east in the county of Montcalm was traced by Mr. Adams, while in Howard and Morin its limit was noted by Mr. Deeks. Owing to the present unfinished condition of the work in Argenteuil and Ottawa counties conclusions cannot be stated. The Laurentian gneiss and limestone at Lachute are overlain by the Potsdam, of which a good exposure is seen about a fourth of a mile east of Lachute station, north of the Canadian Pacific railway, which is apparently conformably overlain by ledges of fossiliferous Calciferous rocks, the fossils being obtainable from ledges in the North river, near the paper mills, at a very low state of the water only. The Calciferous apparently extends thence to the Ottawa, though much of this area is heavily covered with drift, but at Carillon nearly horizontal Chazy sandstones are exposed which extend thence up to Grenville. At St. Andrews a prominent ridge of Laurentian red gneiss begins on the east side of the North river and extends for about seven miles eastward with a breadth of about two miles. This has not before been noted. It is separated from the area north of the Lake of Two mountains by ledges of Potsdam sandstone. The general attitude of all the fossiliferous strata in the vicinity of the Ottawa river and for some miles to the south is horizontal.

"The limestone of the Laurentian system in the county of Argenteuil would appear from the observations of the past season to represent its upper portion. They are generally seen to occupy synclinals in the gneiss and a succession of these limestone synclinals with gneiss anticlinals can be traced for many miles across Argenteuil and Ottawa counties. The limestones hold inclusions of rusty gneiss which have once existed as interstratified bands and have been drawn out and frequently twisted into curious forms. Scattered crystals of apatite, pyroxene, graphite and sometimes garnet occur in these beds, and often fragments of crystalline orthoclase which on weathered surfaces stand out prominently, and at first sight cause the rock to assume the aspect of a conglomerate. The lower portion of the limestone bands are associated with layers of quartzite and rusty gneiss, with beds of a whitish highly felspathic rock, and these are generally repeated regularly on each side of the limestone synclinals, passing downwards into greyish, greyish-red and reddish gneiss. The general strike of the rock is a few degrees east of north, but at several points the direction changes to nearly east and west and occasionally the various members appear to be overturned. It has been found very difficult to trace the limestone areas continuously, owing in part to these being to a large extent concealed by drift, but also to the fact that many of them are local in their development, as can be seen by their frequently thinning out and ending often quite abruptly both to the north and south. In the northern part of Argenteuil the limestone decreases in development and on the branch of the Upper Rouge called the Macaza disappear altogether; this may, however, be to some extent due to the covering by drift, but not altogether. East and north of Lachute the beds of limestone also become very limited, but going west through Grenville, Petite Nation, &c., they become much more extensively developed.

"The economic features of the district examined by us north of the Ottawa, in Argenteuil and eastern Ottawa counties, are at present comparatively unimportant. Deposits of mica, graphite and asbestos occur quite frequently, and some of these have been opened up but no mining has been done in this section for many years. The most easterly observed outcrop of serpentine limestone, with asbestos, was at Silver lake, half a mile south-west of the inland lake at Wentworth. The asbestos veins were few and of small size. Small crystals of apatite and pyroxene were observed in limestone near Maskinongé lake, one mile and a half south of St. Jovite in Grandison, but nothing of economic importance was noted.

"The party left Ottawa on the 8th of June and returned on the 14th of October. Expenses of the season $1,136.

Roads surveyed by waggon wheel ..... 850 miles
do do pacing ..... 110 do
Track survey of Devil's river..... 25 do

"My associates during the past season were Messrs. W. E. Deeks, B.A., Robert MacDougall, B.A., and J. F. E. Johnston, Graduate Royal Military College, Kingston."

Mr. F. Adams, of McGill College, kindly undertook to complete the examination and mapping of the Laurentian area which lies to the north of the Island of Montreal and on which he had been working before he retired from the survey in 1890.

On this work he furnishes the following interesting report :—

"Leaving Montreal on June 22, I joined Dr. Ells at Grenville the same afternoon and proceeded at once with him to Chute aux Iroquois and Trembling lake where we arrived on the 24th of June, this district being on the line between the map above referred to and the sheet adjoining it to the west, which is being surveyed by Dr. Ells. The special work to be accomplished in this district was the determination of the limit to the north-west of the great Morin anorthosite area and the relation of the limestone bands to it. The former was fixed by a track survey of the Devil's river, an exceedingly rough stream, which runs in a southerly direction through the township (not yet named) lying north-west of Archambault and joining the outlet of Trembling lake about a mile from the lake. The study of the relations of the limestone bands to the anorthosite, however, was less satisfactory, large exposures of the former being found, but their relation to the anorthosite could not be determined, in most cases owing to the heavy drift which covers much of the country.

"No further reference to the north in this district is here required, as a report on it has been made by Dr. Ells. I returned to Grenville on the 22nd July.

"On the 4th of August I again left Montreal and remained in the field until the 27th of August completing my examination of various parts of the area, working as far east as the township of Brandon which was very carefully examined.

"The geology of the whole district, which comprises an area of about 4,000 sq. miles, in the counties of Berthier, Joliette, Maskinongé, Montcalm, Argenteuil and L'Assomption, has now been worked out and it is hoped that the map will be ready this spring. Speaking generally it will extend from Berthier in the east to Trembling mountain on the west, and from Cypress lake on the north to Lachute on the south.

"The area examined is occupied for the most part by rocks of Laurentian age, which to the south-east are unconformably overlain by Cambrian or Cambro-Silurian strata. The Laurentian rocks consist of gneiss in great variety, interstratified with beds of quartzite, amphibolite and crystalline limestone. In the eastern part of the area these strata lie nearly flat, but to the west they become more and more sharply folded. Sometimes interstratified with these and sometimes intruded through them are a number of masses of gabbro or norite rich in plagioclase (anorthosite). These, together with some of the associated gneisses and limestones, were formerly supposed to constitute a separate overlying series, to which the name Upper Laurentian was given. Their boundaries have, however, now been traced out, and their stratigraphical relations determined and they have been found to be without doubt igneous rocks, while the associated gneisses and limestones form part of the ordinary Laurentian complex. The 'Upper Laurentian,' therefore, in this typical area does not exist. In addition to these basic igneous rocks, masses of eruptive granite and other acid rocks occur in several parts of the district."

Mr. Giroux was requested to go over and revise the boundaries of the Palæozoic formations north-west of the St. Lawrence, on the south border of the Three Rivers sheet and the adjoining north border of the Montreal sheet of the Eastern Townships map in the counties of L'Assomption, Berthier and Maskinongé. On this work Mr. Giroux reports as follows:—

"I left Ottawa on the 15th of July, but owing to some difficulty I had in getting good canoe men I could not begin work before the 25th of July, on which day a micrometer survey of the L'Assomption river was begun from the dam, a short distance above the old saw mill of the town of Joliette. This river is very crooked and affords very good exposures of highly fossiliferous brownish weathering calcareous sandy rock or impure limestone full of grains of quartz. The strata are nearly horizontal. Ledges of these rocks crop out here and there, in ascending the river, for a distance of about a mile and a quarter, where there are exposures of brownish weathering coarse whitish grey sandstone (Potsdam). The beds are disturbed and the rock is very much decomposed for three or four inches from the surface. At Bordeleau's mill, two small excavations had been made where the rock contains small bunches and strings of iron pyrites. The beds dip S. 60° E. $<$ 12°. These sandstones extend as far up as Rapide à Nadeau, or about 19 miles, by the river, in a northerly direction from the town of Joliette. At the foot of this rapid there are ledges of coarse crystalline hornblende gneiss which soon changes into a more quartzose grey

gneiss. About one-third of a mile further up the river two farmers spent all their money digging for gold in patches of calcite which they mistook for quartz. The small scales of mica, the fine fragments of hornblende, and a few crystals of iron pyrites which shine in the rock are probably what led these men astray.

"We ascended the river to the mouth of Black river, and in all that distance, about 40 miles, the Laurentian rocks are well exposed; they consist of gneisses which vary greatly in composition, being at times very micaceous, then hornblendic, and then again very highly quartzose and garnetiferous. As a rule the foliation is very indistinct, and it is only in very few places that the dip which varies in direction and from an angle of 27° to 37° degrees could be observed. The banks of the river are very irregular in height, varying from 25 to about 125 feet, and are composed of fine and coarse sand, with bands of small pebbles which are always underlain by bluish grey clay. In some places, however, the banks are all clay. As a rule rock exposures can be seen at rapids only; but as these are numerous a good section is afforded. All along Black river from its mouth up to Black lake, a distance of seven miles, there are fine exposures of various gneisses. In some places it presents a mottled appearence due to patches of almost pure quartz, and others of hornblende and mica. In places the rock shows specks of graphite and iron rust. The predominating colour of these gneisses is brownish grey, weathering grey and having a general strike of N. 30° E. to N. 30° W.

"Black lake measures about six miles around and has low shores which are even swampy in places. In the bottom of the largest bay known by the name of 'Monatac bay,' an old Indian by the name of Monatac settled about 60 years ago and reported that he had a gold mine near his shanty which was generally believed. Even now, many persons in the district firmly believe that there must be a great deposit of gold there. I examined the spot and found ledges of grey gneiss containing yellowish brown mica, the old Indian's gold! We then ascended Black river as far up as range line XII–XIII of the township of Brandon. Thence, we portaged across to Lake Matambin which we surveyed, and then descended the river Matambin to Lake Maskinongé. Around Lake Matambin are ledges of brownish grey gneiss and grey mottled yellowish quartzite, micaceous where the banding is distinct.

"Matambin river is very crooked and is of very little geological interest, as it shows only one small exposure of dark hornblendic gneiss from its head to its mouth.

" At the south-eastern end of Lake Maskinongé there are exposures of about 300 feet wide of a fine-grained reddish gneiss, much broken, reddish weathering and cut in different directions by irregular veins of reddish coarsely crystalline quartz-felspar and chlorite rock. More exposures of brownish grey and grey very highly quartzose gneisses can be seen on the west shore of the lake from about a mile and a-half south of Matambin river; the foliation is very indistinct, but in some places it was distinct enough to determine the strike as S. 31° E. with easterly dip. About a quarter of a mile from these gneisses are ledges of a reddish brown, fine-grained, compact, highly felspathic rock. This extends to a cliff of about 150 feet high and about 700 feet long, composed of much twisted and mixed quartzose felspathic hornblendic and micaceous gneisses. These and the above described rocks are the only ones seen on Lake Maskinongé, the shore of the northern part being low and sandy, and the rest of the southern shore covered with boulders.

"" The survey and examination of Lake Maskinongé being completed, we ascended the Mastigouche river for a distance of fourteen miles. We then made a portage across the mountains to Lac à la Chute, two miles and a-half north-north-west. From the mouth of the river up to the portage there are many ledges of various kinds of gneiss to be seen dipping approximately S. 35° E. $<$ 25°. About a quarter of a mile from the mouth of this river there is a small exposure of a greyish quartzose calcareous rock, containing much white calcite in places and full of iron pyrites and rounded grains of a light green mineral (pyroxene). Hills of gravel and sand, 10 to 60 feet high, occur in places along this distance. Mastigouche river is very rough from the portage road above mentioned to Lac à la Chute. There are nine falls one after the other in this short distance. All the rocks are varieties of gneiss. Traces of magnetic iron ore occur in places, and in others large crystals of brittle black mica. The Mastigouche river was surveyed for about 20 miles north of Lac à la Chute before taking an easterly direction through a chain of small lakes which led us to two lakes, one being the head of the east branch of the Mastigouche, and the other the head of the west branch of the river Du Loup. These two lakes are separated by a band of gneiss only about 25 feet wide, and therefore the watershed portage was easily crossed. The country comprised between Lac à la Chute and 'Lac Sans Bout,' which is a few miles south of 'Lac au Sorcier,' is very poor both in timber and soil. The land is swampy and stony; scrubby spruce growing on rocks coveredwith very little decomposed vegetable matter and wet moss-covered surface gives the country a very uninviting appearance. From 'Lac Sans Bout,'

which is about six miles long, we proceeded to 'Lac au Sorcier,' and then down the river Du Loup, which was surveyed to its mouth. The timber in the neighbourhood of the two last mentioned lakes consists of spruce, tamarack, a few pines and scrub cedars, and is the best seen on all our route. The river Du Loup is very rough, and its bed is generally covered with immense blocks and boulders of gneiss. Good exposures of gneiss are often met with, and the rapids and falls there are on this stream from its head to a few miles below Hunterstown are too numerous to detail. At about 22 miles south of 'Lac au Sorcier' there are very fine exposures of grey gneiss, showing a much contorted banding, but with a general dip of S. 20° E. $<$ 20°. At Hunterstown there is a band of whitish grey micaceous limestone, about five feet wide, interstratified with the gneiss. No ledges of rocks newer than Laurentian can be seen on the river Du Loup. Fossils were collected from the following places: Chicot river, north of St. Cuthbert, Fafard's quarry, Defond's quarry and McGee's quarry, all close to one another, in the parish of St. Cuthbert, from Barrette's quarry in the parish of St. Barthélémi, Gagnon's quarry in the parish of St. Justin, and from many other places.

"The Canadian Pacific branch railway, from Joliette to St. Gabriel de Brandon, was surveyed, and also many roads, so as to fix the boundary of the Palæozoic rocks and define as well as possible the different formations of the Cambro-Silurian, but the country being so much drift-covered, it is very hard, if not impossible, to do so accurately.

"A pretty good deposit of bog iron ore was observed in the county of Joliette, along the railway. The Canada Iron Furnace Co., of Radnor, began to work this deposit last July, and their foreman informed me in September, 1891, that he thought he would be able to ship about 200 car loads of the ore to the blast furnace in Radnor by the fall.

"Prospecting for gold in the Laurentian system, in the county of Joliette, has been going on for years, and there was quite an excitement created in the town of Joliette last summer about a gold mine having been discovered along the Brassard or Mattawin road at a place called 'La Barrière,' in the unsurveyed portion of the township of Courcelles. This place was opened and worked by a company styled: 'Compagnie des mines d'or de Mattawin.' In the report of the Commissioner of Crown Lands of the Province of Quebec for the year 1890, Mr. Obalski, the Government mining engineer, speaking of it says:

"'From the latter property, several samples taken by myself in a small vein a few inches wide, were assayed by Messrs. Ladoux & Co.,

New York assayers, and while two of the samples gave no traces of gold, a third gave the following result:—

Gold, 1·83 oz. per ton of 2,000 pounds.
Silver, 2·65 oz. do

"I collected samples from the mine and Mr. Obalski was kind enough to give me some of the quartz of which Messrs. Ladoux & Co. report so favourably, and these samples were given to Mr. Hoffmann, chemist to the Geological Survey, to analyze and were found by him to contain only a trace of gold and no silver.

"I returned to Ottawa on the 6th of November, having during the season surveyed 315 miles of rivers, lakes and roads, viz., 215 miles of rivers and lakes by micrometer and 100 miles of roads by pacing. Expenditure for the season, $806."

Professor Laflamme was requested to make an examination of certain portions of the north-west shore of the St. Lawrence, between Malbaie and Tadousac with a view to revise and complete the delineation of the geological formations in that district. On this work Professor Laflamme reports as follows:—

"The Cambro-Silurian formations, so often seen in contact with the Archæan rocks along this coast, are generally extremely contorted. There are nearly everywhere traces of displacements and overturnings, in which respect they differ widely from the same formations as found in the neighbourhood of Quebec and Lake St. John.

"It seems to me that these perturbations, the complicated positions of the beds, the numerous fractures met with on all sides, might well have something to do with the slight earthquakes which occur generally several times in a year in this part of the country.

"From statistics which I have collected on the spot, these seismic phenomena have at present a tendency to diminish in intensity and violence. Yet it is quite probable that the maximums may recur from time to time, at intervals, which it is almost impossible to determine precisely.

"Observations on the earthquakes, as gathered from the inhabitants, are too divergent and contradictory to give any assistance in locating the centre or centres of disturbances.

"The only mineral of economic importance met with during the exploration is limestone. It is used for lime and for building stone. I have already mentioned in my last year's report the sandstone of Malbaie, which furnishes excellent building material.

"The limestone which occurs as a band of greater or less width along the coast disappears completely two or three miles below Malbaie, Thence to Tadousac, nothing but steep banks of Laurentian granite are met with. The general aspect of the country is absolutely the same as along the Saguenay shore, and the mineral composition of the rocks in both places is identical.

"At the request of a number of persons I have examined certain deposits of minerals which were thought to be of value. Unfortunately, none of them realized the hopes conceived of them."

Mr. Low, assisted by Messrs. H. Y. Russel, B.A.Sc., A. A. Cole, B.A., and J. B. de Boucherville, B.A., was engaged during the past summer in working out the geology, and in correcting and extending the topography of that part of the N.W.¼ sheet of the Eastern Townships map between its eastern boundary and the St. Maurice river, comprising the southern portions of the counties of Champlain and Portneuf.

Mr. Low left Ottawa on the 9th of June, and was joined in Quebec by Mr. Russel, where a few days were spent tracing plans in the Crown Lands office and in examining the rock sections on the north side of the city. The boundary of the anorthosite area which extends eastward from behind Chateau Richer to beyond Ste. Anne de Beaupré, was traced to the limits of the N.E. sheet of the map. Men having been engaged the party proceeded to Rivière à Pierre station on the Quebec and Lake St. John railway, and there separated, one party, under Mr. Russel, to make pace surveys of the roads already mapped and chain surveys of new roads; and the other party, consisting of Mr. Low and two canoe men, to examine the rocks along the principal water courses.

The Batiscan river was first descended from Laurentides station to its mouth. The rock exposures along the river are numerous to within three miles of Ste. Geneviève where the country becomes low, and the river banks are cut out of deposits of stratified clay and sand.

Along the upper part of the river the rocks are tilted at high angles, and are much contorted both on dip and strike; but throughout the part below Nôtre Dame des Anges the dips are quite moderate and are almost always towards the east. At Nôtre Dame a large area of massive quartzite is seen, having a breadth of over one thousand yards; this passes gradually into a light coloured quartzose mica gneiss on both sides. Quartz veins penetrate the quartzite and hold large crystals of a light coloured mica, along with black tourmaline and hornblende. A small crystal of apatite was also found here. Some of

the mica is large enough to be of commercial value, but is often considerably crumpled. The St. Maurice river was next examined from the Grandes Piles to its mouth. The rocks here were found to be like those of the lower part of the Batiscan river inclined at low angles towards the east. The gneisses have a more basic character than those to the eastward, and in many places ilmenite or titanic iron ore is a constituent mineral. This is generally found in small grains disseminated through the rock, but at times is found in larger masses, chiefly in pegmatite veins. White and red crystalline limestone occurs in small bands or veins in several places near the Petites Piles; it is rendered impure by a large mixture of green pyroxene and yellow mica.

The next exploration was from Lake Edward to the St. Maurice river, coming out on that stream at La Tuque. This journey was made by an old overgrown portage route which leaves Lake Edward on its west side opposite the Grand Island, traversing five small lakes on the headwaters of the Petite Vermilon river and five others on the Petite Bostonnais river into Little Wayagamack lake, and thence by Lake Wayagamack and the latter river into the St. Maurice, some three miles below La Tuque. The Wayagamack lakes are fine bodies of water, the smaller having a shore line of nine miles, the larger of twenty-six miles; both lakes are surrounded by fine wooded hills, and their clear water is full of large trout.

From La Tuque, the St. Maurice river was descended to the Grandes Piles; numerous bands of white crystalline limestone were noted at different points along the river occurring in a basic ferruginous gneiss. The largest mass of this limestone is found in the second range in the township of Polette, two miles inland from the river; here the exposures show a development of white limestone over four hundred yards wide which is said to extend inland some three miles further. Much of this limestone is fine-grained and free from impurities, while the remainder is coarser grained and holds reddish mica, green pyroxene and traces of graphite. Crystals of mica are said to have been found here, but no specimens of it that would be of economic value were seen.

On a point about one mile above the mouth of the Mattawin river is a large vein of dark red pegmatite holding masses of magnetite, the only known locality in this region of such ore free from titanic acid.

The next canoe trip was taken through lakes Long and Mekinac, the last being a fine body of water some fourteen miles long with perpendicular cliffs on the east side, rising in places six hundred feet above the lake. Its water is clear and very deep, as a chance sounding gave two hundred and sixty-five feet. The cliff on the east side gives

an almost uninterrupted section, which shows the gneisses to be arranged in a series of folds, with high dips to the westward and low ones towards the east. A few small veins of crystalline limestone were seen near the axes of the anticlinals. The discharge of Lake Mekinac was followed to its discharge into the St. Maurice river. On the north side of the Mekinac river and along a tributary flowing out of Trout lake, large masses of iron ore have been found in a dark greenish red gneiss composed chiefly of orthoclase and epidote, but as all the ore yet found contains a large percentage of titanic acid it is practically of no value. Similar ore is found in a large quartz vein, on the west side of the St. Maurice river, about seven miles above the Grandes Piles and near Lake Bouchard, in the Seigniory of Radnor, also in the township of Shawenegan, and about the lakes of the Laurentide Fishing Club. In the vein at Lake Bouchard a small mass of apatite was found associated with the iron, mica and pyroxene.

On the 6th of August the road surveys having been completed, that party was disbanded, Messrs. Cole and Boucherville returning home and Mr. Russel joining in the canoe work.

The Black river was explored from the crossing of the Quebec and Lake St. John railway as far as its junction with the Ste. Anne river, and then a trip was made from Lake Edward to Lake Batiscan by way of the Lac des Passes route, the return journey being down the Eclair river, the discharge of Lake Batiscan.

The rock sections along the new line of railway from Rivière à Pierre to St. Tite junction were next examined and were followed by a canoe trip through lakes Long Masketsy and Roberge to the headwaters of the Eaux Mortes river, which was descended to Lake Mekinac; thence a portage route was followed through Trout, Sleigh, Castor and Batiscan lakes to the St. Maurice. The remainder of the season was taken up visiting the mineral localities of the region and in a short trip up the Jacques Cartier river for a more detailed examination of some of the rocks exposed in the adjacent country.

At Lac Tortue the Canada Iron Furnace Company have lowered the water of the lake some four feet, and as the lake is very shallow with slightly sloping banks, a large area is laid bare around its edge, and here the bog-iron ore which has been formed in the lake as flat concretions is washed out of the surface mud with hand sieves, while the ore in the deeper part of the lake is raised by a dredge which carries three rows of buckets on an endless belt.

Apart from Lac Tortue, in all the flat country about Three Rivers on both sides of the St. Lawrence, bog-iron ore is found in patches which vary from three to eighteen inches in thickness. The ore is

gathered by the farmers from their lands, and brought in and sold at the furnace. As iron smelting has been in operation about Three Rivers since 1737 the supply of ore in the vicinity is somewhat exhausted, but new supplies of great extent have been found about Gentilly, opposite Three Rivers, and along the Joliette branch of the Canadian Pacific railway, so that enough ore will be forthcoming to run the new furnace at Radnor which will have a capacity of thirty to fifty tons a day, smelting magnetite from St. Jérome along with the bog ore.

Ochre is a common mineral in this part of the province and is at present worked in two localities at St. Malo, eight miles from Three Rivers, and at St. Tite junction on the Piles Branch railway.

At St. Malo the deposit has been proven across twenty-two lots and in width from one hundred to three hundred yards, with a depth from one to twenty feet. At St. Tite junction the ochre occurs in two gulleys which join, and run into the St. Maurice; the ore has been proven along both gulleys for nearly half a mile and has everywhere a considerable thickness.

The St. Maurice Metallic Paint Co. and the Johnson Paint Co. have furnaces for burning the ore at St. Malo, the former grinding the burnt material at Cap Magdeleine near Three Rivers, the latter at Montreal. At St. Tite junction a furnace and grinding mill are in course of erection by the Radnor Paint Co. During the summer upwards of five hundred and fifty miles of canoe exploration was accomplished in the northern portion of this region, together with eighteen miles of chained and four hundred and eighty-three miles of paced survey along the roads of the settled southern area. Total cost of the exploration $1,414.06.

Mr. Robert Chalmers left Ottawa on the 6th June for New Brunswick with instructions to continue the detailed survey and mapping of the superficial deposits in the counties of Westmoreland, Kent, Albert and Northumberland, and the investigation of the glacial phenomena connected with these deposits. The following is his report on the progress of this work :—

"The maritime parts of this area have now been pretty thoroughly studied. But the district drained by the south-west Miramichi river requires further exploration, especially that portion lying to the west of the main river, and another season's work will be necessary to complete the whole.

"A great part of the area examined is level or slightly undulating, but in Albert county it is hilly and broken. Around the head of

the Bay of Fundy the surface is diversified by ridges which attain a height of from 200 to 400 feet. Between these, tongues of salt marsh extend up the valleys. These marshes are a characteristic feature of the scenery.

"The surface geology of this part of New Brunswick is of profound interest; and the glaciation of the isthmus of Chignecto, in its relation to that of the mainland of New Brunswick and of Nova Scotia, is of special importance. The facts when studied in detail will, in my judgment, show the action of floating as well as of land-ice. On the site of the marine railway, now under construction across the isthmus, and along the New Brunswick and Prince Edward Island railway, the exposed ledges exhibit striæ varying from S. to S. 50° W. (true meridian). These have been produced by ice moving across the isthmus from the north-east. And as no high land exists in that direction nearer than Labrador or Newfoundland, the hypothesis of their having been caused by floating ice during the Pleistocene subsidence of the land here seems a reasonable one. This view is supported by the facts respecting the glaciation of the higher grounds on both sides of the isthmus. In Eastern Albert and in Westmoreland and Kent counties, N.B., the striæ indicate ice movements directly towards the Bay of Fundy and Strait of Northumberland, while in Cumberland county, N.S., the land-ice appears to have moved down the slopes westwardly towards the open Bay of Fundy, or Pleistocene sea, then forming a strait between New Brunswick and Nova Scotia. On the whole, the district is one offering special advantages for the study of the relative movements of land and floating ice.

"An increased interest was given to the study of glacial phenomena and Pleistocene changes of level by the visit in October of Baron G. de Geer, a member of the Geological Survey of Sweden, who is actively engaged in similar investigations for that survey. He made special investigations in New Brunswick respecting the height of the Pleistocene shore line, or, as he terms it in Scandinavia, the 'marine limit,' and by independent measurements made at St. John, Moncton, Bathurst and Dalhousie junction he found that this limit of the marine beds, as laid down by me, is approximately correct. The hypothesis that the Pleistocene upheaval was greater in New Brunswick than in Nova Scotia was sustained by observations made by Mr. Wilson and myself later on. East of Nappan river, N.S., we discovered a well-defined shore line 135 feet above high tide level and traced it upwards of four miles. The importance of this Pleistocene 'marine limit' lies in the fact that when the land was at this level (viz., 225 feet at Moncton, N.B., and 135 feet at Nappan, N.S., lower than it is at the pre-

sent day), the Bay of Fundy would be connected with the Straits of Northumberland, and, consequently, those parts of the isthmus of Chignecto on which striæ are found would be submerged to a depth sufficient to allow floating ice to pass over them.

"A discovery of some importance made by Mr. Wilson was that of marine fossils in the boulder-clay at Negrotown Point, St. John Harbour. The deposit was also examined by Baron de Geer and myself.

"The recent and stratified deposits of Westmoreland and Albert counties are varied and interesting, and those of tidal origin, viz., the salt marshes, are unique. These marshes comprise, in Westmoreland and Albert counties alone, an area of 35,000 acres, and have long been noted for their fertility. Of late years, however, they have deteriorated. This remark applies more especially to those portions which have been dyked and cropped continuously for a century or more, without the application of any fertilizing material to the soil, which has, in consequence, become deficient in plant-food. Lime and wood ashes have been recommended; but improving them in this way is slow and expensive. A scheme inaugurated by the more intelligent farmers of Sackville would, if systematically carried out, be more effective and economical, viz., the cutting away of portions of the dykes and aboideaux and flooding the marshes with the tidal waters of the Tantramar and other rivers, which flow through them. The tides, which rise high enough to overflow these marshes, if the dykes were broken, carry in red mud and deposit it on their surface. This is an admirable fertilizer, its efficiency having been abundantly proved by the experience of the Sackville farmers. This system of improving them will probably be adopted by all the owners of exhausted marsh lands around the Bay of Fundy. It seems the natural method of restoring them, partially at least, to their original fertility.

"The depth of the marsh mud is variable, but increases seaward. Immediately underlying it is a layer of fossiliferous blue clay, which rests on a peat or forest bed. At Aulac, Intercolonial railway, the latter attains a thickness of 20 feet, and is overlain by 80 feet of marsh mud. These marsh and peat beds indicate, therefore, a subsidence of the land here within the recent period of about 80 feet. Intelligent observers inform me that the peat or forest bed is continuous or nearly so, throughout, underlying the salt marshes everywhere.

"In reference to the soil on the higher grounds, it may be stated that the eastern part of Westmoreland county comprises some of the best agricultural lands in the province. Along the Petitcodiac river there are also fine farming tracts. On the Millstone Grit area, how-

ever, the soils are deficient in lime, and would be much benefited by frequent applications of it.

"In Westmoreland county, the forest growth is recent, except in a few limited areas. The more extensively wooded portions of Albert and Kent counties are, however, covered by the original forest, which still contains large spruce, hemlock and hardwood trees. In the last-mentioned county, forest fires are rapidly destroying the timber tracts.

"The materials of economic importance found in the surface deposits of the district examined may now be briefly referred to.

"Bog-manganese occurs in Albert county,' near the Dawson settlement. On a branch of Meldona creek, an extensive bed of it has been opened up, and a branch of the Albert railway constructed to it. Kilns for drying the material have also been erected. This deposit covers about 25 acres of ground, and appears to be quite thick—in one opening the thickness being 26 feet. The ore is a loose amorphous mass, which can readily be shovelled up, and contains, in layers and patches, a considerable percentage of bog-iron ore, or red ochre. Indeed, very little of the material appears to be wholly free from iron, though large portions have merely a trace of it. The deposit lies at the foot of a hill, and its accumulation there appears to be due to springs. These are still running down the hillside, and, doubtless, the process of producing bog-manganese is still going on. Operations have temporarily ceased at this mine. Indications of other and similar beds of bog-manganese have been met with at the base of this hill further west.

"Bog-iron ore was found on the south side of Buctouche Harbour, Kent county, occupying an area of several acres. Where openings were made in two places, the deposit showed a thickness of from 12 to 15 inches.

"Just south of Richibucto Head, another deposit of this material was observed, but its extent and thickness was not ascertained. Bog-iron ore was also noticed on the south side of the mouth of Kouchibouguac river by Mr. Wilson, and in a number of other places. No use has yet been made of it.

"Peat bogs occur at Richibucto Head inside of the sand beaches, also along the Kent Northern railway above Kingston. Two bogs were seen along the Intercolonial railway between Berey's Mills and Canaan stations. Smaller peat bogs were noted on the isthmus of Chignecto, and in numerous other places.

"Brick kilns are in operation at Lewisville, near Moncton, and at Folly Point, Westmoreland county, deposits of brick clay are common in many parts of the district.

"Gravel pits have been opened at Albert, on the Albert railway; at Memramcook (gold is reported to have been found in the latter); at Westmoreland Ridge, near Aulac, and on the Kent Northern railway, near Mill Creek, gravel and sand deposits are quite abundant in the district.

"My assistants during the season were Messrs. W. J. Wilson and W. D. Matthew, of St. John, N.B. Mr. Wilson, who has assisted me during part of four seasons, was in the field from the 1st of July to the 15th of August, and from the 14th of October to the close of field work, on the 20th November. Mr. Matthews was with me from the 15th of June to the 24th of July. Both these gentlemen performed their duties in every respect most satisfactorily. Mr. Wilson and I reached Ottawa on the 2nd of December, and he is now assisting in the preparation of the maps for publication."

The cost of the season's work, including the salaries of Messrs. Matthew and Wilson, to the 15th of August, is $957.02.

Mr. Fletcher was instructed to continue the work of previous years in Nova Scotia. He left Ottawa for the field on the 17th of June and returned on the 15th of December. He was again assisted, during the entire season, by Messrs. M. H. McLeod and D. I. V. Eaton, and during several months by Professor Coldwell and Messrs. W. B. Almon and F. A. Coldwell.

Mr. Eaton, who was for some days employed in tracing and reducing plans in the office of the Iron Company at Londonderry, and in the Crown Lands Office at Halifax, did not reach Ottawa until the 24th of December.

Mr. Fletcher's summary of the season's field work is as follows:—

"The observations and surveys during 1891 were chiefly in the counties of Colchester and Cumberland, in the districts of Onslow, Londonderry, Economy and Parrsboro', north of Cobequid bay and Minas basin, comprising an area of about 500 square miles.

"The head of Cobequid bay presents many thousand acres of dyked marshes under excellent cultivation and the upland also is fertile. Numerous thriving, pretty villages dot the low shore as far as Economy, below which the scenery is strikingly wild and picturesque, and the coast is well known to collectors for the abundance and beauty of the rare minerals found in its trap formation, no part of the world except the trap district of India being, according to Professor Marsh, richer in zeolites than the shores of the Bay of Fundy. The mountains are for the most part under forest except in small settlements or where

tracts have been cleared in the neighbourhood of the Londonderry mines to furnish charcoal for iron smelting.

"The geological formations are the extension of those described in the Summary Reports for 1889 and 1890, comprising Triassic, Carboniferous limestone, Devonian and igneous rocks; and the additional evidence collected greatly strengthens the views expressed in those reports regarding their relations to one another.

"Red, soft, crumbly Triassic sandstone fringes most of the shore as far as Five Islands, below which it is only in small patches where protected from the fury of the tides—which rise to a height of 50 or 60 feet, with currents running eight miles an hour—by imposing precipitous capes and islands of basalt and amygdaloid built up in fine symmetrical columns or worn into deep caverns, pointed arches and lofty pinnacles.

"The Carboniferous limestone appears in the rivers or on the shore at several points between the head of Cobequid bay and Economy. From Swan creek to the mouth of Parrsboro' river it rests in small patches upon Devonian rocks and the unconformity of these two series is well displayed; the former having the usual association of dark grey and red soft marl, sandstone and conglomerate with gypsum and fossiliferous limestone, while the latter consist of crumpled slates and quartzites, cut by igneous dykes, and by veins of limonite, ankerite, quartz, &c., but full of fossil plants and *Naiadites*. From another unconformable contact immediately west of Partridge Island, the Carboniferous limestone rocks occupy most of the shore as far as Port Greville, presenting remarkably fine illustrations of contorted and faulted strata, some of which have been greatly disturbed without affecting the beds above and below. Among these is a band of coaly bituminous shale, two feet thick, full of fossil plants, Crustaceans and *Naiadites*. Another belt of this formation extends from Phinney's brook to Spencer's island.

"The Carboniferous limestones have been quarried near Partridge island and at Clarke's Head. At another quarry at Kirkhill, two miles and a half north-west from Parrsboro', a dark grey flaggy limestone, in a nearly vertical attitude, includes lenticular layers of coal, one of which is said to attain a thickness of two feet at the bottom of a shaft 75 feet deep. The coal ignites readily, burns with a bright flame, leaving a light porous coke which yields a quantity of whitish or reddish calcareous ash. Another deposit of from two to four feet of slaty coal at Brookville was examined in 1878 by Mr. Scott Barlow. It has been opened by several pits in De Wolf brook, a short distance up stream, in a conglomerate composed of pebbles of the slates and quartzites of the adjoining brooks and of the shore, interstratified

with layers of soft argillaceous shale fit for whetstones and whitish quartzose sandstone. Other unimportant discoveries of coal have been made in the East River of Five Islands, Great Village river and other streams.

"The Devonian rocks are precisely like those of Riversdale, Union, Stewiacke and the coast of Hants county, described in the Summary Report for 1890. Sir Charles Lyell in 1843, while including the beds on the Shubenacadie river with the Carboniferous limestone formation, states that in five cases where Sir J. W. Dawson and he traced the junction, they found it to be a line of fault, and at the point of contact one face of the fault was in every case formed of gypsum. He further states that this is not in a rent or fissure, but seems to belong to the stratification which is nearly flat. In the Cobequid Hills, and also at some points on the shore, the Devonian rocks are intersected by masses of syenite and diorite. They come from beneath the Lower Carboniferous, on the shore between Moose creek and Partridge island, and again between Port Greville and Phinney's brook, where they are associated with a mass of crystalline limestone, apparently a vein. The iron ores of Londonderry—which give employment to 150 miners, and yield annually about 40,000 tons of ore—of Portapique and North rivers, of Birch Hill and other places, are also in these rocks as well as the veins of quartz, baryta, limestone and dolomite of Londonderry, Five Islands and Phinney's brook; while the asbestos (fibrous hornblende) of Lynn and Harrington river, and the altered diorites or serpentine, and the felsites of New Prospect occur among the associated igneous rocks.

"In addition to the fossils mentioned last year as having been obtained from the Economy river, in the neighbourhood of the gold (?) mine of Peleg brook, numerous stipes of ferns resembling, according to Sir J. W. Dawson, *Aneimites acadica* of the Lower Carboniferous, were found among the dark slates of Murphy brook.

"The newer or Triassic series of igneous rocks has attracted attention from all who have visited this district, and many of the contacts with the Triassic sandstone and other rocks have been minutely described. Along the line of junction the two are intimately mixed and angular masses of both are cemented into a sort of breccia passing into amygdaloid with cavities filled with zeolites. The amygdaloid contains magnetic iron ore in masses and veins one foot wide and under, exceedingly irregular in their course, and often terminating abruptly, so that little dependence can be placed upon them for mining although the ore is very rich. Of this nature are the iron ore deposits of Gerrish Mountain, Cape Sharp and Cape d'Or. Native copper and ores of this

metal and traces of manganese ores are also found in the trap. Collections of its characteristic minerals may be made from veins, nodules and geodes at Five Islands, Two Islands, Wasson's Bluff, Partridge Island, Cape Sharp, Spencer's Island, Cape d'Or and other places. The minerals referred to comprise amethyst of great beauty and brilliancy, moss and fortification agates of rich colours and varied surface, red and yellow jasper, pure white chalcedony of very fine texture and smooth surface, well adapted for cameos and other ornaments, and sometimes curiously zoned or marked with stripes of different shades of colour; calcspar in rhombohedrons or of the dogtooth variety; zeolites, including stilbite, heulandite, analcime, laumonite, thomsonite, chabazite and other species in beautiful crystalline aggregations or in perfect distinct crystals. Asbestos in small seams is found at Blue Sack.

"At the mouth of Fox river is a bank of fine sand, and great accumulations of drift sand, gravel and clay occur in this region."

The expenditure on the season's explorations, including the salaries of all assistants, was $1,430.66.

Mr. Faribault continued and made good progress with the very excellent detailed work he is doing in mapping the structure of the gold-bearing rocks on the Atlantic coast of Nova Scotia and on which he furnishes the following report and interesting remarks. Personal observation enables me to concur in the opinion he expresses both as regards the correspondence of the Quebec gold-bearing rocks with those of Nova Scotia, and also as regards the position of the rich leads and their relation to axial folds. The latter, if correct, must prove of the greatest practical importance if intelligently applied in the further development of gold mining in Nova Scotia and also in directing prospecting for veins in the alluvial fields in Quebec.

"On the way to Nova Scotia, I took occasion to visit the Little Ditton gold district in the Eastern Townships of Quebec, with the view of comparing the Lower Cambrian rocks there with the auriferous series of Nova Scotia. Like all those who have examined both localities, I have no doubt that these auriferous rocks are of the same age. The Little Ditton rocks like those of Nova Scotia may be divided into two distinct groups, a lower or quartzite group and an upper or graphitic ferruginous slate group. They present the same lithological character as the two groups in Nova Scotia, and there are good reasons to believe that the gold of the Ditton alluvial deposits is derived, as in Nova Scotia, from numerous quartz veins which run along the sharp anticlinal axes into which these rocks have been folded. Although a great deal may be expected of the deep deposits of the old rivers which

have not yet been worked, the future of the gold mining industry in Quebec must as elsewhere lie in the working of the solid veinstone.

"The section surveyed this season in Nova Scotia lies westward of that surveyed in 1889 and 1890, and extends along the sea shore from Porter's lake to Halifax harbour, and northerly to the Shubenacadie and St. Andrew's rivers, covering an area of 305 squares miles in Halifax county and 70 squares miles in Colchester county. Besides this, Mr. Eaton surveyed 130 miles of roads in Hants county to be used as tie-lines in next year's contemplated work.

"The greater part of the region is occupied by the auriferous Lower Cambrian rocks cut by the western end of the belt of granite examined last year which extends to within two miles east of Waverley, and also by a small granite mass three miles north of Waverley. In the northern portion, the gold-bearing rocks are overlain by the Lower Carboniferous formation along the valleys of the Shubenacadie, Gay's and St. Andrew's rivers and a few of their tributaries.

"Two or three beds of dolomitic limestone from six inches to four feet thick were found at various places at the bottom of the upper graphitic ferruginous slate group, between layers of greenish talcose slate. These beds may contain fossils, but search made for them has so far proved unsuccessful.

"The anticlinal axes were minutely examined and traced, as in former years, on account of their close relation to the auriferous belts. Within the region examined, the geological structure of the gold district of Lawrencetown, Montague, Waverley and Oldham was carefully studied. Lawrencetown has been but little worked. The yield of the three other districts has been as follows :—

Districts.	Yield for 1890.	Total Yield from 1862 to 1891.
Montague	2,263	32,581
Oldham	2,775	41,242
Waverley	403	53,874
Total in Nova Scotia...	24,358	506,675

"Special attention was given to the gold district of Oldham, it being a typical district, worked to a great extent and exposing to great advantage the quartz leads, all of which were prospected by means of surface trenches on account of the small thickness of the drift. A detailed geological map of this district, on a scale of 500 feet to one inch, with sections, was compiled on the ground. It shows the elliptical structure of the anticlinal fold, with all the known quartz veins, both interbedded and transverse, and also the numerous faults affecting them, and proves clearly that the richness of a lead depends altogether

on its position and relation to the structure of the elliptical dome of the fold to which it owes its origin. In this work I am specially indebted to Mr. J. E. Hardman, B.Sc., M.E., manager of gold-mining properties in Oldham and Waverley, for much valuable information which his great experience in gold-mining enabled him to give.

"Auriferous leads have also been prospected at Elmsdale, South East Passage, and other places along anticlinal axes; and traces of antimony ore are reported to have been found at Wyse's Corner.

"Some facts which have an important bearing upon the question of deep mining, may here be introduced, in view of the great interest taken at present by the mining community in the subject. From a study of the districts east of Halifax, and especially of that of Oldham, it is plain that whenever an interbedded lead is followed some distance on the surface, or to great depths, its relation to the axis of the anticlinal, and consequently to the stratigraphy of the fold, is constantly changing, and its size and workable value must consequently be affected; so that it is improbable that a lead found rich and of good size on the surface can be followed profitably to great depths. The limit of depth may vary from a few feet to 400 or 800 feet according to the structure of the anticlinal fold, the position of the lead and the extent to which it has been denuded. The problem of deep mining seems thus to depend on the location of a zone of rocks containing the parts of the leads which are of sufficient richness, because they keep the same relative position to the axis of the anticlinal. In most of the districts the zone of rich leads has the anticlinal axis for its centre, and it is probably the centre of the auriferous zone to a depth practically unlimited. Such is the case in the eastern part of the province, at Seal Harbour, Isaac's Harbour, Goldenville, Harrigan Cove, Salmon River, Fifteen Mile Stream, Killag, Mooseland, Moose River, Caribou, Gold River, Lawrencetown, Waverley and Oldham. In the few other districts where the auriferous zone is worked only on the north or south side of the anticlinal, the zone would, for the same reason, be parallel to the axis of the anticlinal to an inaccessible depth, as in Isaac's Harbour, Wine Harbour, Beaver Dam, Tangier and Lake Catcha.

"I would, therefore, strongly recommend that deep perpendicular shafts be sunk on the anticlinals, and that cross-cuts be driven on both sides at various depths to test leads which do not crop out to the surface, many of which would probably prove very rich, as they would be cut in their most favourable stratigraphical position and could easily be worked by means of levels and overhead stoping from the cross-cuts and the one perpendicular shaft. This system might be adopted with advantage at the North Star property of Isaac's Harbour, at Golden-

ville, where both sides of the anticlinal have been worked from 500 to 600 feet deep and abandoned, but the middle of the auriferous zone has never been tried; at Fifteen Mile Stream, in the vicinity of the Serpent lead; at Moose River, where Mr. D. Tonquoy has his main shaft; at Waverley, on the east and west side; and at Oldham, west of the Black brook. No such systematic workings have, however, yet been undertaken in Nova Scotia, that I know of, except in Oldham, where Mr. J. E. Hardman began last summer to sink a perpendicular shaft on the anticlinal dome. The result of his undertaking is awaited with great interest.

"The pay streak of the leads in different districts is also a subject of great importance to miners, but, unfortunately, the data necessary to draw conclusions are very meagre, as in most of the mines, especially in old workings, no systematic records of the yield of different parts of the leads have been kept. I hope, however, to be able to throw some light on the subject from the notes I have gathered this summer.

"The materials of economic importance met with in the Lower Carboniferous comprise chiefly unexhaustible and valuable deposits of limestone and gypsum. One belt of fine grey limestone at Gay's River Corner carries a good percentage of argentiferous galena; it runs east and west, rests unconformably upon the lower quartzite group, was worked some years ago where the south-west branch of Gay's river crosses it, and also prospected last summer at Carroll's corner, where some mining areas were taken up.

"The gold district of Gay's river was reopened last spring by the Cole Stream Gold Mining Company, who put up an extensive 50 stamps steam mill and other large buildings. They sank a shaft, immediately north of Daniel McDonald's old works, which gave the following section of the Lower Carboniferous:—

	Feet.
Surface drift	20
Conglomerate containing gypsum, non-auriferous	35
Coarse sandstone	2
Auriferous, irregular conglomerate	8

"This lower auriferous conglomerate is wholly composed of debris of the adjacent Lower Cambrian rocks, apparently in an old river bed, and rests on the lower graphitic ferruginous slate group. Beds of conglomerate similarly situated along the northern boundary of the gold-bearing rocks may prove sufficiently rich to be worked, but the great excitement caused two years ago by exaggerated reports of discoveries of gold in various places, remote from the gold-bearing rocks,

have led a great many to take up valueless ground. (See Summary Report for 1890, page 41.)

"The clay deposits on the Shubenacadie river, between Enfield and Shubenacadie railway stations, are well-known for their superiority for brick making, and brick yards have been in operation along the river bank for a great many years.

"Sand from the Dutch settlement is also used in New Glasgow for the manufacture of the best quality of glass and for moulding purposes.

"I was ably assisted, as in previous years, by Messrs. Archie Cameron and J. McG. Cruickshanks, for six months. I had also Mr. D. I. V. Eaton some two months surveying roads, and Mr. Walter C. Adams for two months.

"The season's work extended till 25th December, and the expenditure entailed, including salaries of all assistants, is $1,420."

From the 17th of July to the 1st of October Professor Bailey, assisted by Mr. Lee Street, continued the examination and survey in south-western Nova Scotia which was commenced in 1890, and on this he reports as follows :—

"The earlier part of the season was devoted to the examination of portions of Queen's and Shelburne counties for the exploration of which there had not been sufficient time during the previous season. These include a large part of the district traversed by the Port Medway river ; the Liverpool river from Lake Rossignol to Liverpool ; Fairy lake, Tobeatic lake, Lake Rossignol and the associated smaller lakes ; the Shelburne river, Broad river, the Roseway and the Clyde together with several islands off the coast. Particular attention was also paid, in accordance with your instructions, to the determination of the position and extent of the various areas of granite associated with the Cambrian rocks both along the coast and in the interior of the counties named.

"In the prosecution of this work it was found necessary, in consequence of the very irregular boundaries of the counties, as well as from other considerations, to extend the observations in some instances beyond the limits of Queen's and Shelburne to which they had previously been confined. A portion of the season was accordingly devoted to the examination of those parts of Lunenburg, Annapolis and Yarmouth counties which are immediately adjacent to those last mentioned.

"The results obtained in these explorations, together with those of the previous season, have been embodied in a report which will be immediately submitted. In attempting, however, to prepare a map to accompany this report, great difficulty has been experienced from the great want of accordance shown by the county maps upon which the field investigations are based. Not only do these differ in the position of lakes and rivers, and show numerous omissions, but even the same county lines upon adjoining maps, such as those of Shelburne and Yarmouth, though drawn upon the same scale, differ widely both in length and direction. Large tracts have, indeed, never been surveyed, and there does not appear to exist at present any materials from which anything like an accurate topographical map of the region can be constructed. The roads in the several counties which have been measured by odometer are fairly accurate, but a certain number of tie-lines, at least, are required to check the latter. Such maps as could be constructed from the data available will be submitted with the report."

Work under the division of Mineral Statistics and Mines was continued by Mr. E. D. Ingall, assisted by Mr. H. P. Brumell in the general work of the division, and by Mr. James White, who was engaged in making mining surveys in the iron and phosphate regions near the Kingston and Pembroke railway.

On the progress of the work under his charge, Mr. Ingall furnishes the following notes :—

"During last winter Mr. Brumell and myself were occupied with the usual work connected with the collecting of mining information, statistical and otherwise, for the annual report, and with the compilation and writing up of the same for publication. Besides this the usual preliminary summary statement of mineral production for 1890 was made up and issued in April. As far as the office routine connected with the above work would permit, advancement was made with the completion of a directory of mineral occurrences, and the representation of such occurrences on maps, several of which are now almost complete. In answer to inquiries a number of 'memoranda of information' have been issued, often embodying material the collection of which occupied in the aggregate much time.

"Mr. White has been engaged plotting his surveys and preparing the maps for publication required before the geological investigation of the Rivière du Lièvre phosphate deposits could be completed.

"These maps being available for use, it was considered advisable that I should during the summer, and as far as time permitted, attempt

the further field studies such as to enable a report to be issued embodying the results of these and previous investigations, which had been necessarily interrupted for some time on account of the pressure of other work.

"Before commencing this work, however, an effort was made to publish the annual report several months earlier than usual. All arrangements were made and the field work was set aside for that purpose, but meeting with insurmountable difficulties in connection with the printing, this intention had to be abandoned. The commencement of the field work was delayed until the 12th August, much fine weather was lost, and its continuance was necessitated as late as the 27th of November in order to complete the first sheet of the map of the du Lièvre phosphate district.

"During the above mentioned period the work done was altogether concentrated in the valley of the Rivière du Lièvre. The details of the pyroxenite belt on which are situated the High Rock, Union and other mines, had been as far as possible worked out during previous seasons. Recent developments, however, gave facilities for the extension of this work, and this belt was followed to the northern limits of the map, the High Falls mine.

"Most of the season, however, was spent in the study of the group of mines situated on the Little Rapids belt, and at the Emerald mine, all of which had necessarily received but limited attention before. The Little Rapids belt was traced for several miles with a view to obtain another instance of the continuity of these pyroxenite belts. Special attention was paid to the details of the rock structure, where the extensive and numerous exposures around the workings, gave a chance to accomplish this.

"The phenomena encountered being read by the light of the knowledge of the rocks of the district obtained during past seasons, presented many interesting points which will be set forth in the detailed report.

"During the latter part of the season I received very efficient aid from Mr. M. A. Bucke, who not only made topographical surveys around the mines, but also assisted generally in the geological work and rendered good service in the delineation of the rock areas.

"Owing to the fact that my own time was largely occupied during the summer and autumn in the above mentioned work, the field work connected with the collection of statistical and other information of a general kind, was necessarily intrusted to Mr. Brumell. During the summer he was engaged as in former years.

in visiting sundry mining districts in order to ascertain the extent and condition of the industries at these points. These examinations were principally confined to the provinces of New Brunswick and Ontario, and may be summarized as follows :—

"In New Brunswick the following points were visited and investigations made :—

"Gloucester county.—Development work was being actively prosecuted on a vein of argentiferous galena by Messrs. Payne and Ellis, of Bathurst. The vein is on Rocky brook, a branch of the Millstream. Work had also been done on a deposit of magnetic iron ore in the same vicinity.

"Albert county.—Investigations were made in the southern part of this county, where a considerable amount of prospecting was being carried on, notably around Shepody mountain and to the westward, where on Sawmill creek a bed of mica-schist, said to contain gold, had been opened up. Work was being carried on as in previous years at the gypsum quarries of the Albert Manufacturing Company, at Hillsboro' and E. W. Lynd's, at Hopewell. Operations had ceased at the Crimora Manganese Company's property in Dawson settlement. A small amount of work had been done at Gawland mountain, without, however, sufficiently promising results to warrant further operations.

"King's county.—The manganese property at Markhamville was still being operated, and although smaller quantities of ore were being obtained, active prospecting was being carried on by means of diamond drills. The manganese mine at Jordan mountain was idle. At Namvigewauk prospecting had been carried on to prove the gold bearng character of the conglomerate ridges of the vicinity. This work had been done under the auspices of the New Brunswick Mineral Developing Company.

"St. John county.—A new plumbago property has been opened up at St. John, and a considerable amount shipped.

"Victoria county.—Gypsum quarrying on the Tobique was being carried on as in former years.

"Carleton county.—Apparently fruitless efforts were being made at the Britton mine, Woodstock, in search of the gold and silver promised by several assays made of picked specimens.

"Charlotte county.—Considerable work had been done in prospecting for nickeliferous pyrrhotite on several bodies of which small shafts have been sunk.

"Throughout the province there seems to have been a general revival of interest in mining matters.

"Visits were also made to various parts of the province in search of further information relating to structural materials.

"In Ontario, west of Toronto, visits were made to several central points for the collection of data regarding structural materials, petroleum and salt, as well as to Essex and Welland counties where boring operations in search of natural gas and petroleum were being actively carried on.

"In Hastings county, mining had been commenced by the South South Africa General and Developing Company, on a rich gold property in Belmont township, and on a deposit of magnetite in the same township by the Belmont Bessemer Ore Company of New York. At Belleville unsuccessful efforts had been made to obtain natural gas by boring.

"Mr. J. White's surveys in the Kingston and Pembroke railway district, already mentioned, were continued with a view to illustrating the mineral developments there. To this end it is proposed to make detailed surveys of the chief mines and also the roads and other topographical features serving to show the conditions of economic mining development in the district.

"During the summer, surveys were made of the roads in the northern part of the district with odometer and compass. The principal iron and phosphate mines were mapped, but otherwise the time at disposal and the nature of the country did not permit of any very accurate or detailed topographical work. As the iron mines had been closed for some time, the pits and underground workings were all full of water and any information relating to them had to be gleaned from outside sources. Another season's work will be necessary to complete the information for the map. During the past year no iron ore was raised in the district and but little phosphate, nearly all the mines producing the latter closing down in July and August.

"Mr. White's field work was begun on the 17th of July and completed on the 9th of October."

Since their return from the field, Mr. Ingall and Mr. Brumell have been occupied with the usual routine and with the detail of the office work connected with the material for the Annual Report. Mr. White has been engaged since his return in making additions and corrections to the topographical sheets of the map of the Rivière du Lièvre district, which were rendered possible as the result of surveys made during the summer. The manuscripts of these are now complete, and the engraving of the upper half is nearly finished, so that the topographical edition should be shortly available. The geo-

logical notes for these must await the elaboration of the material resulting from the field studies, but will be proceeded with as soon as possible.

The expenditure for field work in connection with the above surveys and examinations was as follows:—Mr. E. D. Ingall, $772.70; Mr. H. P. Brumell, $771.88; Mr. J. White, $984.96.

Chemistry and Mineralogy.

Reporting on the work of this division, Mr. Hoffmann says:

"The work in the chemical laboratory during the past year, has been carried out upon the same lines as those heretofore followed. It was chiefly confined to the examination and analysis of such minerals, &c., &c., as were considered likely to prove of economic value and importance. The ground covered included:—

"1. Analyses of fuels, comprising a semi-anthracite and coals from various localities in British Columbia, all of which proved to be of excellent quality.

"2. Analyses of mineral waters and brines. Of the former, some of those from British Columbia may not improbably, judging from the results of a qualitative analysis, prove of therapeutic value. Some of the latter belonged to, and constituted the last of, a series of saline waters—the examination of which had been commenced in the previous year—representing all the principal salt-springs on Swan and Winnipegosis lakes in the province of Manitoba, and on the Red Deer river, district of Saskatchewan, North-west Territory. The object of the inquiry was to ascertain if these brines could be advantageously used for the manufacture of salt.

"3. Analyses of limestones and dolomites. In continuation of the series of analyses of limestones and dolomites already carried out in connection with an inquiry into the individual merits of a number of these stones—from various localities—for structural purposes and suitability as a flux in smelting iron and lead ores or as a glass-making material.

"4. Analyses of nickel and cobalt ores. The greater number of the specimens examined consisted of pyrrhotite from various localities in the districts of Nipissing and Algoma, province of Ontario. These were all found to contain a satisfactory percentage of nickel. A pyr-

rhotite from what is reported to be an extensive deposit, in Charlotte county, New Brunswick, was also examined and found to contain 1·72 per cent nickel, 0·16 per cent cobalt, and 0·31 per cent copper. This material closely resembled much of the ore found in the above mentioned districts. Besides these, many other samples of pyrrhotite from other parts of the Dominion were examined.

Reference may, not inappropriately, here be made to certain other nickeliferous ores, the occurrence of which has been pointed out in previous reports of this Survey. One of these, a steel-grey pyritous ore, from the Wallace mine on Lake Huron, contained 13·93 per cent nickel; whilst of two others found on Michipicoten island, Lake Superior, the one, consisting of an intimate mixture of the arseniurets of copper and nickel, was found to contain from 17·03 to 36·39 per cent nickel, and the other, a hydrated silicate of nickel, gave, after drying at 100° C., 23·91 per cent nickel.*

"5. Gold and silver assays of ores from the provinces of Nova Scotia, New Brunswick, Quebec, Ontario and British Columbia. The greater number coming from the last named province.

"6. Analyses of iron ores from the provinces of Nova Scotia, Ontario and British Columbia.

"7. Miscellaneous examinations. These include the partial analysis or testing, as the case might be, of brick and pottery clays, cement-stones, phosphatic rock, graphite, talc, &c., &c. The talc referred to was almost snow-white in colour and would appear to be almost, if not quite, as well adapted for use as a 'filler' in the manufacture of paper, as the talcose mineral found at Edwards near Gouverneur, Saint Lawrence county, in the state of New York.

"In addition to the work included under the foregoing headings, examinations and analyses have been made of several minerals recently met with, and now for the first time identified as occurring in Canada. The more important, from a commercial standpoint, of these are:— Gersdorffite, nickel arsenosulphide, a rich nickel ore from the township of Denison, district of Algoma, and Danaite, a cobaltiferous variety of mispickel, a useful ore of cobalt, from the township of Graham, also in the district of Algoma. These, with some others of more purely scientific interest, add materially to the list of minerals already known to occur in Canada.

"Amongst the many specimens received in the course of the year, were three of more than usual interest, viz., samples of cinnabar ore

* Geology of Canada, 1863. Chap. XVII, XIX, XX, pp. 505-7; 614 and 737-38.

and native mercury from Seshart channel, Barclay sound, Vancouver island, British Columbia, and a sample of native platinum found, in association with gold, on the bars of the North Saskatchewan river, in the neighbourhood of Edmonton, district of Alberta, North-west Territory. Native platinum had previously only been met with in Canada in British Columbia and, in small quantities, in Beauce county, in the province of Quebec.

"During the period in question, seven hundred and five mineral specimens were received for the purpose of identification or the obtaining of information in regard to their economic value. The greater number of these were brought by visitors, and the information sought in regard to them was not infrequently communicated to them at the time of their calling. In other instances—those where a more than mere cursory examination was called for, or a partial or even complete analysis was deemed desirable, as also in the case of those specimens which have been sent from a distance—the results were communicated by mail. The number of letters written, chiefly in this connection, and generally of the nature of reports, amounted to two hundred and ninety, and the number of those received to one hundred and sixty-one.

"Mr. R. A. A. Johnston has diligently applied himself to, and most satisfactorily carried out, the work entrusted to him. In addition to the gold and silver assays, analyses of limestones, dolomites and nickel ores, he has conducted a great variety of miscellaneous work. Mr. F. G. Wait was principally engaged in the analysis of mineral and other saline waters.

"On the work connected with the mineralogical section of the museum, I have been most ably and zealously assisted by Mr. R. L. Broadbent. He has been engaged in the permanent labelling of specimens—a work which must of necessity be a more or less continuous character by reason of the many frequent additions to the collection; the readjustment of some of the cases, incident upon the introduction of several new table-cases, for the purpose of allowing of a more systematic arrangement of the economic minerals of some of the provinces —and in maintaining the collection in general in an orderly condition.

"The catalogue of this section of the museum, in the preparation of which I have had the hearty co-operation of Mr. Broadbent, will appear in the course of the coming year (1892).

"Very many of the mineral specimens have been replaced by more characteristic ones, and the collection augmented by the addition of

some one hundred and twenty others. Of these, the following were collected by members of the staff:—

1. Ami, H. M. (Survey):

   Argentiferous galena from the Elizabeth claim, Fish river, West Kootanie district, British Columbia.

2. Bailey, Professor L. W. (Survey):

   (*a.*) Staurolite from North East Harbour, Shelburne county, Nova Scotia.

   (*b.*) Garnet on diorite from Chegoggin, Yarmouth county, Nova Scotia.

   (*c.*) Garnet rock from Chegoggin, Yarmouth county Nova Scotia.

3. Barlow, A. E. (Survey):

   (*a.*) Cyanite, seventy specimens. (*b.*) Fibrolithe, eight specimens. (*c.*) Gersdorffite, ten specimens. (*d.*) Huronite, forty specimens. (*e.*) Niccolite, six specimens. (*f.*) Nickeliferous pyrrhotite, one hundred and twenty specimens. (*g.*) Oligoclase, eight specimens. All from the Sudbury district, province of Ontario.

4. Brumell, H. P. (Survey):

   (*a.*) Petroleum from Walker's 'No 2' well, Marshfield, south-west corner of lot 11, range IV, of Colchester, Essex county, Ontario.

   (*b.*) Petroleum from St. Joseph, parish of Dorchester, Westmoreland county, New Brunswick.

5. Dawson, Dr. G. M. (Survey):

   Coal from the Canmore mine, one mile from Canmore station on the line of the C. P. R., south-east side of Bow river, district of Alberta, N. W. T.

6. Ferrier, W. F. (Survey):

   About two hundred specimens of scheelite, tungstate, &c., from lot 1, range VII, township of Marlow, Beauce county, Quebec.

   These include many fine and rare crystals, as well as a few large specimens suitable for the economic collection.

   Ninety specimens of the silver ores from lots 1, 2, 3, and adjoining ones, ranges XIV, XV, and XVI, Risborough town-

ship, and lot 1, range VII, Marlow township, Beauce county, Quebec; also about twenty-five specimens of minerals associated with these ores, some of which have not yet been fully identified.

6. Giroux, N. J. (Survey):
   Chromite (two specimens) from the townships of Leeds and Thetford, Megantic county, province of Quebec.

7. McEvoy, J. (Survey):
   Muscovite (three specimens) from near the junction of Canoe river with the Coldwater, British Columbia.

8. McInnes, W. (Survey):
   (*a.*) Argentite with pyrite, fluorite and calcite, from the Beaver mine.
   (*b.*) Argentite and sphalerite with fluorite from the Beaver mine.
   (*c.*) Argentite with native silver, and sphalerite, in calcite and quartz, from the Porcupine mine.
   (*d.*) Galena with sphalerite, in quartz, from the Badger mine.
   (*e.*) Magnetite, from Greenwater lake.—All from the district of Thunder bay, Ontario.

9. Selwyn, Dr. A. R. C.:
   Auriferous quartz, from the Gladstone mine, township of Marmora, Hastings county, Ontario.

10. Smith, W. H. C. (Survey):
    Magnetite, from Big Turtle river, district of Rainy river, Ontario.

11. White, J. (Survey):
    (*a.*) Celestite, from lot 7, range X, of Bagot, Renfrew county, Ontario.
    (*b.*) Moulding sand, from lot 3, range V, of north Sherbrooke, Lanark county, Ontario.

And the undermentioned constituted presentations:

1. Campbell, John, Nanaimo, British Columbia:
   Limonite, from Texada island, British Columbia.

2. Chubbuck, C. E. D. Ottawa:
   Phlogopite, from lot 13, range XV, of Hull, Ottawa county, province of Quebec,

3. Claxton, F. J., Victoria, British Columbia. :
   Cinnabar ore, from Seshart channel, Barclay sound, Vancouver island. British Columbia.

4. Coughlin, D. :
   Nickeliferous pyrrhotite, from lot 9, range VI, of Lorne, district of Algoma, Ontario.

5. DeWolf and Munro, Vancouver, British Columbia. :
   (*a.*) Pottery clay, from Guichon creek, Nicola river, British Columbia.
   (*b.*) Specular iron, from the junction of Nicola and Coldwater rivers, British Columbia.

6. Davey, Capt. T. R., per W. F. Ferrier (Survey) :
   From the Harvey Hill mines, Leeds township, Megantic county, Quebec. :
   Chalcopyrite, twenty-five specimens.
   Bornite, twelve specimens.
   Chalcocite, eight specimens.
   Molybdenite, three specimens.

7. Firth, W., per R. G. McConnell (Survey) :
   Vivianite, from the 'Ramparts,' Porcupine river, Yukon district.

8. Hammond, H. C., Winnipeg, Manitoba, per Dr. G. M. Dawson (Survey) :
   Argentiferous galena, from Vermont creek, McMurdo district, East Kootanie, British Columbia.

9. Haycock, E. B., Ottawa :
   (*a.*) Phlogopite, with plant inclusion, from north half of lot 10, range V, of Hull, Ottawa county, province of Quebec.
   (*b.*) Phlogopite, dressed sheet, from same locality as the preceding.

10. Laperrière, M., per N. J. Giroux (Survey) :
    Picrolite, from lot 18, range IV, of Durham, Pontiac county, province of Quebec.

11. Mackay, J. W., per Dr. G. M. Dawson (Survey) :
    Native copper, from above Stein creek, Fraser river, British Columbia.

12. McLellan, S. :
    Phlogopite, from lots 11 and 12, range XVI, of Hull, Ottawa county, province of Quebec.

13. McCuaig, R. C. W., Ottawa :

Muscovite, from lots 4 and 5, range XI, of the township of Miller, Frontenac county, Ontario.

14. McRae, Hector, Ottawa :

(*a.*) Apatite in pyrite, from lot 11, range V of Templeton, Ottawa county, province of Quebec.

(*b.*) Core of garnetiferous granite, from boring at last men tioned locality.

15. Nellis, T. F., Ottawa :

(*a.*) Phlogopite with inclusions of albite, apatite, garnet and pyrite, from lot 10, range XII, of Hull, Ottawa county, province of Quebec.

(*b.*) Phlogopite with inclusion of molybdenite, from same locality as the last.

(*c.*) Phlogopite with inclusion of pyrite, from same locality as the two preceding.

16. Poole, H. S., Stellarton, Nova Scotia :

Sphalerite and chalcopyrite, from the Albion mines, Pictou county, Nova Scotia.

17. Röeser, F., Kootanie Smelting and Trading Syndicate, Revelstoke, British Columbia, per H. M. Ami (Survey) :

Ingot of argentiferous lead, smelted from ore from the Monarch claim, at the Revelstoke smelter.

18. Ryckman, S. S., M.P., Hamilton, and W. H. Scott, of Illecillewaet, British Columbia :

Argentiferous galena, from the Elizabeth claim, Fish river, West Kootanie district, British Columbia.

19. Smart, Capt. W. J., Montagu, Nova Scotia :

Auriferous quartz, from the Rose lead, Montagu mine, Halifax county, Nova Scotia.

20. Soues, F., Clinton, British Columbia, per Dr. G. M. Dawson (Survey) :

Native gold, from the Bonanza claim, Cayoosh creek, near Lillooet, British Columbia.

21. Sperry, F. E., Sudbury, Ontario, per A. E. Barlow (Survey) :

Polydymite, from the Vermilion mine, lot 6, range IV, of Denison, district of Algoma, Ontario.

22. Warmington Stone and Marble Company, Garden River, Ontario:

(*a.*) Limestone polished, from Echo lake, district of Algoma, Ontario.

(*b.*) Limestone polished, from Garden River, district of Algoma, Ontario.

"Mr. C. W. Willimott has, for the most part, been engaged in making up collections of minerals and rocks for various educational institutions. The following is a list of those to which such collections have been sent:—

1. St. Mary's Academy, Windsor, Ont..	Consisting of	103	specimens.
2. City Museum, Vancouver, B.C.....	do	106	do
3. Collegiate Institute, Napanee, Ont.	do	106	do
4. Protestant Board of School Commissioners, P.Q.....	do	106	do
5. College of Hull, Hull, P.Q.....	do	96	do
6. Elgin Street School, Ottawa, Ont..	do	96	do
7. Model School, Windsor Mills, P.Q.	do	108	do
8. Upper Canada College, Toronto...	do	108	do
9. Waterville Model School, Waterville, P.Q.....	do	108	do
10. Public School, St. Stephen, N.B...	do	96	do
11. do St. Lambert, P.Q ..	do	91	do
12. Preston Mechanics' Institute, Preston, Ont.....	do	96	do
13. St. Patrick's High School, Halifax, N.S.,.....	do	96	do
14. Legislative Assembly, Winnipeg, Man.....	do	108	do
15. High School, Bowmanville, Ont...	do	106	do
16. do Oshawa, Ont.....	do	91	do
17. do (Victoria), Moncton, N.B.....	do	108	do
18. Panet Street School, Montreal, P.Q.	do	91	do
19. Mount Allison University, Sackville, N.B.....	do	145	do
20. Bathurst Village School, Bathurst, N.B.....	do	108	do
21. Central School, Brantford, Ont....	do	108	do
22. Lunenburg County Academy, Lunenburg, N.S.....	do	108	do

" The following collections are in course of preparation for, and will shortly be sent to, the undermentioned institutions :—

1.	Collegiate Institute, Morrisburg, Ont.	consisting of	108 specimens.
2.	do Peterborough, Ont	do	108 do
3.	School of Practical Science, Toronto, Ont.	do	108 do
4.	Morrin College, Quebec, P.Q.	do	108 do
5.	High School, St. George, N.B	do	108 do
6.	do Georgetown, Ont	do	108 do
7.	Central School, Moncton, N.B	do	108 do

" A collection of two hundred and fifty specimens, sent by the College of St. Laurent, Montreal, for identification, was named and returned.

" In the course of the summer months Mr. Willimott visited—with the object of procuring further material for the making up of collections, and cabinet specimens for the Museum—the townships of Buckingham, Hull, Low, Masham, Portland, Templeton, Villeneuve and Wakefield, in Ottawa county, province of Quebec; those of Bromley, Brudenell, Ross and Sebastopol, in Renfrew county, and that of Cameron, district of Nipissing, in the province of Ontario.

" In the prosecution of this work he has succeeded in collecting a large and varied assortment of minerals, and at the same time made many interesting and useful observations in regard to their mode of occurrence. The collection comprised :—

	Specimens.
Albite, massive	50
Albite, crystals	15
Albite with smoky quartz, fluorite and amazon-stone	25
Apatite, crystals	230
Apatite in calcite	36
Biotite	44
Fluorite with albite and sphene	50
Fluorite with amazon-stone	40
Graphite	48
Gummite	12
Hornblende, groups of crystals	20
Hornblende with tremolite	96
Microcline, massive	60
Microcline, crystals	8
Mountain cork	20
Muscovite	75

	Specimens.
Orthoclase, groups of crystals	75
Phlogopite	45
Phlogopite, crystal	1
Pyrite with pyrrhotite	110
Pyroxene, crystals	300
Pyroxene, groups of crystals	50
Quartz	35
Quartz, groups of crystals	50
Scapolite, crystals	6
Scapolite, groups of crystals	60
Spessartite	50
Sphene, crystals	30
Sphene in calcite	20
Tourmaline, crystals	17
Tourmaline in albite	88
Uraninite (diss.)	36
Wollastonite in calcite	50
Miscellaneous associations	30
Three minerals (under examination) represented by	77
Total number of specimens collected	2,039
Galena from Bedford (applied for)	300 lbs.

"The foregoing include very many handsome cabinet specimens, the most conspicuous amongst which are some white and reddish crystals of albite; crystals of black tourmaline; fine specimens of spessartite; crystals of Wollastonite in sky-blue calcite, one some two inches in length and a little over one inch in breadth and well terminated; a crystal of phlogopite, fifteen inches and a-half long, three inches and a-half diameter at the top, four inches and a-half diameter at the centre, and weighing some fifteen pounds; also a very handsome group of crystals of microcline."

Mr. W. F. Ferrier, lithologist, reports that during the year, as in 1890, he has been engaged in the study, arrangement and classification of the stratigraphical collection of rocks. Early in the year new cardboard trays were ordered to fit the drawers under the flat cases devoted to this collection. Thirty-nine of these drawers were gone over, the specimens cleaned and provisionally arranged in the new trays,

worthless material was rejected and three boxes of duplicates were carefully labelled and placed in store. This work involved the handling of over 1,800 specimens. There are 141 more drawers, all the specimens in which will have to be similarly gone over before the best and most suitable series can be selected for the exhibition cases, and their systematic arrangement carried out.

Superintending the preparation of the rock sections required for the microscopical determination of the characters of the specimens also occupied considerable time; 142 such sections were prepared and studied during the year.

On the 21st of July Mr. Ferrier left Ottawa to make some lithological investigations in the Eastern Townships, more especially in Broughton and Leeds.

In the spring while examining the rocks collected by Mr. Webster in 1879, Mr. Ferrier had recognized in a specimen from lot 1, range VII of Marlow, a small fragment of scheelite or tungstate of lime. He therefore also visited this locality and succeeded in finding it in some quantity in quartz veins, cutting Cambrian slates, and accompanied by its decomposition product tungstate or tungstic acid. Galena, copper and iron pyrites, blende and other minerals were also found in the veins.

On the 10th of August he returned to Ottawa and was occupied chiefly in microscopical work till the 30th of September when he again visited the locality, remaining there till the 8th of October. The tungsten minerals were found in nearly all the veins examined, but in some only in small quantity.

The best locality, apparently, is that from which the original specimen came, where they are rather abundant in the vein. Though little more than a foot wide at its outcrop, further development might reveal the tungsten ore in quantities sufficient to justify mining on this vein. No ore of tungsten had hitherto been recognized in situ* in Canada. Its discovery is of interest at a time when so many experiments are being made with steel, in view of the remarkable and valuable properties possessed by tungsten steel.

Tungstic acid has also been used in calico printing to produce a yellow colour.

The discovery is also interesting in connection with the fact that scheelite is very commonly accompanied by ores of tin and that for several years past I have indicated this south-eastern portion of the province of Quebec as the district where this ore should be sought,

*Geology of Canada, 1863, p. 503.

and where, if anywhere in Canada, the search might prove successful. In Phillip's mineralogy it is stated: "This mineral (scheelite) occurs both crystalline and amorphous, particularly in the depositories of tin ore at Schlackenwald and Zinnwald, in Bohemia, and in Monroe county (Conn.), United States."

Mr. Ferrier collected many fine crystals of scheelite as well as large samples of the ore, for the museum. An analysis, by Mr. R. A. A. Johnstone under the supervision of Mr. Hoffmann, was made in the laboratory of the survey, and showed the scheelite to contain 79·9 per cent of tungstic acid, or within 7 per cent of the theoretical quantity.

The full analysis will appear in Mr. Hoffmann's report on the chemical work of the survey.

Since the 8th of October Mr. Ferrier was chiefly occupied in the examination of specimens collected during the summer by various members of the staff in order to ascertain their character by means of the microscope and blow-pipe. These examinations include a detailed report on specimens from Chateau Richer, Quebec, to accompany Mr. Low's report on work in that district, and also a microscopical examination of Huronian rocks from the Sudbury district collected by Mr. Barlow. This was being proceeded with at the close of the year. The cost of the season's work in the field was $209.89.

PALÆONTOLOGY AND ZOOLOGY.

Mr. Whiteaves reports that the third part of the first volume of "Contributions to Canadian Palæontology" was published in May last. It consists of a systematic and descriptive report, of fifty-eight pages octavo, illustrated by six full page lithographic plates, on the fossils of the Devonian rocks of the Mackenzie River basin, for the most part collected by Mr. R. G. McConnell in the years 1887, 1888 and 1890. A full suite of the specimens to which it refers has been placed on exhibition in the museum, and such duplicates as remain have been labelled for distribution to educational institutions in Canada.

A paper on "the Orthoceratidæ of the Trenton Limestone of the Winnipeg basin" has been written for the Transactions of the Royal Society of Canada, and is now printed in the volume for the current year. This paper consists of 10 pages quarto, illustrated by seven full page lithographic plates.

During the past year, also, three descriptive and illustrated papers on purely palæontological subjects have been written for and printed

in the "Canadian Record of Science." The first of these, which is entitled "Descriptions of Four New Species of Fossils from the Silurian Rocks of the South Eastern Portion of the district of Saskatchewan," was published in the April number of the "Record," and consists of eleven pages octavo of letter press, illustrated by one full page lithographic plate. The second, which, with the third, was published in the October number of the "Record," consists of a description of a large new species of *Panenka* from the Corniferous limestone of St. Mary's, Ontario, and is illustrated by one full page lithographic plate. The third is a note "on the Occurrence of Paucispiral Opercula of Gasteropoda in the Guelph formation of Ontario," and is illustrated by one woodcut.

The third part of the "Contributions to Canadian Micro-Palæontology," by Professor T. Rupert Jones, F.R.S., referred to in the last annual report as having been received in MSS., was published in August. It consists of forty-two pages of text, illustrated by four full page lithographic plates.

It has been decided to devote the second volume of the "Contributions to Canadian Palæontology" to an illustrated monograph on "Canadian Fossil Insects," which Professor S. Scudder, of Cambridge, Mass., the most experienced authority on this subject in America, has kindly promised to prepare. The first part of this volume, consisting of a paper, of twenty-six pages large octavo, and illustrated by one full page lithographic plate, "on the Tertiary Hemiptera of British Columbia," was published last April, and the second part is now nearly ready for the printer.

The manuscript of a considerable portion of the fourth part of the first volume of the "Contributions to Canadian Palæontology" has been written and eight of the lithographic plates required to illustrate it have been printed off. As stated last year, this report, when complete, will consist of a descriptive and systematic report on the unusually large collections of fossils made by Mr. Tyrrell in 1888 and 1889 from the Devonian rocks of lakes Manitoba and Winnipegosis. That part of the letter press which is now nearly ready for the printer consists of descriptions or identifications, as the case may be, of the whole of the species of sponges, corals, echinodermata, vermes, polyzoa, brachiopoda and of part of the pelecypoda, represented in those collections, and it is hoped that the whole report will be ready for publication in the spring. The Stromatoporoids in these collections have already been kindly reported upon by Professor H. Alleyne Nicholson, of the University of Aberdeen, in a paper in the Annals and Magazine of Natural History (London, England) for April, 1891, in which the species are described and figured.

Since the systematic "List of the Fossils of the Hamilton Formation of Ontario" was published in 1887, in the second part of the first volume of "Contributions to Canadian Palæontology," so many additional species from that formation have been received and so much new information about its fauna has been obtained, that it is thought desirable to publish a supplement to this list at an early date. With a view of making this supplement as complete as possible, about a week last summer was spent in an examination of all the exposures of the Hamilton formation near Thedford and Arkona and in a study of the fossils obtained therefrom during the past four years by the Rev. Hector Currie, of Thedford. Some interesting additions to this local fauna were thus made, and the writer is greatly indebted to Mr. Currie for his courtesy on this, as on a previous and similar occasion, and for the loan of some of the rarest specimens of fossils from his cabinet.

In Zoology, an important collection of the mammalia, birds and reptiles of the Rocky Mountain park, and a series of about 175 specimens of birds and small mammalia from Indian Head, Assiniboia, have been received during the year from Professor Macoun. A few interesting additions have been made to the zoological collections in the museum through Dr. G. M. Dawson, in connection with the British Behring Sea Commission, being chiefly donations from various gentlemen, or purchased as noted elsewhere. These include the skin and skull of a Pacific walrus, the skeleton of an adult male fur seal, some bones of the extinct *Rhytina* of Behring Island, a specimen of the sooty albatross from the coast of British Columbia, &c.

Besides a few birds which have been put up as skins, nine specimens of Canadian mammalia, one hundred and six specimens of birds, and one turtle, have been skilfully mounted during the past year, by Mr. S. Herring, the taxidermist to the survey, but most of these are intended for the museum which it is proposed to establish in the Rocky Mountain park at Banff. Among the more interesting specimens of native mammalia recently added to the survey museum, and not already enumerated, are a Rocky Mountain sheep, a fine example each of the "fisher" and cross fox, both from Norway House, and presented by Mr. Horace Belanger, and a yellow-haired porcupine from Illicillewaet.

During the director's absence from the city, on field work, the duties of acting director have, as usual, devolved upon Mr. Whiteaves, and, in addition to the correspondence entailed thereby, 263 official letters have been received during the year and 227 written.

Mr. Weston reports that, with the exception of one month spent in field work, the whole of his time, from the 15th of January up to the

end of the year, has been occupied in work in the palæontological and archæological branches of the museum, in the rearrangement of specimens and the incorporation of new ones into the collection, in the writing of labels, in making improvements in the contents of many of the glass cases, in the preparation of fossils either for study or for exhibition in the museum, in the making of microscopic sections of rocks and fossils, and in other office work. From the 1st to the 27th of July he was engaged in the examination of various rocks in the city of Quebec, on the north shore of the Island of Orleans and along the north shore of the St. Lawrence between the mouth of the St. Charles river and St. Joachim. At each of these localities interesting collections of fossils were obtained, some of which will, it is expected, throw additional light on the stratigraphical relations of the rocks from which they were obtained. Among these fossils are a large series from the Hudson River formation along the north shore of the Island of Orleans, and a fine collection from the Utica slate in the vicinity of the mouth of the St. Charles river.

Mr. H. M. Ami reports that during the past year, with the exception of two months spent in the field, he has been employed in the examination and determination of the species in various collections of fossils made by members of the staff. He has completed the examination and comparison of some graptolites from the graphite-bearing slates of St. John, New Brunswick, and has made a list of fossils from an outcrop of Silurian rocks, on the east branch of the River Philip, Cumberland county, Nova Scotia, recognized by Mr. Scott Barlow in 1876. It lies sixteen miles to the west from the outcrop of the same formation at Wentworth, on the Intercolonial railway. For Mr. A. Low he has identified and prepared lists of the species in four collections from the Trenton limestone below St. Alban, above and below St. Casimir, and on River Charlotte, P.Q. He has also examined a small collection of graptolites from Côte Sauvageau, near Quebec city, and has prepared lists, for publication in Dr. Ells's report, of fossils from Philipsburg, St. Armand, Mystic, Stanbridge, Lake Memphremagog, and other localities in the province of Quebec, that were collected in 1890 by Dr. Ells and Messrs. Whiteaves and Deeks. The specimens examined from these well-known Cambro-Silurian localities were about 1,300. A preliminary examination has been made by him of about 500 specimens of fossils, collected by Mr. Giroux in the counties of Joliette, Berthier and Maskinongé, with a view of revising the boundaries of the Chazy and Trenton formations in those districts. Miscellaneous collections of fossils from Ontario, Quebec and Nova Scotia, made in past years by Messrs. Weston, McInnes, A. Ogden,

and H. Fletcher, from rocks of Cambro-Silurian and Silurian age have been examined and lists of the species prepared.

Some progress has been made in making up collections from the duplicate specimens in the museum, for distribution. Specimens have been sent to Mr. G. F. Matthew, St. John, N.B., and to Col. Grant and Mr. Wm. Turnbull, of Hamilton, in exchange for specimens received from them. Suitable collections of fossils are being prepared for the University of Toronto, the University of Fredericton, for Acadia College, Wolfville, N.S., and for other educational institutions. He has examined and, so far as their condition permitted, named, for the Rev. J. Carrière, principal of St. Laurent College, a miscellaneous collection of fossils, ranging from the Cambrian to the Cretaceous. Labels have been prepared, to be printed, for specimens in the museum from the Trenton, Devonian and Post Pliocene formations. He assisted in reading and correcting the proofs and revises of a palæontological publication prepared for the Survey, by Professor Rupert Jones.

From the 17th of July to the 15th of September Mr. Ami was occupied in field work, chiefly on and in proximity to the line of the Pacific railway in the Selkirks from Revelstoke eastward to Beaver Mouth and Donald, and thence to the summit of the Rocky mountains east of Field. He carefully examined the natural exposures and rock cuttings between Revelstoke and the summit of the Selkirks, but was as unsuccessful in finding fossils in these rocks as Dr. Selwyn and Dr. Dawson had been when they examined them in 1890.

Between Beaver Mouth and Donald, two miles west of the latter, the numerous exposures were likewise carefully examined and in these he succeeded in finding an abundant fauna; crustaceans, pteropods and brachiopods; the genera, Olenellus, Agnostus and Hyolithes were noticed, thus confirming the supposed Lower Cambrian age of these rocks. East of Donald, at the Glenogle slate and flag quarries, between Palliser and Golden, an interesting collection was made of the graptolites of that locality. At Field the trilobite beds on the western flank of Mount Stephen were visited, and an interesting collection made, containing about 25 species and 500 specimens of the Middle Cambrian fauna, first discovered in Mt. Stephen by Mr. McConnell.* At Anthracite, near Banff, about 100 specimens of fossil plants were collected from the Cretaceous rocks of that vicinity.

Besides the foregoing examinations Mr. Ami reports having ascended Moose creek, the south branch of the Illecillewaet for two miles and that the only rocks seen were dark coloured argillites inclined at a high angle. On the 10th of July, with a view to finding the contact of the gneissic rocks with the newer overlying series of the Illecillewaet

valley, he left the railway five miles above Illecillewaet and ascended the Flat creek trail seven miles to the summit. He then descended by Slick creek and Jeopardy slide five miles into the Fish river valley. One day was spent in the Fish river valley and the exposures for four miles down on the left bank to the mouth of Granite creek were examined. Granite creek was ascended for about one mile, to about 1,500 feet above Fish river, at which elevation massive granite occurs and apparently extends to the summit of the range. Specimens of all the rocks here seen were collected, and also samples from a vein of argentiferous galena then recently discovered and on which some 18 claims had been registered. On the 12th of July, he returned to Illecillewaet. The next day Corbyn trail was ascended to the summit of the range between the Illecillewaet and the North Fork, and specimens of the rocks were collected.

Five specimens of the galena above referred to have been assayed in the laboratory of the survey, giving 108·6, 109·3, 149·9, 175·7 and 204·1 ozs. to the ton of 2,000 lbs. and about 80 per cent of metallic lead.

Mr. Lambe reports that during the first half of the year he was engaged in a study of the large collections of fossils made by Messrs. Tyrrell and Dowling from the Devonian rocks of Lakes Manitoba and Winnipegosis in 1888 and 1889, assisting in their identification and determination. He has prepared drawings of a large number of the species of sponges, corals, polyzoa, brachiopoda, pelecypoda and gasteropoda contained in these collections, which, with the exception of those of the gasteropoda, have been already lithographed on stone and the entire issue of 1,100 copies printed, forming plates 33, 34, 35, 36, 37, 38, 39 and 40 for the Contributions to Canadian Palæontology, vol. i, pt. iv. (Shortly to appear.)

During the latter half of the year he was occupied in an examination of the Orthoceratidæ from the Trenton rocks of Lake Winnipegosis, assisting Mr. Whiteaves in their identification and determination. He has prepared drawings of these fossils, which form part of collections made by Mr. Weston in 1884, by Mr. Tyrrell in 1889, and by Messrs. Dowling and Lambe in 1890, reproductions of which appear in plates 5, 6, 7, 8, 9, 10 and 11 of the Transactions of the Royal Society of Canada for 1891 (now in the printers' hands) illustrating Mr. Whiteaves' paper on the Trenton Orthoceratidæ of Manitoba, &c.

He has begun a classification of collections of fossils recently made from Lake Winnipeg, and has made a number of drawings for the better illustration of *Edrioaster Bigsbyi*, Bill.; *Amygdalocystites florealis*, Bill.; and *Pleurocystites filitextus*, Bill., from the Trenton rocks at

* Annual Rep. Geol. Survey, 1886, Part D.

Ottawa. During the month of January, he was engaged in an examination of some fossils collected by Mr. McConnell in the Athabasca river, in 1890, and in preparing drawings for their illustration. These are published, in plate 32 of the Contributions to Canadian Palæontology, vol. 1, pt. iii. He has devoted some time to the examination of the fossils described in the papers published by Mr. Whiteaves in the Canadian Record of Science for April and October, referred to on p. 49 of this report, and has made all the drawings that are reproduced to accompany these papers.

In August he visited Peterborough, Woodstock and St. Mary's, Ont., and made collections of fossils from the exposures of Trenton limestone in the former place and from the Corniferous rocks of the latter, and later, in October, he spent a few days with Dr. Ells, in the vicinity of L'Orignal and Hawkesbury, Ont., collecting fossils from the Trenton and Chazy rocks near these localities.

The following is a list of specimens collected by officers of the survey during the past year, or presented to its museum through them :—

Dr. G. M. Dawson :

Specimens obtained in connection with the Behring Sea Commission, as under :—

Eight Haida (Queen Charlotte Island) trumpets and whistles, and one castanet—Purchased.

One pair snowshoes, King's Island, Okeeogmut tribe, Eskimo.
One bird snare made of whalebone, Kotzebue Sound, Eskimo.
Net, Kotzebue Sound, Eskimo.
Skin of Pacific walrus, from Behring Strait.
} Presented by Capt. M. A. Healy.

One pair snowshoes, Nunivak Island, Behring Sea, Magemut tribe, Eskimo.
One bird-dart, Nunivak Island, Magemut tribe, Eskimo.
} Presented by Capt. Hadley, H.M.S. "Pheasant."

Specimens of Sponges and Sertularians from various localities.

One skull of the Pacific walrus (*Odobœnus obesus*), from Kamtschatka.—Purchased.

Seal and sea otter spear, and throwing stick for same, Atka Island, Aleut.—Purchased.

Sixteen skins of birds from Behring Sea.—Collected by J. M. Macoun.

Four skins of birds from Behring Island.
Bones of *Rhytina Stelleri*.
Skeleton of male fur seal.
} Presented by Mr. N. Grebnitzky.

Skull of *Rhytina*, from Behring Island.—Purchased.

Several specimens of *Velutina coriacea* from St. Paul's island.

J. F. Whiteaves :—

A number of specimens of fossils from the Hamilton formation near Thedford and Arkona, Ont.

Prof. Macoun :—

About fifty specimens of fossils from the Lower Carboniferous rocks of the Rocky Mountain park, Alberta.

R. W. Ells & W. E. Deeks :—

About 1,000 specimens of fossils from various localities in the counties of Missisquoi, St. John, Laval, St. Hyacinthe, Bagot and Iberville, in the province of Quebec, and Russell and Prescott, in the province of Ontario.

R. G. McConnell :—

Twenty fossils from the Cretaceous rocks of the foot-hills of the Rocky mountains.

J. B. Tyrrell :—

Head of caribou (*Rangifer Caribou*) from Hole river, Manitoba.

T. C. Weston :—

About 250 specimens of fossils from various localities along the north shore of the St. Lawrence, between Quebec city and Cape Tourmente, also on the Island of Orleans.

L. M. Lambe :—

200 specimens of fossils from the Trenton and Chazy limestone at Peterborough, L'Orignal and Hawkesbury, and about 100 from the Corniferous limestone of Woodstock and St. Mary's, Ont.

A. P. Low :—

About seventy-five fossils from the Trenton and Black River limestone of Jacques Cartier county, P.Q., also twenty specimens of Post-Tertiary fossils from the same district.

R. Chalmers :—

A number of specimens of four species of fossils from excavations in marine alluvium at the west end of the Chignecto ship railway, at the head of the Bay of Fundy, and fossil wood of two species of trees from New Brunswick.

Numerous examples of twelve or more species of fossils from the Leda Clay and interglacial beds at Duck Cove and Negrotown Point, Lancaster, St. John county, N.B.

H. M. Ami :—

About 600 specimens of fossils from the Selkirk and Rocky mountain ranges, along the line of the Canadian Pacific railway.

Specimen of the yellow-haired porcupine (*Erethizon dorsatus* var. *epixanthus*), from Corbyns' trail on the Illecillewaet.

N. J. Giroux :—

About 500 specimens of fossils from the Cambro-Silurian rocks at numerous localities in the counties of Joliette, Berthier and Maskinongé, in the province of Quebec.

D. B. Dowling :—

About 500 specimens of fossils from the Cambro-Silurian and Silurian rocks of the west shore of Lake Winnipeg and islands adjacent thereto.

A few Indian implements and small pieces of pottery from the mouth of the Little Saskatchewan river, Manitoba.

J. McEvoy :—

Ten fossils from the Carboniferous limestone of White valley, Okanagan valley, B.C.

James Macoun :—

Twenty-five specimens of fossil plants from Hastings, near Vancouver, B.C.

The additions to the palæontological, ethnological and zoological collections in the museum, by presentation, exchange or purchase, are as follows :—

By presentation :—

Horace Belanger, chief factor Hudson's Bay Co., Norway House :—

Fine specimen each of the fisher *(Mustela Pennantii)* and cross fox *(Vulpes vulgaris* var. *decussatus)* from the Nelson river, Keewatin.

Patrick Neville (Deputy Inspector of Mines, N.S.), Bridgeport, C. B. :—

Thirty-three fine slabs of fossil plants from the Sydney coal field, and a lower jaw of a walrus from Cape Breton.

William Maddin (Deputy Inspector of Mines, N. S.), Westville, N. S. :—

Thirty specimens of fossil plants from the Springhill coal mines, N. S.

H. S. Poole, Stellarton, N. S. :—

Thirty specimens of fossil plants from the coal mines near Stellarton.

James Robertson, Albert Mines, Albert county, N. B. :—

Twenty-five specimens of two species of fishes (*Rhadinichthys*) from the Albert mines.

J. W. Tyrrell, C.E., Weston, Ont. :—

Eskimo mittens and boots of seal skin, the latter with waterproof feet; Eskimo boots, waterproof; Eskimo boots, harp-seal skin, with feet of the skin of the square-flipper seal; and Eskimo slippers; all from North Bluff, Hudson Strait.

J. B. Tyrrell, Geol. Survey, Ottawa :—

Cree-Stony Indian saddle from Wolf creek, Alberta.

Hyacinthe Proulx, Ottawa :—

Stone gouge found near the Rideau river, Carleton county, Ont.

Frank Butler, Ottawa :—

Hunter's knife and pipe-bowl from Alberta, used by Blood Indians of the Blackfeet tribe.

John F. Fenton, Huntley, Carleton county, Ont. :—

Indian stone implement of singular and unusual shape, found by donor on his own farm, con. 3, lot 8, Huntley.

Martin Griffin, jun., Ottawa :—

Egg of wood peewee (*Contopus virens*).

J. D. Moore, St. Mary's, Ont. :—

Specimen of *Orthoceras* from the Corniferous limestone of St. Mary's.

Prof. Henry M. Seely, Middleborough College, Middleborough, Vt.:—

One species of fossil from the Cambrian, two from the Calciferous, and two from the Chazy of the states of Vermont and New York.

Prof. F. Schmidt, St. Petersburg, Russia :—

Nine species of fossils from the Cambrian and Silurian rocks of Estland and the Baltic.

Alfred Ogden, House of Commons, Ottawa :—

Twenty specimens of fossils from the Trenton limestone at Rochesterville, Ont.

By Purchase :

From J. Stewart, Ottawa :—

Thirty-three rare or unusually perfect specimens of fossils from the Trenton limestone, near Ottawa.

Rev. G. W. Taylor, Victoria, V.I. :—

Specimen of an undescribed decapod crustacean from the Cretaceous rocks of Vancouver island.

BOTANY, &C.

In the last Summary Report on the work of this division it is stated that Professor Macoun was occupied on Part VI. of the Catalogue of Canadian Plants, and on the Catalogue of Canadian Birds. Part VI. has been completed, more than one-third of it has been printed, and the completed Catalogue of Canadian Birds will be ready for the printer before the end of the present month.

As these works are the result of the observation and collections of more than thirty years, it is hoped they will be well received, and prove useful to botanists and ornithologists throughout the world.

On the further work of this division during the year, Professor Macoun reports :—

" In compliance with your suggestion, that I should undertake the preparation of a Catalogue of Canadian fungi, with special reference to the edible and to the poisonous species, I have been working at it at intervals during the past six years. I now know nearly 800 species of Canadian Fungi, and during the coming summer hope to be able to gather enough material to enable me to write up the whole subject next winter.

" The agarics, which include most of the edible and poisonous fungi, change so rapidly after being gathered that drawings must be made from the fresh plant, and it is desirable that some arrangement be made to get this done during next spring and summer. During the month of September last large collections were made in the vicinity of Ottawa of these species, and Mr. Lambe made water-colour drawings of them in the evenings. He did the work remarkably well, and I would respectfully suggest that a small sum be placed in the estimates to remunerate him for this work in the past and for the prospective work of next spring and summer. I may say that unless an arrangement is made with some person in Ottawa to make the drawings, I can proceed no further with this desirable and useful work.

"Having completed the collection of material for the Catalogue of Birds, I am now gathering data for a Catalogue of Canadian fresh-water Fishes, and should like you to authorize me to prosecute that work as a supplement to my other work when in the field.

"Early last May you requested me to endeavour to complete the set of photographs of Canadian trees, and about the last of that month I went to the Niagara district where I knew there were many rare and well-grown specimens. I was not disappointed, and in the course of a little over two weeks forty very fine trees were selected, of which Mr. Topley took excellent photographs. My time being limited, I had to return to Ottawa before good specimens of all the western trees could be selected, as I had been requested by you to proceed to Banff in order to make a collection of specimens of the fauna and flora of the Rocky Mountain park and vicinity for the museum proposed to be established at Banff.

"About the 1st of May, I telegraphed to Victoria, to Mr. William Spreadborough, who had been with me two years in British Columbia, to come to Banff and commence making a collection of the birds and mammals. He reached Banff on the 7th of May and at once commenced work. He was very successful and had obtained 251 skins before I joined him.

"On the 20th of June I left Ottawa and reached Banff on the 25th, commencing work the same day. From that date to the 24th of August, I was continuously employed collecting and drying plants, and in making notes on the flora and fauna of the park. These notes have been put into order since my return, so that should a report on the natural history of the park be at any time required it can be written in a very short time. During the two months I spent at Banff and in its vicinity I collected over 1,000 species of plants, and since my return have examined and arranged them all. Most of these have been mounted, labelled, and placed in a cabinet made for their reception.

"Early in May, at your request, I instructed the taxidermist to commence setting up birds for the Banff musuem, and as far as I am aware he has been at that work ever since.

"The avi-fauna of the Rocky Mountain park will be found to consist of about 150 species, but it seems desirable that all the waders, swimming birds and grouse of the prairie region should be included in the collection, as nearly all travellers are sportsmen and they should be enabled to see for themselves the great variety of game birds that inhabit the Canadian prairies.

"A few small mammals and all the species of fishes known to be in the waters of the park were obtained. The skins of the larger fishes

were brought to Ottawa, and numerous entire specimens of the small minnow that lives in the warm water of the sulphur springs. That it does live in the warm water is undoubted, but it also lives in cold water and there attains a larger size. We traced it from the warm springs through pools of water in the tufa mounds below them to the marshes on a level with the Bow river. We saw none in the river, but it may be there nevertheless. The chief peculiarity about this fish is its large pectoral fins—very large in proportion to its size.

"Knowing that the Catalogue of Canadian Birds would likely be printed this winter, I and Mr. Spreadborough went from Banff to Indian Head, a locality peculiarly well suited for collecting the birds of the prairie region. After three days I came on to Ottawa, while Mr. Spreadborough remained there collecting for four weeks. The result was 152 skins of birds and small mammals, and a list of all the birds found in September in that district.

"Since my return to Ottawa, I have been busy—when not engaged on either of the catalogues above mentioned, on the routine work connected with the Natural History branch. This work is greatly hampered by the very insufficient accommodation afforded for its prosecution. You are aware that for three years this has been obvious, and though the attention of the Department of Public Works has been called to it repeatedly, nothing has yet been done to remedy it.

"It was intended that Mr. Jas. M. Macoun should accompany me to Banff, but his appointment as secretary to Dr. G. M. Dawson, of the British Behring Sea Commissioners, made a change in plans necessary. After my departure for Banff Mr. J. M. Macoun continued the work upon which he had been engaged since the opening of spring, viz., collecting plants in the vicinity of Ottawa, the flora of eastern Ontario being but poorly represented in our herbarium. On the 1st of July he was appointed secretary to Dr. G. M. Dawson, Behring Sea Commissioner for Canada, and since that date he has done no work for this branch excepting after office hours. While in Behring sea he collected plants whenever an opportunity was afforded and brought back with him the most valuable collection of arctic and sub-arctic plants that has yet been received into our herbarium. Many new species have already been described and others have not yet been determined.

"Since his return to Ottawa on the 20th of October, his duties in connection with the commission have occupied him during the regular office hours. In the evenings and at other times he has continued the usual routine work in the Natural History branch, and has been completing the collection of plants intended for the Banff museum; in a

few weeks all work in connection with it will be finished. He has been, besides, engaged in examining and naming the various collections of flowering plants that were made during the summer, or that have been received from other collectors, and getting out the specimens to mount. Since the 20th of October, 1,711 sheets of specimens have been labelled and mounted.

"All work, except the mounting of specimens, in connection with the herbarium has, as in former years, been done by Mr. J. M. Macoun. During 1891, 5,378 sheets of specimens were mounted and placed in the herbarium, many more than during any previous year. Of these 4,490 are flowering plants and 888 are cryptogams. Of the flowering plants 1,943 are Canadian, 2,142 are European and 405 are from the United States.

"4,526 sheets of specimens were sent to public institutions and to private individuals in exchange for desiderata. Of these 1,391 are cryptogams and 3,135 are flowering plants. Of the above total 1,823 specimens were presented to the following American and European institutions:—

British Museum	212
Central Experimental Farm	172
Department of Public Instruction, Quebec	55
McGill University	100
National Museum, Washington	428
Harvard University	112
Shaw School of Botany, St. Louis	200
Columbia College	221
Michigan Agricultural College	183
Department of Agriculture, Washington	140

"Among the more valuable collections of plants received for the herbarium during the year may be mentioned those sent by J. A. Morten, Wingham, Ont., Jas. White, Edmonton, Ont., and Wm. Scott, Ottawa, and about 1,000 species presented to the herbarium by W. Bicknell, Bordighera, Italy. The last named is a remarkably fine and valuable collection, for which the special thanks of this Survey are due to Mr. Bicknell.

"Since the 31st of December, 1891, in connection with the work of this division, 429 letters of sufficient importance to copy were written and about the same number received."

MAPS.

Maps in course of Preparation and Published during 1891.

North-West Territory, 9 sheets, 20 to 26 inches long, by 16 inches broad, showing waters followed by the members of the Yukon Expedition, 1887-88, and reaching from longitude 111° to 144°, and latitude 59° to 68°, to accompany report by Mr. McConnell, published 1891	8 miles=1 inch.	
Index map of the above do do	48 miles=1 inch.	
North-West Territory, Athabaska and part of British Columbia, to illustrate work of Mr. McConnell, 1889-90, and reaching from longitude 110° to 120° and latitude 54° to 60°, in draughtsman's hands	8 miles=1 inch.	
British Columbia, Kamloops sheet (Dr. Dawson) ready for publication	4 miles=1 inch.	sq. m. 6,400
British Columbia, Shuswap sheet (Dr. Dawson) in progress	do	6,400
British Columbia, Placer Mines of Cunningham Creek (Mr. Bowman)	About 27½ chs=1 in.	34
British Columbia, Quartz veins and Placer Diggings, Grouse Creek (Mr. Bowman).	do 25 chs=1 in.	14
British Columbia, Placer Mines of Antler Creek (Mr. Bowman)	do 26 chs=1 in.	38
British Columbia, Plan of Lightning Creek (Mr. Bowman)	400 ft.=1 in.	17
British Columbia, Plan of Williams' Creek (Mr. Bowman)	About 10 chs=1 in.	12

The above (five) mining plans are in hand, and will shortly be ready for publication.

Manitoba; Map showing the whole of Lake Winnipeg (Mr. Tyrrell) in progress	4 miles=1 inch.	48,600
Northern Manitoba (part of) in progress (Mr. Tyrrell)	2 miles=1 inch.	5,000
Northern Manitoba (Mr. Tyrrell) ready for publication	8 miles=1 inch.	20,000
Western Ontario, Lake of the Woods, sheet No. 2, ready for publication	2 miles=1 inch.	2,000

Western Ontario (Hunter's Island sheet) sheet No. 7 (Dr. Lawson) ready for publication	4 miles=1 inch.	3,456
Western Ontario, (north of Hunter's Island) sheet No. 6 (Mr. Smith) in progress	do	3,456
Western Ontario, sheet No. 9 (Mr. McInnes) in progress	do	3,456
Ontario, sheet No. 130, Sudbury mining district (Dr. Bell) published with part F, Annual Report, vol. V., 1890-91	do	3,456
Ontario, sheet No. 125, south of Sudbury sheet, in progress	do	(about) 1,800
do do No. 115, ready for draughtsman	do	3,456
do General map in progress	do	
Quebec, N.E. ¼ sheet (Eastern Townships map) ready for publication	do	4,500
Quebec, S.W. ¼ sheet (Eastern Townships map) in progress	do	4,500
Quebec, N.W. ¼ sheet (Eastern Townships map) in progress	do	4,500
Quebec and Lake St. John district, 2¼ sheets in progress (Mr. Low)	do	6,912
Quebec, ¼ sheet, 18 S. E (Messrs. Bailey & McInnes), ready for engraver		3,456
Quebec, ¼ sheet, 18 N. E. (Messrs. Bailey & McInnes), in progress	do	(about) 500
Quebec, Lièvre River and Templeton phosphate region, Ottawa county, 2 sheets (Mr. Ingall); sheet No. 2 engraved; sheet No. 1 ready for engraver	40 chns=1 inch.	220
New Brunswick, surface geology, ¼ sheets, 1 S.W., 1 S.E., and 1 N.E., 3 sheets (Mr. Chalmers), ready for publication	4 miles=1 inch.	6,650
Nova Scotia, ¼ sheet, 11 N.W. in the engraver's hands	do	
do ¼ sheet, 11 S.W. (Messrs. Fletcher & Faribault), published 1891	do	(about) 650
Nova Scotia, ¼ sheets, 4 N.E. and 4 S.E. (Messrs. Fletcher & Faribault), in progress	1 inch=1 mile.	

LIBRARY—SALES AND DISTRIBUTION OF PUBLICATIONS.

The librarian, Dr. Thorburn, reports that during the year, from the 2nd of January to the 31st of December, there have been distributed 8,593 publications of the Geological Survey Department, comprising annual reports, parts of these, special reports and maps. Of these, 5,918 were distributed in Canada; the remainder, 2,675, were sent to foreign countries as exchanges to scientific and literary institutions, and to a number of individuals engaged in scientific pursuits. In most cases, the institutions and individuals receiving the survey publications reciprocate by supplying the library with copies of their publications, or otherwise rendering important assistance in the work of the survey.

It may be stated that the general list of exchanges now amounts to 782, and, be sides these, there are upwards of 1,000 others receiving reports on palæontology, mineral statistics and botany. Due care has to be exercised in the distribution of the publications. Were all the applications granted, the supply, which is limited, would soon be exhausted. It is deemed advisable to retain a sufficient number in stock with which to supply future requirements. A large number of the earlier reports are already out of print, and can no longer be supplied.

The number of books, pamphlets and maps presented to the library last year was 2,307. Besides these, 146 books were purchased, and 38 periodicals, on geological, mineralogical and natural history subjects, were subscribed for.

The number of books bound in 1891 was 256.

The letters and acknowledgments sent to the library for publications distributed during the year were 1,952, and the number of letters sent out by the librarian was 1,053.

There are now about 9,000 volumes and 3,600 pamphlets in the library.

Attention is again called to the altogether insufficient space available for library purposes. The cases are all filled, and a large portion of the books are piled up round the library floor and in other parts of the building, and consequently, in many cases, it is difficult to find works which are required for consultation by members of the staff.

Sales of survey publications for the year ending 31st December, 1891, amounted to $3,550.03.

VISITORS.

The number of visitors to the museum during the year was 20,363, being an increase of 2,063 over 1890, and of 10,814 since 1882, the first year of the opening of the museum in Ottawa.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The strength of the staff at present employed is 56, viz., professional, 37; ordinary, 19.

During the calendar year the following changes in the permanent staff have taken place:—

Mr. W. F. Ferrier, appointed lithologist.

Mr. N. J. Giroux do assistant geologist.

Mr. A. E. Barlow do do

Mr. S. Barlow, chief geographer, promoted to the rank of chief clerk.

Mr. H. P. Brumell, promoted from the third to the second class.

The amount available for the fiscal year ended 30th June, 1891, was:—

——	Grant.	Expenditure.
	$ cts.	$ cts.
Civil list appropriation	47,330 00	
Geological Survey and Museum appropriation	60,100 00	
Artesian boring appropriation	10,000 00	
Civil list salaries		41,792 50
Wages of temporary employés		19,001 16
Exploration and survey		27,473 81
Boring operations, Deloraine, Man		6,514 48
Printing and lithography		9,605 39
Stationery, mapping materials and Queen's Printer		1,823 55
Purchase of specimens		309 40
Purchase of books and instruments		545 35
Purchase of laboratory apparatus and chemicals		508 05
Incidental and other expenses		1,805 72
		109,379 36
Less—Paid in 1890		6,534 66
		102,844 70
Add—Advances to field explorers		5,159 75
Unexpended balance, civil list appropriation		5,537 50
do general do		3,888 05
	117,430 00	117,430 00

The correspondence of the department shows a total of 10,852 letters sent, and 6,947 received.

I have the honour to be, Sir,
Your most obedient servant,
ALFRED R. C. SELWYN,
Deputy Head and Director.

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON A PORTION OF THE

DISTRICT OF ATHABASCA

COMPRISING THE COUNTRY BETWEEN

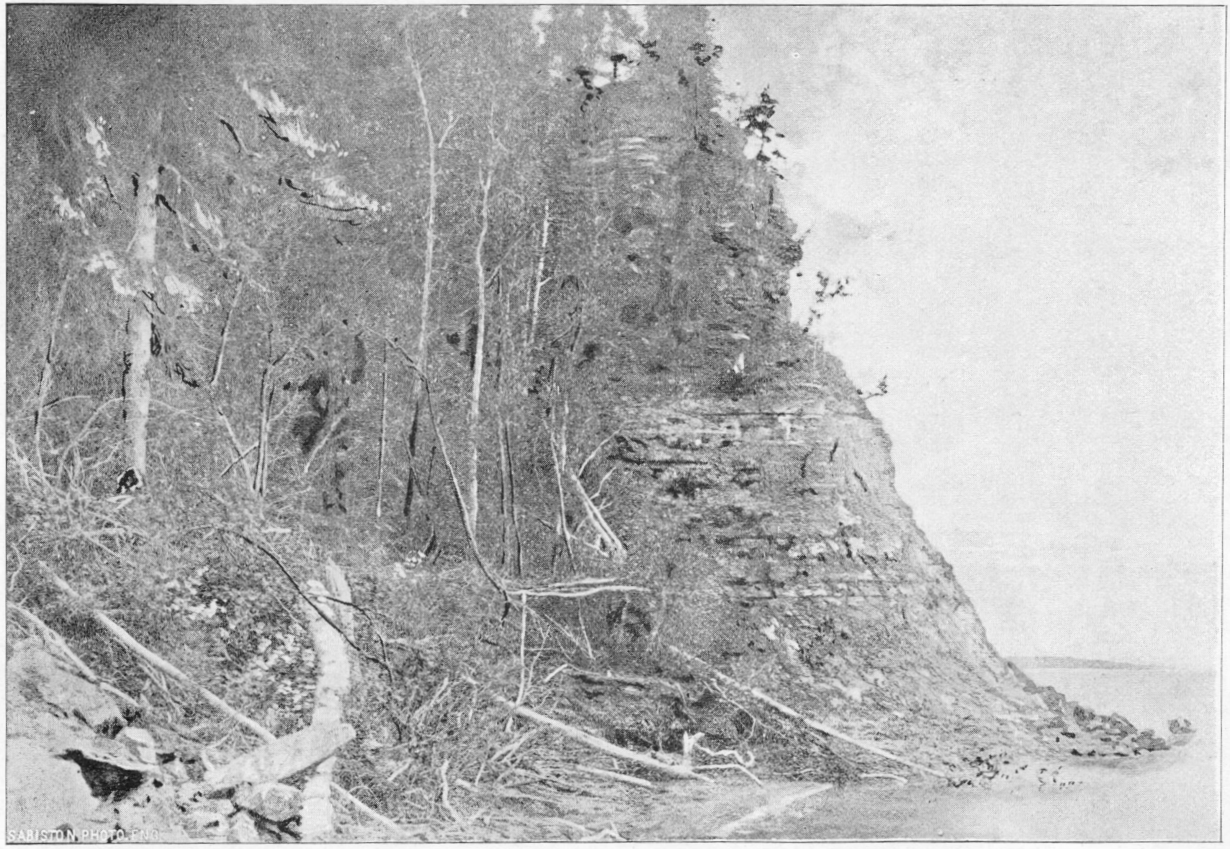
PEACE RIVER AND ATHABASCA RIVER

NORTH OF LESSER SLAVE LAKE

BY

R. G. McCONNELL, B.A.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY.
1893



R. G. McConnell, Photo., August, 1890.

CLIFF OF TAR SANDS, ATHABASCA RIVER.

To Alfred R. C. Selwyn, C.M.G., LL.D., F.R.S., &c.,
Director and Deputy Head,
Geological Survey of Canada.

Sir,—I beg to submit herewith a report on the geology and the general characters of the country in the vicinity of the Peace and Athabasca rivers. An index map of the region and two geological sections accompany the report. A map on a scale of eight miles to the inch has been completed, but is not yet published.

I have the honour to be, sir,
Your obedient servant,

R. G. McCONNELL.

Geological Survey Office,
Ottawa, December, 1892.

INTRODUCTORY.

Previous Explorations, General Physical Features and Agricultural Capabilities.

The history of the Peace and Athabasca country commences in 1778 when Peter Pond, subsequently a partner in the North-west Company, pushing north-westward in search of new fur districts, reached the Athabasca by way of Methy Portage and the Clearwater River, and descending it, founded a fort known as the "Old Establishment," about thirty miles above its mouth. In 1788, this post was abandoned and a new one built on the south shore of Lake Athabasca, on what is now known as "Old Fort Point." Still later, this site was also deserted and a better one selected on the north shore, near the outlet of the lake. A general map of the North-west was published by Peter Pond in 1785. Peter Pond's travels.

Peter Pond's venture proved extremely remunerative, and he was followed by other traders who gradually spread themselves over the then unknown country to the north and west. A complete survey of the Athabasca appears to have been made by David Thomson.* This energetic but little known traveller made a track survey in 1799 of Lesser Slave River, and of the Athabasca from the mouth of the Pembina to Clearwater Forks. In 1803, he filled in the gap between the Forks and Lake Athabasca, and in 1810 ascended the river and crossed the Rockies by the Athabasca Pass, thus completing his traverse. Peace River was ascended and surveyed by Sir Alexander Mackenzie in 1792, from its mouth to a point about six miles above the Smoky River Forks, but a post had been established some years before, near the present site of Fort Vermilion. In 1793 he completed his journey and explored the river to its source. David Thomson's surveys. Mackenzie's journey.

The portion of the Athabasca between the Clearwater Forks and the lake was examined and briefly described by Franklin in 1819 and 1825, and by Richardson in 1848, and as it formed part of the principal inland route to the Arctic Ocean, it was also travelled by Back, Simpson and other Arctic explorers. In 1843, Lefroy descended the Clearwater and the Athabasca River, and in 1844 ascended Peace River to Dunvegan, and then leaving the river travelled eastwards to Other explorers

*Brief narrative of the journeys of David Thomson in North-western America, by J. B. Tyrrell, M.A., Proc. Can. Ins., 1887-88, vol. VI., p. 135.

Edmonton by Lesser Slave Lake. Lefroy observed for latitude and longitude and established the magnetic variation at a number of points along his route. In 1875, Dr. Selwyn, Director of the Geological Survey, mapped and reported on the upper part of Peace River, as far down as the mouth of Smoky River, and in the same year Professor Macoun, who accompanied him proceeded down the river to Lake Athabasca, and returned east by the usual Athabasca-Clearwater route, while Dr. Selwyn reascended Peace River, and returned by British Columbia.* In 1879, Dr. Dawson examined Pine River, Smoky River and other branches of Peace river. In 1883, W. T. Thompson, D.L.S., extended the regular instrumental surveys of the Dominion Lands Branch, Department of the Interior, into the Peace River country. In 1882, a track survey and geological examination of the Athabasca, below the mouth of Lake La Biche River, was made by Dr. R. Bell†, and finally, in 1884, a micrometer survey of the lower parts of both the Peace and Athabasca rivers, was made by Wm. Ogilvie, D.L.S.

Area of country.

The country between the Peace and Athabasca rivers north of Lesser Slave Lake, comprising an area of about 44,000 square miles, was not entered by any of the travellers referred to and remained entirely unknown until the present exploration was undertaken.

General description.

The greater part of this district may be described as a gently undulating wooded plain, diversified with numerous shallow lakes, muskegs and marshes. Small prairie patches, manifestly due to forest fires, occur north of the west end of Lesser Slave Lake, at several points along the Loon and Wabiscaw rivers, also on Peace River around Fort Vermilion and at other places, but their tota area is relatively

Trees.

insignificant. The principal forest trees are the white and black spruces, *Picea alba* and *nigra*, the balsam-fir, *Abies balsamea*, the Banksian pine, *Pinus Banksiana*, the larch, *Larix Americana*, the aspen, *Populus remuloides*, the balsam-poplar, *Populus balsamifera*, and the canoe birch *Betula papyracea*. The species of spruce occur along many of the river flats, and on the uplands they are found nearly everywhere except on the drier hills. The white spruce attains, in favourable localities, a diameter of two feet or more, but it is usually much smaller. It is the most valuable tree in the district. The Banksian pine grows thickly on the sandy and gravelly ridges, while the aspen prefers a loamy soil and characterizes the best agricultural parts of the country. The larch, balsam, balsam-poplar and birch, although found in every part of the district, are more scattered and

*Geological Survey of Canada, Report of Progress, 1875–76.

†Geological Survey of Canada, Report of Progress, 1882-3-4.

do not form continuous forests like the spruce, Banksian pine and aspen. On the lower part of the Wabiscaw and Loon rivers a large irregular branched, rough barked cottonwood was noticed, which is probably *Populus monilifera*.

Elevations.

The rolling plains between Peace River and the Athabasca are relieved by several high ridges or plateaus, all of which owe their origin to a differential denudation of the soft rocks on which the plains are based. Of these Marten Mountain is situated north-east of Lesser Slave Lake, above which it rises to a height of about 1,000 feet. The Buffalo Head Hills commence abruptly about fifty miles above the mouth of the Loon River, with an elevation of about 2,500 feet above the sea, and running in a south-south-westerly direction die away opposite the mouth of Battle River, while Birch Mountain extends for nearly ninety miles along the lower part of the Athabasca, from which it is separated by a plain fifteen to twenty miles wide. Among the smaller elevations are Trout Mountain, which is situated north of the Wabiscaw River, and the Thickwood Hills, which lie south of Birch Mountain. The uplands of the district, like the lowlands, are all wooded, and are dotted everywhere with lakes and marshes.

Rivers.

The principal watercourse of the district is the Wabiscaw-Loon River. This stream, with its numerous tributaries, drains nearly half the region. Among the other rivers are the Pelican, Red, Moose and Tar rivers, flowing into the Athabasca; Birch River draining into Lake Claire; and the Red, Wolverine and Cadotte's rivers are tributaries of Peace River. The main rivers branch in the interior of the district into a multitude of small winding streams, few of which have valleys of any size, and they usually flow in a sluggish manner, often expanding into lakes in the flat districts, but break over the steeper slopes of the country in a series of strong rapids. With the exception of the lower part of Loon River, none of these rivers are navigable by steamers.

Lakes.

A noticeable feature of the district reported on is the multitude of lakes which occur everywhere, scattered over plains, plateaus and ridges. The lakes range in size from broad sheets of water twelve to fifteen miles in length, to small ponds a few feet across. They are usually shallow and weedy, and in many cases are being gradually filled up with *Sphagnum*. Many of the smaller lakes of former times have been completely filled up and are now represented by muskegs. The origin of most of the lakes is due to the numerous shallow depressions in the boulder-clay floor of the district, becoming filled with water; but in some instances they appear to have been caused by the damming up of some of the smaller streams by beavers.

Lake Claire, Lake Mammawee, and a number of other smaller lakes in the north-eastern part of the district, differ in origin from those just described, as they occupy part of the common delta-plain of the Peace and Athabasca rivers, which stretches from the west end of Lake Athabasca up both these streams for many miles. They represent portions of Lake Athabasca separated from the main basin by accumulations of stream detritus. These lakes are everywhere very shallow, their ordinary depth seldom exceeding nine feet, even in their deepest parts. In seasons of exceptionally high water, the low marshy plain separating them from the main lake, and from one another, is flooded, and they become re-united. Lake Claire is the largest of the group, being from ten to fifteen miles wide, and from twenty-five to thirty miles in length. The northern part of this lake has not yet been surveyed.

Agriculture.

The agricultural capabilities of portions of the Peace-Athabasca district are promising, but have not yet been thoroughly tested. Vegetables of various kinds are grown yearly without difficulty, at Fort Vermilion, Lesser Slave Lake, Whitefish Lake and Trout Lake, while potatoes are grown by Indians even on the summit of Birch Mountain, at a height of 2,300 feet above the sea. Wheat and other cereals have been fairly successful at Lesser Slave Lake and at Fort Vermilion, the only places where they have been tried. The prairie country around Fort Vermilion equals in fertility the famous Edmonton district and appears to enjoy an equally good climate, its higher latitude being compensated for by its more western situation, and by its lower elevation. This district is about 1,000 feet above the sea. In the interior, narrow strips of aspen-covered, but excellent land are usually found along the main rivers, and surrounding many of the lakes; and numerous areas, often equal in size to eastern counties, might be selected, which appear well adapted for cultivation, but the numerous swamps, muskegs and marshes, which separate these areas, detract greatly from their value. The western, and especially the north-western, portion of this district contains the most promising agricultural lands.

Description of Routes.

Canoe traverse from the Athabasca River to Peace River by way of the Pelican, Wabiscaw and Loon Rivers.

Canoe traverse from the Athabasca to the Peace.

The field season of 1888 was commenced by making a canoe traverse across the unexplored country lying between Peace River and the Athabasca, by way of the Pelican, Wabiscaw and Loon rivers. The

length of this traverse from the mouth of the Pelican to the mouth of the Loon, is about 200 miles, measured in a straight line, but the distance actually travelled, following the winding courses of the various streams, amounted to nearly 400 miles, and occupied altogether about three weeks. Two portages, one of three miles and the other of two miles, occur on the route, and great care had to be exercised in descending the unknown Wabiscaw River with its numerous rapids, but with these exceptions, no especial difficulties were encountered. Portages.

The Pelican River empties into the Athabasca about 102 miles below Athabasca Landing. Its length, from its source in Pelican Lake to the Athabasca, is about twenty-seven miles, measured in a straight line, but fully twice this distance following the numerous windings of the stream. It has a total fall of 544 feet, the greater part of this descent occurring in the last five miles, where it breaks through the plateau down to the level of the Athabasca. The lower portion of the stream in which this rapid descent takes place is unnavigable, and the traverse began by making a disagreeable portage of three miles out of the valley of the Athabasca—which is here 350 feet deep—through aspen and spruce forests and across muskegs to a point on Pelican River above the rapids. Pelican River.

From the east end of the portage to Pelican Lake, Pelican River maintains a general westerly direction, it has an average width of fifty to sixty feet, its current, as a rule, is sluggish, but boulder bars forming short rapids occur frequently for the first ten miles, and occasionally all the way up.

It is exceedingly crooked, and in one place a portage of less than a mile, saved a detour reported to be ten or twelve miles.

The principal tributaries of Pelican River are: Muskeg River, which enters it from the north, and is fully equal in size to the main stream; and Crooked Neck River and Long Lake Creek, which join it from the south. The country adjoining the Pelican River is low and generally wooded, chiefly with spruce and aspen, but in places the river winds through wide marshy flats covered with wild hay. The flat country extends southward to Pelican Mountain, a wooded ridge which can be seen from several points along the river, and which is said to extend westward to Marten Mountain, at the east end of Lesser Slave Lake.

The channel of Pelican River above the portage is only a few feet deep, and affords no geological sections, seldom even cutting down to the boulder clay. The small amount of erosion

performed by this stream evidences an origin subsequent to the Glacial period.

Pelican Lake.

Pelican Lake, the head of Pelican River, is a small lake about four miles in length and one to two miles in width, it is very shallow, and its water has the usual brownish colour of water issuing from muskegs. Its shores are low, and it is surrounded by shelving sandy and gravelly beaches.

Pelican Lake, like the majority of lakes in this district, occupies a shallow depression in the boulder clay and associated drift deposits, and has no connection in any way with the pre-glacial features of the country.

After crossing Pelican Lake, the traverse led up Beaver Creek, a small stream, in places, scarcely large enough to turn the canoe.

Beaver Creek.

Beaver Creek was followed in a westerly direction for two miles, and as the stream then turned to the south, we left it, and made a portage of two miles across the watershed, between the Athabasca and Peace rivers, to Sandy Lake, one of the sources of Loon River. Sandy Lake is rounded in outline, with a diameter of four to five miles, it is deeper than Pelican Lake, and its waters are clearer. Its height above the sea is 1,910 feet. Its shores are low, and like Pelican Lake, it occupies a hollow in the drift. Sandy Lake drains westward by Sandy Lake Creek into Wabiscaw Lake. Sandy Lake Creek is a stream of from fifty to seventy feet wide, and its length, measured in a straight line, is eleven miles. About half way down, it expands into a small lake, and two miles further on falls over the Devil's Rapids, where it makes a descent of about fifty feet. A portage of about a mile in length leads past the rapids, but they are not dangerous. The country bordering Sandy Lake Creek is generally wooded, but opposite the rapids a large space has been cleared by fires, originating from the camping places at the ends of the portage, and now forms a typical prairie. At the Devil's Rapids, Sandy Lake Creek develops a small valley, but no rocks are exposed. In the greater part of its course its bed is only a few feet below the general surface of the country.

Sandy Lake.

Sandy Lake Creek.

Wabiscaw lakes.

At the head of the Wabiscaw River, are the two Wabiscaw lakes. The upper lake is about six miles long, and from two to three wide; its water is shallow and is filled with small algæ, probably belonging to the genus *Aphanizomenon*. South of the lake, the flat or slightly rolling plain, wooded with aspen and spruce, which characterize the region, is terminated at a distance of twelve to fifteen miles by a range of low hills, connecting Pelican and Marten mountains. In other directions no high land is visible.

The stream connecting the two Wabiscaw lakes is about three miles in length and winds sluggishly through a marshy flat covered with wild hay.

The lower Wabiscaw Lake is about eight miles long with an average width of three miles. It is deeper than the upper lake, and its water is clearer. Boulder clay is exposed in two places along its eastern shores, but no outcrops of the older rocks were seen. Numerous boulders occur along the beach in places. These consist principally of Archæan gneisses, but others of sandstone and limestone are not uncommon. Boulder clay outcrops.

The Wabiscaw lakes are drained by the Wabiscaw River, which, with its continuation, Loon River, is the most important stream in the district examined; it has a course of 290 miles and drains an area of about 14,200 square miles. The principal tributaries are Bear, Trout, House and Loon rivers, which join it from the west, and Wood Buffalo, Pine and Panny rivers, which enter it from the east. Most of these streams have their sources in lakes, but they have not yet been explored. Tributaries of Loon River.

The Wabiscaw River, after leaving Wabiscaw Lake, runs in a south-easterly direction to Pine River, a distance of about forty-seven miles, in a straight line; its width varies from 75 to 120 yards; for some miles from its head the current is sluggish and the channel of the stream is encumbered by numerous gneissic boulders, through which we had some difficulty in finding a passage. Twelve miles from the lake, Bear River joins the Wabiscaw from the west, and is almost equal to the latter in size. It heads in Bear Lake, but is continued under the name of Whitefish River to Whitefish Lake, and has only been partially explored. Above the junction of Bear River with the Wabiscaw, the latter is interrupted by a series of short rapids, but after passing these it is easily navigable for many miles. At the rapids the river cuts through a small ridge, and a valley about fifty feet deep is developed, while above and below the banks disappear, and the bed of the river is only a few feet below the general level. The adjacent country is all well wooded, chiefly with aspen, interspersed with groves of spruce. Five miles below Bear River, Trout River comes in from the same side. This stream is about sixty feet wide and originates from the Trout lakes. Below Trout River the Wabiscaw is easily navigable, the current averaging about two miles an hour, and is uniform in appearance until near Wood Buffalo River; at this point the slope of the stream increases and rapids occur at the extremities of all the bends. Wabiscaw River. Character of adjacent country.

Current of rivers.

From Wood Buffalo, to House River the current of the Wabiscaw is generally rapid, and stretches of rough water occur frequently. Two miles above House River a recent change in the course of the stream was noticed. Here the river, apparently within the last few years, has broken through the tongue of land separating two of the bends, and rushes with great velocity between the high boulder-clay banks of the narrow gap thus formed. The old channel is now quite dry for about two miles. Below House River the Wabiscaw winds for some miles through a flat, swampy region; further on it straightens out and runs with a swifter current through a somewhat higher region. Here a valley from fifty to sixty feet deep is gradually developed, but disappears again before reaching Pine River. From Pine River the Wabiscaw bends more to the west and runs in a general north-westerly direction towards the Buffalo Head Hills. Between Pine River and Two Lakes Creek, canoe navigation is comparatively easy, although a few small rapids occur about half way down. The average width of the stream is about 100 yards, and the current runs at a rate of from two to four miles an hour.

Channel changed.

Navigation.

Valley deepens.

Two large tributaries come in from the north, the names of which I could not learn. Descending the Wabiscaw, its valley gradually deepens and at the mouth of Two Lakes Creek, it is 350 feet deep. The banks are generally wooded, chiefly with aspen, mingled in places with spruce. Twelve miles below Two Lakes Creek the Wabiscaw falls over the Grand Rapids, so-called, although they are not very formidable. These rapids are about a mile in length and consist of three distinct rapids; the upper two were run without trouble by keeping close to the left bank, but the lower one is shallower and crowded with boulders, and we were obliged to cross to the right hand and let the canoe down with a rope; at high water no trouble would be experienced in shooting the whole rapid. Nine miles below the Grand Rapids, Panny River, one of the largest tributaries of the Wabiscaw comes in from the east. This stream is about 100 feet wide, and is reported to head in Chippewyan Lake, but it has not been explored.

Grand Rapids

Loon River.

A few miles lower down, Loon River joins it from the west and thence gives its name to the main stream. Loon River heads in Loon Lake, which is described on a succeeding page. Loon River is much smaller than the Wabiscaw, enters the latter at right angles, and has no geographical right whatever to give its name to the common stream. From the junction of the Wabiscaw and the Loon rivers, to Muddy River, a distance of about thirty miles in a straight line, Loon River has a current of about three miles an hour and is almost free from rapids. The valley is about 250 feet deep, and with its steep grassy and wooded banks often presents a very picturesque appearance.

Muddy River is about sixty feet wide ; it drains part of the Buffalo Head Hills, and its waters are usually discoloured by sediment, derived from the waste of the shales of which these hills are composed. Muddy River.

Below Muddy River, Loon River skirts the base of the Buffalo Head Hills for some miles, and appears to cut through their lower slopes, as the valley acquires an increased depth and assumes for some distance the appearance of a cañon. In this reach, steep banks often exceeding 400 feet in height, cut out of the dark Cretaceous shales, narrowly inclose the river. The current of the river is also swifter than usual, and strong, but easily-run rapids are numerous. The valley of the Loon River maintains its narrow gorge-like character for about fifteen miles, but before reaching Bat River the elevation of the country through which it cuts is suddenly lowered, the valley becomes shallower and wider, and the naked scarps are replaced to a large extent by woody and grassy slopes. Below Bat River the Loon River becomes very tortuous and continues so all the way to Peace River. The river flats become large and are occasionally partly open, in some cases giving evidence of having been cleared by ice. A few miles above its junction with Peace River the current of Loon River decreases to two miles an hour, the valley disappears, and the width of the stream increases to about 150 yards. Two miles above its mouth it receives Bear River, a small muddy stream coming from the direction of the Buffalo Head Hills. Narrow valley. Current lessens.

The Loon-Wabiscaw River might possibly be navigated, by powerful steamers, as far as the Grand Rapids, during the season of high water, and by using the line occasionally, but with the exception of a few miles of still water above its mouth, it can hardly be considered a navigable stream.

Peace River.

Peace River is formed by the junction of the Finlay and Parsnip rivers, two transmontane streams, and is the largest and longest of the tributaries of the Mackenzie. It rises in, and drains a large district west of the Rocky Mountains, and then continuing eastwards, intersects the axis of that range, and drains the country lying along its eastern slopes, through four degrees of latitude. Its length, from the confluence of the Finlay and Parsnip rivers, to the point at which it unites with the waters flowing from Lake Athabasca to form Slave River is 757 miles, but measuring from Summit Lake, the source of its principal branch, it is approximately 905 miles. Peace River. Length of Peace River.

Peace River forms the eastern boundary of the region embraced in this report, and was examined from the Smoky River Forks to the mouth of Red River, a distance of 311 miles.

Between Smoky River Forks and the mouth of Battle River, a distance of 108 miles, the general course of Peace River is northerly. Its average width in this distance is about 400 yards, but it occasionally expands to nearly twice this size. The current has a uniform rate of about four miles an hour. The valley is deep, and in places presents a very picturesque appearance. It is about two miles wide, and at the mouth of Smoky River the water is not less than 700 feet below the level of the plateau. Going northward the valley becomes gradually shallower, and at Battle River its bottom is only 600 feet below the plateau. The banks are often scarped, and where composed of sandstone are precipitous.

Valley of Peace River.

Traverse to Wabiscaw River.

A short traverse was made on foot from a point about three miles above Battle River eastward to Wolverine River, and up that stream for some distance. After climbing out of the valley of Peace River, which is here 600 feet deep, we passed through a spruce, aspen, and Banksian pine forest, about a mile wide, and then entered a rolling country partially cleared by forest fires. Beyond this, all the way to Wolverine River, the trail crosses a succession of wide muskegs, sandy ridges, covered with Banksian pine, and loamy ridges, covered with aspen. Wolverine River, where we reached it, is a small sluggish stream about thirty feet wide. Its valley is about fifty feet wide, but the banks are not scarped, and no exposures were seen. We followed it up for about ten miles through small prairies, aspen woods and muskegs, and then, finding that it afforded no geological information, or prospect of any, we returned.

Uniform appearance of river.

Below Battle River, to the Vermilion Falls and rapids, a distance of nearly 200 miles, Peace River is rather monotonous and the current is less rapid, having a uniform rate of about three miles an hour. The valley decreases in depth to about 100 feet, and the sandstone cliffs, which lend variety to the upper stretches of the river, disappear, and are replaced by grassy and wooded slopes, or by the sombre clay shales of the Cretaceous. Islands become more numerous, and the bars gradually change from gravel to sand.

Traverse to Buffalo Head Hills.

From Fort Vermilion, one of the establishments of the Hudson's Bay Company, 152 miles below Battle River, a traverse of about forty miles was made inland to the Buffalo Head Hills. For the first ten or twelve miles the trail led across a partially wooded and fertile prairie, and then through marshes, alternating with wooded ridges to Buffalo Lake, a small sheet of water from two to three miles long, and about

R. G. McConnell, Photo., July, 1889.

VERMILION FALLS, PEACE RIVER.

a mile wide. Buffalo Lake is bordered by extensive meadow lands, covered with luxuriant grass. After leaving it, we passed through an aspen wood, crossed two small streams flowing into Bear River, and then for some miles, travelled through a belt of partly wooded, partly open country, which lies at the foot of the Buffalo Head Hills. The greater part of the land just described, is well fitted for settlement.

Buffalo Head Hills.

The Buffalo Head Hills are about fifty miles long, and from twenty-five to thirty miles wide, with a height of 2,500 feet above the sea. The northern and north-eastern escarpments are the boldest, and rise to a height of 1,000 feet above the plains at their base. To the southward, the relative elevation gradually decreases, and the hills appear to die away opposite Black River. The summit, so far as observed, is a level, slightly-rolling plain densely wooded with aspen and spruce.

Vermilion Falls.

Below Fort Vermilion, Peace River runs in an easterly direction for forty-six miles to the Vermilion Falls and Rapids. Vermilion Falls, like the Cascade Rapids on the Athabasca, are caused by the river falling over a low limestone ledge. The height of the falls varies according to the volume of water. At low water they are from fifteen to twenty feet high, while at high water, they become greatly reduced, and on one occasion were descended in safety by a York boat. Peace River at this point is nearly a mile wide; the falls are not continuous all the way across, but are interrupted at several points by the higher portions of the limestone ledge. A mile above the falls a strong rapid occurs, a third of a mile in length, and these two obstructions constitute the only serious break in the navigation of Peace River for hundreds of miles.

Peace River below Vermilion Falls.

Peace River was not examined below Vermilion Falls. In its lower stretches the river averages nearly a mile in width, the current is gentle and uniform and the valley almost disappears. A small rapid occurs at one point, but does not obstruct navigation except during low water.

Red River.

Two Red rivers heading in Birch Mountains.

In the district reported on there are two Red rivers, one draining into Peace River and the other into the Athabasca. Both head in lakes situated within a few miles of each other on the Birch Mountains, and the Indians frequently carry their canoes from one stream to the other. The westward-flowing Red River empties into Peace River five miles below the Vermilion Falls. It is about 240 miles long, and averages about 200 to 250 feet in width. Its name is derived

from the reddish-brown colour of its waters. It was ascended for about 100 miles, measuring in three stretches along the river, but for fully 160 miles following the tortuous course of the stream.

Description of Red River.

From its mouth, to Owl River (Oho sipi), a distance of fifty miles, measured in a straight line, Red River follows a general direction a little west of south. For some miles above its mouth it is confined by low limestone cliffs, and the current is swift, with occasional rapids. Further up, the limestone banks disappear, and the river winds for many miles between low boulder-clay, and mud banks, through a flat, wooded and monotonous country. Thirty miles above its mouth, rapids commence again, and extend for several miles, and a valley about 100 feet deep is developed. The plateau adjoining the river has been burnt over in places, and small prairie patches appear occasionally. Near the head of the rapids, the river has recently broken through the neck of one of the bends, and the water, pouring with great velocity through the new and much shortened channel, strikes the opposite bank with great force; a part of it is deflected up the old channel, and passing completely round the bend, a distance of about a mile, falls into the river again above the break. The curious feature is here presented of a river reversing its course for a considerable distance. This, of course, only happens when the river is flooded. Above the rapids the current gradually diminishes, the valley disappears, and the river continues to be easily navigable as far as Owl River; above Owl River, a small stream, fifteen to twenty feet wide, enters Red River from the left. At Owl River, Red River approaches to within a few miles of the Wabiscaw, and the Buffalo Head Hills, which are situated on the further side of the latter stream, are plainly visible at an estimated distance of ten to fifteen miles. Above Owl River, Red River bends almost at right angles to its former course and runs in a direction a little south of east to the Birch Mountains. A few miles above Owl River, rapids commence again, and short stretches of rough water occur frequently for fifteen or twenty miles, above which they disappear and the current remains uniform as far as Burnt River. Burnt River is a stream about forty feet wide and is the first large tributary of the Red River. Its water is dark and is evidently derived from the numerous muskegs of the region. Above Burnt River, small rapids reappear and increase in frequency until the river becomes one continuous and wild rapid; and, as a walk of eight or ten miles up the valley showed the rapids to continue for that distance at least, it was decided to return, as our supplies were almost exhausted. In these rapids Red River has a fall of fully 250 feet over the western face of a gradual rise in the general elevation of the region. A view

Course of river reversed.

Burnt River.

Long rapids.

from the summit showed a range of hills in a direction which I took to be the Birch Mountains. From the foot of the long rapids, we descended to Peace River, easily in four days, although the ascent had cost us ten long days of hard labour.

Navigation of Red River.

Red River is not a navigable stream and can only be ascended, even in canoes, during high water. It is, however, quickly affected by rains, and the showery weather which we experienced while on it, kept it in a fairly high stage and enabled us to proceed. Like most of the streams in the district its valley is insignificant and affords little geological information.

Lesser Slave Lake.

Description o Lesser Slave Lake.

Lesser Slave Lake is a long and comparatively narrow sheet of water, extending in an east and west direction along the southern border of the region already described. It is sixty-one miles long, has an average width of eight miles, a maximum width of twelve miles, and covers altogether an area of 484 square miles. Lesser Slave Lake, notwithstanding its size, is very shallow, seldom exceeding ten feet in depth in low water, and over a large part of its area is much less. The deepest part of the lake lies to the east of the narrows, south-west of Marten Mountain. The north shore of the lake is fairly regular in outline, with stony and sandy beaches, while low bluffs of boulder clay and Cretaceous shales occur occasionally. The southern shore is nearly everywhere marshy, and affords no exposures. A series of plateaus from 800 to 1,000 feet high, of Laramie sandstone and shale, runs parallel with the southern shore at a distance of eight to ten miles, but decreases in height westward, and terminates in a low ridge running round the bay, which forms the western end of the lake. Along the northern side, the land slopes up from the shore to a height of 150 feet, but after passing Marten Mountain going eastward, it suddenly rises to a height of about 1,000 feet, forming the elevation known as Marten Mountain. This range of hills follows the north-eastern shore of the lake for some distance, and then stretches eastward to Pelican Mountain. No exposures were found on it, but it is evidently a continuation northward of the Laramie plateaus south of the lake.

Forests.

Marshes covered with wild hay occur along the southern and western shores of Lesser Slave Lake, and a small prairie has been cleared by forest fires, north of the west end of the lake, but the country generally is covered with the same monotonous spruce and aspen forest which characterizes the whole northern region.

Feeders.

The principal streams flowing into Lesser Slave Lake, are, from the west, Heart River; from the north, Salt Creek, the Narrows River

and Marten River; and from the south, Swan River and two smaller streams, the names of which I did not ascertain. The outlet is from the eastern end, by Little Slave Lake River into the Athabasca. All of the streams emptying into Lesser Slave Lake are insignificant in size and can only be navigated in high water with small canoes. An attempt was made in September to ascend Marten River, which skirts the western base of Marten Mountain for some distance, but this was found to be impossible owing to the numerous piles of driftwood which blocked the river every few hundred yards. Heart River is reported to be navigable for a considerable distance, and by ascending it, and portaging for two miles, to a chain of lakes, canoes can be taken to Whitefish Lake.

Traverse from Lesser Slave Lake to the Wabiscaw River by Whitefish Lake, Bear Lake and Trout Lake.

Country between Lesser Slave Lake and Whitefish Lake.

The trail to Whitefish Lake leaves Lesser Slave Lake at the crossing of Salt Creek near its mouth, and runs in a general north-easterly direction. The distance in a straight line is twenty-eight miles. After leaving Lesser Slave Lake the trail leads across a hay-covered flat, only slightly raised above the lake, and then following up Salt Creek mounts the plateau which is here about 200 feet high and passes for some miles through a rolling well-grassed prairie, the evident product of forest fires. Ten miles from the lake, the limit of the open country is reached, and the trail enters the forest, and then winds along the dry wooded ridges which separate the numerous muskegs and beaver meadows with which the country abounds. Horse Creek, a small stream probably tributary to Heart River, is bordered by two miles of open country, after passing which the trail leads through an aspen forest nearly all the way to Whitefish Lake.

Whitefish Lake.

Whitefish Lake is from ten to twelve miles long, and four to six miles wide. Its shores are low and featureless, and it is surrounded on all sides by an aspen-covered country, which, if cleared would afford excellent farming land. It drains northwards by Whitefish River into Bear Lake, and thence into the Wabiscaw. It is 2,075 feet above the sea level. At its western end it is connected with a smaller lake by a sluggish stream two miles in length, on which is situated a small trading post belonging to the Hudson's Bay Company. A small clearing has been made in the vicinity of the post, and some potatoes and other garden produce are annually grown, but the inhabitants depend for their subsistence, principally on the whitefish with which the lake abounds, and from which it has taken its name.

From Whitefish Lake the trail to Trout Lake leads for some miles through an aspen forest, where the travelling is fairly good, and then crosses a succession of sphagnum-filled hollows, alternating with wooded ridges to Swampberry Creek (Wĭ-si-ki-ni-mi-ni Si-pi). This stream is about twenty feet wide and flows through a wide valley with sloping wooded banks. It afforded no exposures. It was crossed shortly after reaching it and we followed down its left side through numerous muskegs and marshes until it emptied into a lake of the same name. Swampberry Creek.

At Swampberry Lake the writer separated from the pack train, which was sent on to Trout Lake, and made a canoe traverse to Bear Lake. Swampberry Lake is a shallow sheet of water about four miles long and one mile wide, and is surrounded by low marshy shores and spruce-covered flats. Its outlet, a small weedy stream from fifteen to thirty feet wide, empties, after a short course, into Whitefish River, the outlet of Whitefish Lake. This stream is about thirty feet wide. It has low banks overhung on both sides by willows, and flows at the rate of two to three miles an hour. No rapids were found on it, but it is occasionally blocked with piles of drift wood making portages necessary. It is extremely crooked, and at one point, a great bend, said to take nearly a day to go round, was avoided by making a short portage to a small lake. This was crossed, and its shallow and weedy outlet descended to Whitefish River, the whole traverse occupying about an hour. Below the portage, Whitefish River is from fifty to sixty feet wide, and winds for a number of miles through wide marshy meadows, in the middle of which it receives Shoal River, a small stream about twenty feet wide. Below Shoal River a ridge is crossed, the banks become higher, and the tamarack and willow are replaced by an aspen forest. A second wide marsh then appears, followed by a ridge, through which the banks are thirty feet high and show boulder clay in one or two places, but nothing older was seen. Beyond the ridge the bordering flats again become marshy and continue so until Bear Lake is reached. Canoe traverse to Bear Lake.

Bear Lake receives two other small streams, besides Whitefish River which we descended. It empties into Bear River which flows into the Wabiscaw twelve miles below Lake Wabiscaw. It is four to five miles long and about two miles wide, and, like the other lakes of the district, occupies a shallow basin in the drift. A low ridge skirts its eastern shores and a second ridge running south-eastward terminates in a rounded wooded hill near its outlet, and may afford exposures where cut by the river, but I was unable to visit it. Bear Lake.

Trail from Bear Lake to Trout Lake.

From the mouth of Whitefish River we crossed to the northern end of the lake, then *caching* the canoe, set out on foot for Trout Lake. The trail led almost due north, through an aspen forest, with occasional swamps and muskegs. Nine miles from the lake we came to a small stream flowing eastward, and shortly afterwards to Trout River, which we followed up for two miles, and then crossed. Trout River empties the waters of Trout Lake into the Wabiscaw. It is a shallow but rapid stream about seventy feet wide, and has much clearer water than other rivers of the district. It skirts for some distance, and partly cuts through, the elevation known as Trout Mountain. Its valley showed no sections, and the loose rocks in its bed were exclusively Archæan, and afforded no indications of exposures in its upper part. After crossing Trout River, the trail led to the summit of a ridge about 300 feet high, forming part of Trout Mountain, and then continued parallel with Trout River, to Mudpout Lake (Ni-ye Sâ-ga-hà-gan), passing through deep muskegs and over sandy ridges covered with Banksian pine the greater part of the distance.

Mudpout Lake.

Mudpout Lake is an expansion of Trout River, and is about three miles long by a mile wide. It is connected with Trout Lake by a short stream, two miles long, on which is situated a small trading post of the Hudson's Bay Company.

Trout Lake.

From the Hudson Bay post at Trout Lake, an exploratory trip was made northward to the Wabiscaw River, in order to connect with the traverse down that stream. A guide and canoes were obtained at the fort, as the way led through a chain of lakes connected with Trout Lake. Trout Lake is divided into two parts, by narrows half a mile in length. The lower lake is five to six miles long, and four to five miles wide at its widest part. The comparatively clear condition of the water, is due to the latter passing through a chain of lakes, and on the way, depositing its sediment; and is illustrated by the fact, that trout are obtained there in abundance. A wooded ridge follows the north-eastern shore of Trout Lake, and our guide stated that

Manitou Lake.

Manitou Lake lies behind this ridge. Strange tales are told of this lake by the Indians. Drums beaten by invisible hands have been heard by the awe-struck Indians; fires have been seen at night dancing over the surface of the water, and Indians have mysteriously disappeared, their canoes being afterwards found right side up and uninjured.

The upper Trout Lake is ten miles long, and at its upper end widens into a bay six to seven miles wide. It is connected by a small winding stream with Good Fish Lake, a small body of water about two miles long. After leaving Good Fish Lake we crossed Rush Lake, and followed a short stream a mile and a half long into

Long Lake, and thence into Round Lake, the head of the series. The stream connecting Long Lake and Round Lake is two miles in length, and is interrupted by a series of rapids, necessitating a portage of half a mile.

Lakes on Trout Mountain.

From Round Lake a portage of nearly a mile is made to Kidney Lake across the watershed separating Two Lakes Creek from Trout River. Kidney Lake is situated on nearly the highest point of Trout Mountain, and has an approximate elevation above the sea of 2,320 feet, or nearly the same as Birch Mountain. Two miles from Kidney Lake the trail reaches the edge of Trout Mountain, and a gradual descent of 320 feet is made. At the foot of this escarpment is Two Lakes, the source of Two Lakes Creek. Camped on the shore of this lake, I found a solitary Iroquois Indian the only representative of his tribe in the whole district. From Two Lakes a good trail led northward through alternating forest and muskeg to the Wabiscaw River, meeting the latter about a quarter of a mile below Two Lakes Creek. The valley of the Wabiscaw at this point is 350 feet deep, and the total descent from the top of Trout Mountain to the river is 820 feet. No sections of any kind were seen along the route examined.

Country south of Trout Lake

After returning to Trout Lake, I accompanied the pack-train on the return journey to Lesser Slave Lake. For some miles from the Post at Trout Lake the country is of the most worthless description, wide muskegs alternating with sandy ridges covered with Banksian pine, and with occasional aspen-covered ridges. Five miles from Trout Lake we crossed a tributary of Trout River about thirty feet wide, winding between marshy flats in a valley about 100 feet deep, and seven miles further on came to Shoal River. From this point a side trip was made on foot to Loon Lake, the source of Loon River. An old trail, impassable for horses, owing to the numerous muskegs and marshes, but practicable on foot, was followed for a distance of about twenty-two miles, as far as Red Earth Creek, a tributary of Loon River. From Red Earth Creek we struck westward until we reached the Loon River, and then followed it up to the lake. Between the crossing of Shoal River and Loon Lake, muskeg and marsh alternate monotonously with pine and aspen ridges, and, with the exception of an aspen-covered strip along Loon River, very little country suitable for any purpose was seen.

Trail to Loon Lake.

Loon Lake.

Loon Lake proved to be much smaller than expected. It is about seven miles long, with an average breadth of about two miles. It is shallow, with low banks, and is situated in the midst of a low wooded and marshy district. The eastern shore is bordered by a wide marsh, the home of innumerable flocks of wild fowl. Loon Lake is much lower than Trout Lake, being only about 1,660 feet above the sea.

After rejoining the pack-train, we continued south-westward along the Trout Lake trail, wading for most of the distance through muskegs and marshes to Swampberry Lake, where I separated from the pack-train on the way north. From Swampberry Lake back to Lesser Slave Lake the same trail was followed as on the way out.

General description of country north of Lesser Slave Lake.

The country north of Lesser Slave Lake, bordering the Trout Lake trail, may be described, generally, as a lightly rolling plain, elevated about 2,000 feet above the sea, the surface of which consists of a network of low ridges, wooded with aspen, spruce and Banksian pine, separated by muskegs, marshes, beaver meadows and shallow lakes, some of which are ten or twelve miles long. The streams are small and have little excavating power, seldom cutting through the drift to the rocks beneath, and consequently affording little geological information.

Athabasca River.

Athabasca River.

The Athabasca is the most southerly of the three great tributaries of the Mackenzie. It rises in the summit ranges of the Rocky Mountains between latitude 52° N. and longitude 54° N., and after a north-easterly and northerly course of 776 miles empties into Lake Athabasca. From thence, its waters are conveyed by Slave River to Great Slave Lake, and thence by the Mackenzie to the sea.

Portion examined.

The Athabasca was examined in the course of the present exploration, from its junction with Little Slave River to its mouth, a distance of 456 miles. Between Little Slave River and Athabasca Landing, a distance of 66 miles, the course of the Athabasca River is at first easterly and then southerly. Its width averages about 250 yards, and it occupies a valley 350 feet deep and about two miles wide. The current has a fairly uniform rate of three to four miles an hour, and the river is easily navigable.

At Athabasca Landing, which is the terminus of the cart trail from Edmonton, the goods required in the fur trade are shipped northward and westward by steamers and York boats, to the Peace, Athabasca, and Mackenzie River districts.

From Athabasca Landing to the Grand Rapids, a distance of 153 miles, the general course of the river is northerly, its width varies from 250 yards to 400 yards, and the current, except for occasional accelerations, is fairly steady at three to four miles an hour as far as the mouth of the Pelican River. Between Pelican River and the Grand Rapids, three rapids occur, viz., Pelican and Stony Rapids, and the Rapide du Joli Fou, so called on account of an unskilful steersman running his boat against the most conspicuous rock in the channel.

Rapids.

These rapids obstruct the navigation of the river in low water, but at medium or high water they are easily ascended and descended by the steamer plying between Athabasca Landing and the Grand Rapids. The river valley in this stretch is 300 to 400 feet deep, and the banks consist of a succession of slides due to the plastic character of the clay shales through which it is cut. The grade of the Athabasca River between the mouth of Little Slave River and the head of the Grand Rapids amounts to 2·72 feet per mile, the total fall being 596 feet. Valley.

At the Grand Rapids, the character of the Athabasca River entirely changes, its grade becomes greatly increased, and for the next seventy-six miles, or as far as its junction with Clearwater River, there are swift and dangerous rapids every few miles. At the Grand Rapids the river falls between fifty and sixty feet in about half a mile. The rapids are caused by the river meeting and cutting through a soft sandstone terrane of the Cretaceous. This sandstone is filled with hard spherical concretions which become gradually liberated as the matrix is slowly worn away. The concretions, some of which are six to eight feet or more in diameter, now pave the channel of the river, and the water in its swift descent, breaks over them in a tumult of waves and foam. The Grand Rapids are unnavigable by craft of any kind. There is a small island about a quarter of a mile long opposite the worst part of the rapids; boats are brought down to the head of the island and their contents portaged across by means of a short tramway which has been built by the Hudson's Bay Company. From the foot of the island, the river is again navigable, but it continues rough for two or three miles. After passing the Grand Rapids, and the rough water below them, the Athabasca runs smoothly for over twenty miles, and then rushes down the Burnt Rapids. In this stretch the valley is deep and gorge-like. The banks are from 500 to 600 feet high and are often terraced by differential denudation. At the Burnt Rapids the river is shallow and filled with boulders, but the fall is not so great as at the Grand Rapids, and we had no difficulty in descending them. The canoe channel follows the left bank. The Burnt Rapids are followed by sixteen miles of smooth water, below which the river falls in quick succession over the Boiler, Middle and Long Rapids, all of which occur within a stretch of seven miles. These three rapids are similar in character to the Burnt Rapids, and owe their existence to a steeper declination than usual, combined with an accumulation of boulders in the channel of the river. They are all navigable at ordinary stages of the water, both with canoes and York boats. Five miles below Long Rapids the river makes a sharp bend, at

Change at Grand Rapids.

Grand Rapids.

Deep valley.

Burnt Rapids.

the extremity of which is Crooked Rapid, where two ledges of limestone project into the stream from the right side, but no trouble was experienced in running down close to the left bank. Below Crooked Rapid the river falls over several limestone ledges, forming Rock Rapids and the Little and Big Cascades. Small falls extending partly across the river occur at these points, but the ledges are broken down in places enabling boats to get through. Below the Cascades the river is unobstructed for eight or nine miles to Mountain Rapid. This rapid, like the Cascades, is formed by the river flowing over a low limestone ledge. A short portage was made here, but at certain stages of the water, a channel navigable by small boats exists near the centre of the river where the ledge has been worn down. Mountain Rapid is the last dangerous rapid on the river. Two miles above the Forks, Moberly Rapid was passed, but the fall there is slight.

Crooked Rapid and Cascades.

Grade of river.

The fall of the Athabasca, between the head of the Grand Rapids and the Clearwater confluence, a distance of seventy-six miles, amounts to 360 feet, an average of 4·7 feet per mile.

Athabasca River below the Clearwater.

Below the confluence of the Clearwater River the character of the Athabasca entirely changes, the rapids disappear, and the river, enlarged to a third of a mile in width, flows smoothly at an average rate of three miles an hour. The valley increases in width and the banks gradually decrease from an elevation of about 400 feet at the Forks to the level of the delta. In passing through the delta the channel divides in several branches, and new channels are constantly being opened and old ones closed by the spring floods. From the Forks to the head of the delta, a distance of 130 miles, and thence to Athabasca Lake, a further distance of thirty-one miles, the Athabasca offers no obstruction to navigation. The steamer "Grahame," owned by the Hudson's Bay Company, has been plying on this portion of the river for some years.

Traverse from the Athabasca to Moose Lake, Birch Mountains, and return by Moose River.

Trail to Moose Lake.

The trail to Moose Lake leaves the Athabasca River about a mile below the mouth of Red River, and follows the valley of the latter for about five miles. At this point Red River bends away to the south, and the trail continues a little north of west across a wide muskeg to Moose River, which it crosses. At the crossing, Moose River is a rapid stream 100 feet wide, in a valley about eighty feet deep, the banks of which are formed of tar sands capped with dark shales.

From Moose River the direction of the trail is a few degrees north of west to the foot of Birch Mountain, a distance of about twelve miles. This district is slightly undulating, with a number of muskegs and marshes in the depressions, and is wooded chiefly with small aspen, spruce and Banksian pine.

Birch Mountain.

The eastern escarpment of Birch Mountain, where the Moose Lake trail crosses it, is about 500 feet high, the ascent is easy, and is made in about two miles. From the brow of the escarpment the surface slopes gradually upward towards the centre of the plateau, where it is about 2,300 feet above the sea, or about 1,500 above the level of the Athabasca. The surface of the Birch Mountain uplands is rolling and drift covered, and near the Moose Lake trail, is indented by a number of old valleys holding small streams and lakes, which are evidently pre-glacial in origin.

The forest is similar in character to that covering the plains beneath, but has been largely destroyed by fires.

Moose Lake.

Moose Lake, the objective point of the traverse, is situated about twenty miles from the edge of the mountain, and occupies a wide depression about 300 feet below the level of the plateau. It is a shallow lake, about two miles long, and is separated into two parts by narrows, on the right side of which are two small huts, used at times by the Hudson's Bay Company as a trading post. It receives from the south, by a short stream, the waters of Buffalo Lake, which is seven to eight miles long and two to three miles wide, and northward is said to be connected by a series of small streams with a chain of five lakes.

The return journey from Moose Lake was made by water, in two small bark canoes, which we were fortunate enough to find on the lake.

Moose River.

Moose River, the outlet of Moose Lake, is sixty-five miles long, measured in two-mile stretches along its course, but following the bends it is fully 100 miles long. It has a total fall of 1,200 feet, or about twelve feet to the mile. Its grade is irregular, and its course is interrupted by several long and wild rapids.

After leaving Moose Lake, Moose River is wide and sluggish for two miles, and then its course is intercepted by a high ridge, in crossing which it contracts, and forms a rapid about a mile long.

Below the ridge it expands into a long shallow sheet of water known as Willow Lake, beyond which rapids continue until the river leaves the mountains. The fall in these rapids amounts to about 250 feet. From the foot of the mountains, the river winds gently along for fifteen or twenty miles, between low wooded banks. Between this reach and

Rapids.

the crossing of Moose River, three strong rapids, separated by short stretches of smooth water, were encountered. The rapids occur where the river cuts through the ridges which cross its course, and are always accompanied by a deepened valley. At the lower, or Big Rapids, the banks of the valley show the same nodular sandstone which outcrops at the Grand Rapids on the Athabasca, and the channel of the stream is encumbered by a multitude of nodules derived from this formation.

Canoes abandoned.

Both canoes were repeatedly broken in descending the numerous rapids. One was abandoned at the foot of the mountain, while the other was left at Big Rapid, which is situated only a few miles from the trail crossing, and we returned to the Athabasca on foot over the same trail used in beginning the traverse.

Between the trail crossing and the Athabasca, Moose River is said to be full of rapids and to be unnavigable.

Muskeg River.

Muskeg River.

Muskeg River enters the Athabasca from the east about thirty-one miles below the Forks. It was ascended for a distance of thirty miles. Like most of the other streams in the district, its lower part is unnavigable, and it is reached by making a portage from the Athabasca to a point on it, about three miles above its mouth. The portage track begins nearly opposite the mouth of Red River and is about a mile long. The general direction of the stream is north-easterly. For some miles above the head of the portage occasional exposures of limestone, capped in places with tar sands, occur in the banks, but further up, the valley disappears and the river winds through a low, marshy and worthless region. The stream here is about fifty feet wide and is blocked every few hundred yards with piles of drift wood and beaver dams. Before returning, a low wooded ridge running in a north and south direction between Muskeg River and the Athabasca was visited, but no exposures were found.

List of Elevations.

Elevations.

The following elevations were obtained by comparing the readings of two aneroids with the readings of the Standard mercurial barometers at Edmonton and Lake Athabasca. Heights obtained in this manner are necessarily only approximate :—

			Feet.
Athabasca	River	(at "Landing")	1,650
"	"	(head of Grand Rapids)	1,200
"	"	(at Clearwater Forks)	840
"	"	(at mouth)	690

	Feet.
Peace River (mouth of Smoky River)	1,225
" (mouth of Battle River)	1,090
" (Fort Vermilion)	950
" (mouth of Red River)	870
Athabasca Lake	690
Lesser Slave Lake	1,890
Whitefish Lake	2,075
Trout Lake	2,130
Loon Lake	1,680
Lake Claire	700
Long Lake	2,269
Kidney Lake	2,320
Pelican Lake	1,910
Buffalo Lake (Birch Mountains)	2,000
Wabiscaw Lake (Upper)	1,720
" " (Lower)	1,705
Wabiscaw River (mouth of Trout River)	1,643
" " (mouth of Two Lakes Creek)	1,484
" " (at junction with Peace River)	920
Birch Mountains	2,300
Buffalo Head Hills	2,500
Marten Mountain	2,890
Trout Mountain	2,350
Plateau south of east end of Lesser Slave Lake	3,090

Decrease in elevation to the north.

The general elevation of the region decreases going northwards from 2,200 feet, the height of the plains south of Lesser Slave Lake, to 700 feet, the height of the lower part of the Peace-Athabasca delta. The rate of decrease averages 6·9 feet per mile.

Geological Sections.

Section on the Athabasca from the mouth of Little Slave River to Lake Athabasca.

La Biche shales.

From the mouth of Little Slave River to Pelican River the valley of the Athabasca is cut out of soft dark grayish or brownish shales (La Biche shales). These shales are usually rather coarsely laminated, are very plastic and when unsupported are easily affected by land-slips. They contain, besides the argillaceous material, nodules and small lenticular beds of limestone, numerous calcareous nodules, and occasionally thin beds of grayish and yellowish sandstone. Iron pyrites occurs in crystals and spherical crystalline aggregates scattered through the shales, and to its decomposition is doubtless in a large measure due the salts in the numerous mineral and chalybeate streamlets which trickle down the faces of many of the escarpments and often

Iron pyrites.

form small red pools at their bases. At one point, about twenty-four miles below the mouth of Lake la Biche River, the La Biche shales have been baked and reddened for about 100 yards along their strike by the combustion of the carbonaceous matter which they contain, but the fires are now extinct.

Burnt shales.

Exposures of La Biche shales.

Exposures of the La Biche shales are infrequent in the valley of the Athabasca above the mouth of Lake La Biche River, but below that point the sections are often continuous for miles. Approaching Pelican River the banks again become wooded and the shales are only occasionally seen. The attitude of the shales is horizontal so far as observed, but owing to the concealment of the bedding by slides, and the washing down of the soft material from above, with the lack of any definite horizon traceable from point to point, small dips, if present, would be unrecognizable.

Horizontality of beds.

Fossils.

Fossils although carefully searched for, proved to be extremely scarce. The following forms, all typical Pierre and Foxhill species, were found in an exposure about twenty-five miles above the "Athabasca Landing:"

Tancredia Americana, Meek and Hayden.
Pteria Nebrascana, Evans and Shumard.
Modiola, sp.
Lunatia concinna, Hall and Meek.
Baculites compressus.

Below the mouth of Lake La Biche River, fragments of *Baculites compressus* and *ovatus* and specimens of *Ostrea congesta* (?) were found in a number of places, and at Stony Rapids, a few miles below the mouth of the Pelican River, I was fortunate enough to find some large well-preserved specimens of *Acanthoceras Woolgari*, Mantell, and a large *Desmoceras* since described by Mr. Whiteaves as *D. Athabascense.**

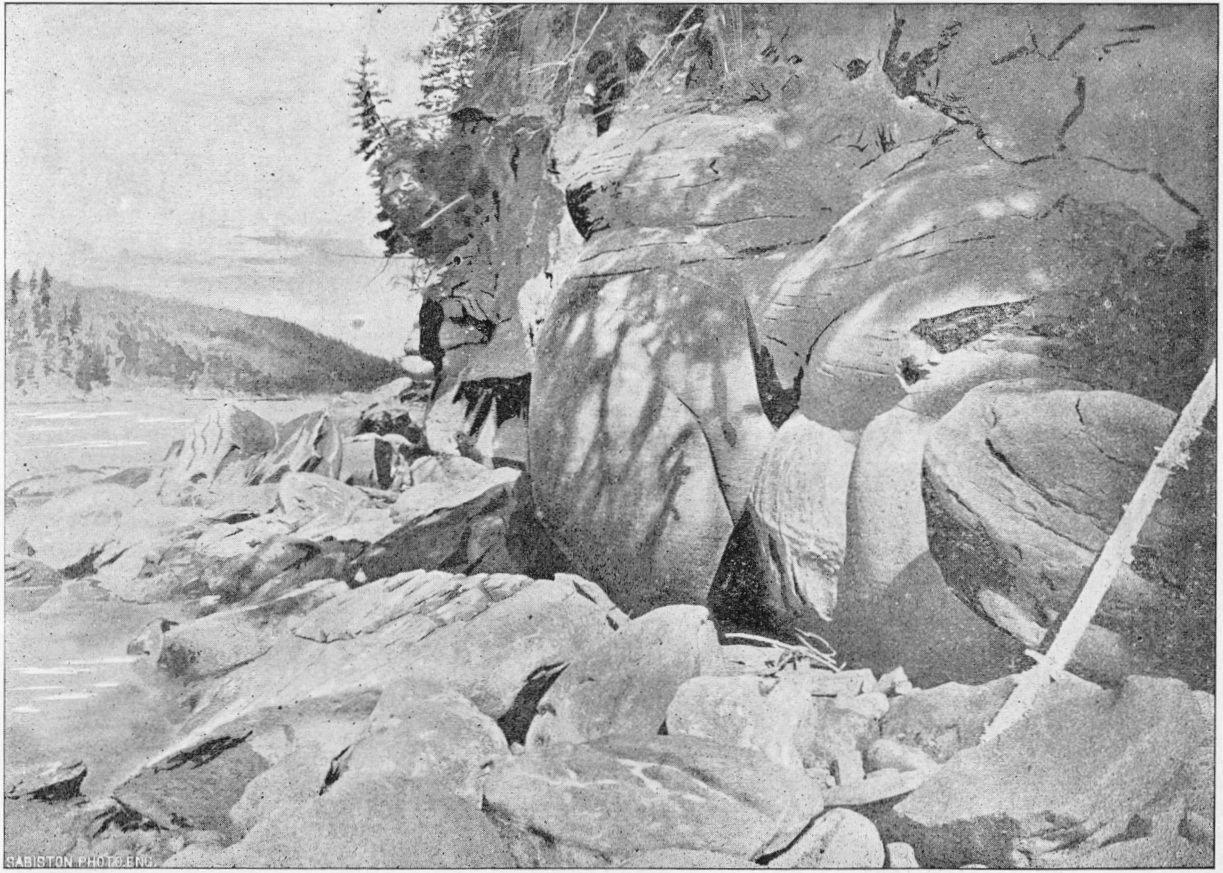
Age of lower part of La Biche shales.

The two latter fossils occur at the base of the shales, and with *Ostrea congesta*, which is usually regarded as a characteristic fossil of the Niobrara, seems to show that the lower part of the La Biche shales are older than Pierre.

Pelican sandstone.

At the mouth of Pelican River the shales are underlaid by a band of sandstone which for the sake of distinction may be called the Pelican sandstone. The Pelican sandstone has a slight dip to the south, of a few feet to the mile, and this added to the fall of the river, causes it to rise gradually in the banks of the valley. It is forty feet thick, and is usually conspicuously white, but is also tinged yellowish and brownish in places, by iron oxide. The lower beds as a rule are soft and crumbly, but towards the top, the granular constituents are cemented by iron, into a hard hemitiferous sandstone passing in

*Trans. Roy. Soc. of Can., vol. X., sec. iv.



R. G. McConnell, Photo, August, 1890.

NODULES IN GRAND RAPIDS' SANDSTONE.
GRAND RAPIDS, ATHABASCA RIVER.

places into a quartzite. No fossils were obtained from the Pelican sandstone and its exact position in the Cretaceous series is therefore doubtful.

Underlying the Pelican sandstone is a shale formation, which, from its intimate relations with the former, may be called the Pelican shale. It makes its appearance a short distance below the mouth of the Pelican River, and is a conspicuous feature in the valley of the Athabasca for many miles. The Pelican shale varies in thickness from ninety to 100 feet, and is very uniform in composition throughout. It is slightly darker and harder than the Pierre shales, and weathers down into a *talus* of small flaky particles. No fossils were obtained from it. Pelican shale.

The Pelican shale is underlaid, about half-way between Pelican River and House River, by a second sandstone formation, for which I propose the name of the Grand Rapids sandstone, as it is well developed at that point. The Grand Rapids sandstone is characteristically yellowish, but is also occasionally whitish, and is coarser-grained than the Pelican sandstone. It is remarkable for the large number of spherical siliceous concretions which it contains, and which range in size up to ten feet or more in diameter. It weathers into steep slopes and cliffs, the faces of which are often studded with the concretionary masses. Lignite seams, varying from a few inches to five feet in thickness occur at intervals through this formation. The following section was measured about ten miles above the mouth of House River. It is in descending order :— Grand Rapids sandstone. Concretions.

Dark soft shales	100′+	La Biche shales.
Whitish and yellowish sandstone becoming ferruginous above	20·00′	Pelican sandstone.
Shales and sands	10·00′	
Sands and shaly partings	10·00′	
Dark shales	90·00′	Pelican shale.
Soft sandstone	4·00′	Upper portion of Grand Rapids sandstone.
Lignite	0·50′	
Soft grayish and yellowish sandstone	15·00′	
	249·50′	

Twenty feet of Grand Rapids sandstone exposed at this point has been grooved horizontally by river ice. At the mouth of House River 150 feet of the Grand Rapids sandstone is exposed, about half its total thickness, above which comes the Pelican shale and sandstone, and about 130 feet of the La Biche shales. At the head of the Grand Rapids, about 200 feet of the Grand Rapids sandstone is exposed. The lower portion near here consists of about fifty feet of a soft yellowish almost homogeneous sandstone, packed thickly with nodules, and weathering into almost vertical cliffs. Resting on this is about 100 feet of alternating sandstone and shales, then Section at House River.

fifty feet of greyish and yellowish sandstone overlaid by a seam of lignite four to five feet thick, above which comes the flaky Pelican shale. Below the Grand Rapids, the Grand Rapids sandstone is exposed for several miles in continuous and almost vertical cliffs, on both sides of the river. Nodules occur throughout the formation, but are more abundant in the lower part, and seams of inferior lignite were noticed at several points. Some of the beds by the addition of small quartz pebbles pass occasionally into a grit or fine-grained conglomerate.

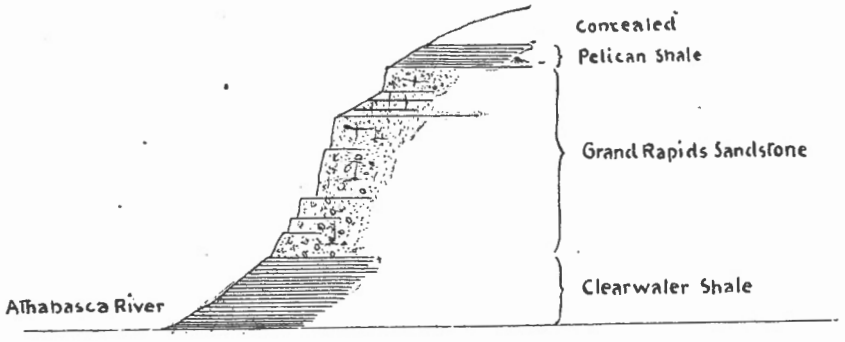
Clearwater shale.

Eight miles below the Grand Rapids at Pte. la Biche the Grand Rapids sandstone is underlaid by an argillaceous formation which will be referred to as the Clearwater shale, as it is well developed on that river. The full thickness of the Grand Rapids sandstone, (300 feet) is exposed at this point. It is overlaid by fifty feet of the Pelican shale. At the junction of the two formations, a small bed of ferruginous conglomerate was noticed. On the west side of the valley, in the Grand Rapids sandstone, there is a seam of lignite about four feet thick. The sandy beds immediately underlying the lignite, have been bleached nearly white.

Rocks at Pte. Brulée.

At Pte. Brulée, eight miles below Pte. la Biche, the valley is deep and gorge-like and a section is shown over 400 feet thick. The Clearwater shale has gradually risen and at this point has a thickness of 100 feet. It is less homogeneous than the Pelican shale, and holds, besides dark and lead gray shales and clays, a considerable proportion of grayish sandstone, greenish glauconitic sandstone and ironstone.

Fig 1



Section at Pte Brulée

Scale 300 Ft = 1 inch.

Above the Clearwater shale the Grand Rapids sandstone rises by cliffs and terraces to a further height of 300 feet. The lower part of the formation is yellowish and filled with nodular concretions, while further up grayish colours prevail and some of the beds become conglomeritic. Resting on the Grand Rapids sandstone is fifteen feet of flaky shales representing the lower part of the Pelican shale. This formation is apparently concealed by surface deposits near this point, as it was not seen to crop out further down the river.

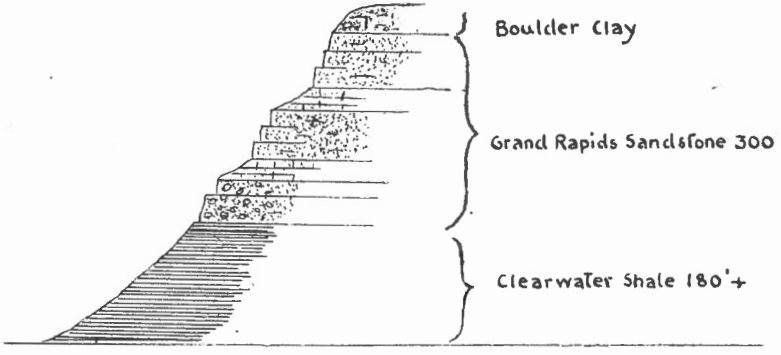
Rocks at Burnt Rapids.

At the Burnt Rapids the Clearwater shale, about forty feet above the surface of the river, holds a bed of greenish glauconitic sandstone about two feet thick, which is highly fossiliferous. The specimens are in a good state of preservation, but most of the species are new and on this account their value in the determination of the horizon in which they were found is greatly lessened. The fauna has, however, a general Benton aspect. Mr. Whiteaves furnished me with the following list of fossils collected at this point as the result of a preliminary examination: a *Camptonectes*, a *Modiola* allied to *M. tenuisculpta*, Whiteaves; a *Yoldia*, like *Y. Evansi*, Meek and Hayden; a *Nucula*, a *Protocardium*, *Callista tenuis*, Hall and Meek; a *Mactra*, a *Cinulia*, *Desmoceras affine*,* Whiteaves; and *Hoplites McConnelli*,* Whiteaves.

Fossils at Burnt Rapids.

Below Burnt Rapids the Clearwater shale overlaid by the terraced Grand Rapids sandstone, is exposed in magnificent sections on both sides of the deep trough-like valley. The following illustration shows the general arrangement of the beds.

FIG 2



Section three miles below Burnt Rapids, Athabasca River.

Scale 300 ft = one inch.

* Trans. Roy. Soc. of Can., vol. X., sec. iv., 1893.

Fossils in Clearwater shale.

Ten miles below Burnt Rapids some fossils were collected from a sandstone bed in the Clearwater shale, among which are *Callista tenuis*, Hall and Meek, a *Mactra*, a *Yoldia*, a *Nucula*, and a *Cinulia*.

Tar sands.

At the head of Boiler Rapid, forty miles below the Grand Rapids, and 193 miles below Athabasca Landing, the base of the Clearwater shale rises above the surface of the valley and uncovers the *Tar sands*, the lowest local division of the Cretaceous. The Tar sands must have

Origin of Tar sands.

consisted originally of almost unconsolidated sands and soft sandstone, ranging in texture from a fine silt to a coarse grit, but have been cemented into a coherent tarry mass, 200 feet thick, by the heavy constituents of the oils which have welled up during past ages, in almost inconceivable quantities from the underlying Devonian limestones. At Boiler Rapid, fifteen feet of the Tar sands are exposed, overlaid by 275 feet of the Clearwater shale, which is its ordinary thickness, above which comes the nodular sandstone and the yellowish and grayish sandstone of the Grand Rapids division. The Clearwater shale at this point yielded *Desmoceras affine*, Whiteaves, a *Goniomya*, and a *Thracia* or *Tellina*.

Rocks at Middle Rapid.

At Middle Rapid, three miles below Boiler Rapid, forty feet of the Tar sands are exposed. The sands are heavily saturated with tar at this point. They are overlaid by the Clearwater shale and the Grand

Thickness of Tar sands.

Rapids sandstone. Two miles below Long Rapid 100 feet of the Tar sands are exposed, and at the head of Crooked Rapid this is increased to 140 feet, the full thickness of the formation at this point. The Tar Sands at Crooked Rapid are massive and show false bedding below, but are stratified in more regular beds above. The saturation is less than usual, and to this fact is due the brownish colour of the beds. Two miles above Crooked Rapid the base of the Tar sands rises above the surface of the water, and discloses a few feet of grayish crumbly evenly-stratified Devonian limestones. The contact between the two formations is apparently conformable and affords little evidence of the vast interval of time which separates them.

Anticlinal at Crooked Rapid.

Crooked Rapid marks the summit of a low anticlinal. Above this point the beds dip in a south-westerly direction at from five to ten feet to the mile, while below, the general dip is to the north, but is very slight, as it averages less than two feet to the mile, and is just about equal to the fall of the river.

Exposure of limestone.

Between Crooked Rapid and the Forks, the lowest beds exposed consist of a few feet of grayish evenly-stratified Devonian limestone. Ledges of this rock cross the river at several points and form small falls and cascades. The limestone is affected by a number of small folds and in two or three places sinks below the surface of the valley.

It is terminated upwards, for some distance below the Crooked Rapid, by a thin bed of conglomerate, consisting principally of sub-angular limestone pebbles ranging from half an inch to an inch in diameter. Siliceous grains fill up the interstices between the pebbles, and the whole is hardened into a compact rock by a calcareous, and in places ferruginous cement. A second variety of this rock consists largely of small ironstone concretions. Conglomerate

Resting on the limestone and well exposed in high cliffs on both sides of the river, is the black plastic mass of the Tar sands. At the Cascade Rapid, this formation is 150 feet thick and is so saturated that pure tar oozes out of the bank in several places and streams down the slope. Tar streams.

The Tar sands increase in thickness, descending the river, from 140 feet at Crooked Rapid to 200 feet at the Forks. The peculiar cleavage, mentioned by Bell*, which they affect in many places, has no general direction, but is usually nearly parallel to the face of the adjoining cliff. Flat plates, an inch or more in thickness, peel off easily and regularly from the ends of many of the beds, but the tendency to cleave does not appear to penetrate far from the surface. Cleavage.

The Grand Rapids sandstone was not observed below the Crooked Rapid. Between that point and the Forks, the upper part of the valley section consists of about 250 feet of the dark and lead gray shales, clays and sands of the Clearwater shale. The beds of this formation are not bituminous.

Below the Forks, or the confluence of the Athabasca and Clearwater, the valley of the former loses its narrow, gorge-like character and becomes wider and shallower, but still continues to afford good sections of the rocks. Evenly-bedded limestones of Devonian age, rising from fifteen to twenty feet above the surface of the river, are almost continuously exposed for a long distance on the right bank. They are horizontal, or nearly so, for some miles below the Forks, but further down, undulate in gentle folds, but seldom show more than the upper fifty feet of the terrane. The limestone is grayish, but often weathers to a light yellow, and is usually more or less argillaceous, in places passing into a calcareous shale. Fossils are numerous, among others, a large Stromatoporoid of variable shape is especially noticeable, from its abundance and size, in most of the sections. The following list of fossils collected between the Forks and Red River is furnished by Mr. Whiteaves :— Devonian limestones.

Chonetes Logani, var. *Aurora*, Hall.
Strophalosia productoides, Murchison.

* Geological Survey, Report of Progress. 1882-83-84, p. 15 C. C.

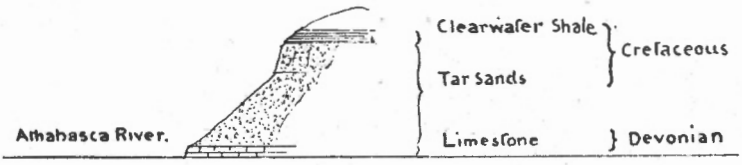
Productella dissimilis, Hall.
Spirifera subattenuata, Hall.
" *inutilis*, Hall.
" *tullia*, Hall, var.
" *Richardsoni*, Meek.
Atrypa Angelica, var. *occidentalis*, Whiteaves.
" *reticularis*, L.
" *reticularis*, var. *aspera*, Schlotheim.
Actinopteria Boydii, Conrad.
Ptychopteria æquivalvis, Whiteaves.
Leptodesma Demus, Hall.
" *Jason*, Hall.
Conularia Salinensis, Whiteaves.
Aparchites mitis, Jones.

These fossils indicate a horizon in the Upper Devonian probably nearly equivalent to the Cuboides zone.

Disappearance of Clearwater shale.

The Devonian limestones are overlaid for some miles below the Forks by heavy sections of the Tar sands, but on account of the decrease in the height of the valley, the Clearwater shale almost disappears.

Fig. 3



Section Six Miles Below Forks
Scale 300 Ft = 1 inch

Description of Tar sands.

The Tar sands hold in places lenticular beds of limestone, lignite seams two or three feet thick and fragments of fossil wood. They vary in colour according to the quantity of tar they contain, from a gray to a dark brown, and jet black. Where heavily saturated streams of tar issue from the banks during the heat of summer, and form pools at the bases of the escarpments. This appears to be the origin as suggested by Bell* of the "tar springs" which occur in the right bank opposite Tar Island, two miles below the mouth of Red River, and in numerous other places.

*Geological Survey, Report of Progress, 1882-83-84, p. 22 C. C.

R. G. McConnell, Photo., July, 1890.

LA SALINE, ATHABASCA RIVER,
SHOWING DEPOSIT FROM MINERAL SPRING.

Mineral springs.

At La Saline, twenty-eight miles below the Forks, several mineral springs occur about half a mile east of the river on the edge of the valley there sixty feet deep. The deposits from the springs, consisting principally of calcareous tufa, cover the face of the escarpment and have also built up a cone on the top of the bank ten to fifteen feet high and about 200 feet wide. An analysis of the water which is strongly saline, is given in another place. Sulphuretted hydrogen gas escapes from the bank in several places and taints the air for some distance from the springs. Besides the calcareous tufa the cone contains small deposits of common salt, gypsum and native sulphur, while pure tar derived from the Tar sands beneath issues from the bank in two places. The springs feed a shallow lake which is situated at the foot of the escarpment, and is surrounded by a clay flat partly bare and partly covered with coarse grasses.

Exposures of limestone.

Devonian limestone is exposed for a couple of miles below the mouth of Red River, but below that point sections seldom occur. There are two small exposures about a mile below Red River, and the limestones are again brought up by a low anticlinal two miles and a half below Calumet River. At this point they are overlaid by fifty feet of light coloured shale. A number of fossils were collected here, from among which Mr. Whiteaves has identified the following species :—

Cyathophyllum Athabascense, Whiteaves.
Spirorbis omphalodes, Goldfuss.
Hederella Canadensis, Nicholson.
Ascodictyon stellatum, Nicholson.
Crania Hamiltoniæ, Hall.
Productella dissimilis, Hall.
Orthis striatula, Schlotheim.
Strophodonta demissa, Conrad.
Spirifera subattenuata, Hall.
" *inutilis*, Hall.
Cyrtina Hamiltonensis, Hall.
Athyris parvula, Whiteaves.
Atrypa reticularis, L.
" " var. *aspera*, Schlotheim.
Rhynchonella pugnus, Martin.
Aparchites mitis, Jones.

Last exposure of limestone.

The last exposure observed of Devonian limestone occurs about ten miles below the Calumet River, or sixty-three miles below the Forks. The beds here have a slight southerly dip. They are fossiliferous, but the species collected, with the exception of *Campophyllum ellipticum* and *Cyrtina Billingsi* are the same as those enumerated in the list

given above. A short distance below the limestone outcrop, some sandstone beds dipping in the opposite direction occur, the exact relations of which are obscure. These beds hold vegetable remains and while soft and tar-soaked in some places, in others they pass into a quartzite. They are unfossiliferous.

Tar sands disappear.

A quarter of a mile below the last limestone exposure the Tar sands, sections of which, ranging in thickness from a few feet to 200 feet, are almost continuously exposed below the Forks, also disappear, and from this point on to the mouth of the river only the boulder clays and associated beds were seen.

These Tar sands are well saturated, and are twenty-five feet thick on the east side of the river, and fifteen feet on the west side, where they hold a small bed of lignite. They are overlaid by forty feet of soft reddish sands, belonging to the period of the Saskatchewan gravels, above which comes a few feet of boulder clay.

Saline spring.

Twelve miles below the last exposure of the Tar sands, and about two miles above the mouth of Red Earth Creek, a copious saline spring bubbles up about 100 feet from the west bank of the river and feeds a considerable stream. Large quantities of sulphuretted hydrogen gas escape at the same place and taint the air for half a mile around. An analysis of the water is given in another place.

Superficial beds.

The superficial beds through which the valley of the Athabasca cuts in its lower part are described under the heading of Glacial Geology. They consist of an upper and lower sandy deposit, separated by red and dark boulder clays. The upper sands and gravels are soaked in places near the surface with tar, and contain beds of sandy nodules cemented by the same material.

Sections on Moose River, Muskeg River, Lesser Slave River and other tributaries of the Athabasca.

Moose River.

Moose River affords the best geological section of any of the tributaries examined. A description of this stream is given in a previous chapter. It forms the outlet of Moose Lake situated near the centre of the Birch Hills, and after a course of about 100 miles, during which it describes a great bend to the south, it falls into the Athabasca forty-six miles below the Forks.

Gray shales.

Two miles below Moose Lake at the first rapids encountered, an exposure of grayish shales holding ironstone nodules was observed. No fossils were collected, but from their stratigraphical position there is little doubt that the shales belong to the La Biche series. Five miles lower down a section of boulder clay seventy-five feet thick was observed, and two miles further on an exposure showed several beds of

boulder clays, separated by layers of sand and gravel, the whole overlying the grayish La Biche shales. The following section in descending order was measured at this point:

	Feet.
Sand and gravel	8
Boulder clay	4
Stratified sands	2
Boulder clay	3
Stratified gravels holding large boulders	3
Boulder clay	3
Gray shales with large limestone concretions	40
	63

Exposures at foot of Birch Mountain.

Four miles below the last exposure, Moose River leaves the Birch Mountains, and winds for some miles through the plains at their base. Boulder clays are exposed along this stretch in a number of places, and dark evenly-bedded shales come to the surface at two points. Ten miles from the foot of the Birch Mountain escarpment, Moose River cuts through a ridge 120 feet high, and for some miles the valley affords good sections. The rocks here exposed consist of forty feet of whitish sands underlaid by twenty feet of dark plastic clays or shale. These beds represent the Pelican sandstone, and shale of the Athabasca section. They are underlaid by a few feet of sandy shales and sandstone, belonging to the Grand Rapids sandstone. A lignite seam two feet thick was observed in two places near the top of the Grand Rapids sandstone.

The Cretaceous rocks are overlaid by a boulder clay band fifty feet thick.

In the next few miles the sandstones of the Grand Rapids division are frequently exposed, and often hold numerous nodules similar to those characterizing the same formation on the Athabasca.

Rocks on Moose River

After cutting through the ridge mentioned above, Moose River bends at right angles to its former course and follows a general northeasterly direction to the Athabasca. Two miles below the bend the river cuts through the Grand Rapids sandstone and exposes the upper part of the Clearwater shale. Below this point the banks are low for some miles and exposures are infrequent, but further down, the valley increases in depth and almost continuous sections of the Clearwater shale are exposed. The rocks of this division consist here of plastic clays and shales, alternating with sandy shales and occasional beds of sandstone and ironstone. Some fossils were collected, among which are the same species of *Nucula*, *Yoldia* and *Camptonectes* found in

the Clearwater shale on the Athabasca. The beds have an easterly dip, and at the Big Rapids they are overlaid by the nodular sandstone of the Grand Rapids division. The following section was measured at the latter point:—

	Feet.	
Boulder clays	10	
Sandy shales	15	Grand Rapids sandstone.
Nodular sandstone.	20	
Sandy shales	15	Clearwater shale.
Clays and shales	40	
	110	

Moose River was not followed for some miles below the Big Rapids, and at the crossing of the Moose Lake trail, the next point examined, the Clearwater shale comes to the surface and is underlaid by sixty feet of Tar sands.

Comparison of Moose River and Athabasca River sections.

The Moose River section in its general character resembles that on the Athabasca, but differs in some of the details. The Pelican shale has decreased from ninety to twenty feet in thickness, and the Pembina shale appears to have become differentiated into an upper part consisting of sandy shales and sandstones, and a lower and more purely argillaceous division.

Red River.

Red River, which empties into the Athabasca twelve miles above the mouth of Moose River, shows, for some miles above its mouth, thick sections of the Tar sands, overlying the Devonian limestones.

Muskeg River

Muskeg River was examined for thirty miles from its mouth. This stream joins the Athabasca from the east about two miles above Red River. It is reached from the Athabasca by a portage, as the lower two or three miles are unnavigable. Tar sands overlying Devonian limestones are exposed for the first three or four miles above the head of the portage, when the limestones disappear, but Tar sands occasionally outcrop for ten or twelve miles further. In the upper part of the valley no exposures were seen.

Exposures on Muskeg River

A mile above the head of the portage the Tar sands, here only twenty feet thick, are overlaid by a bed of hard sandstone or quartzite, which has become developed in them, probably by siliceous infiltration. A mile above the last exposure a crevice in the Devonian limestone was noticed, which had become filled up with well-saturated Tar sands, derived from the overlying formation.

The section on Muskeg River shows that the Tar sands extend at least eight miles east of the Athabasca River.* They are much

*Since writing the above Mr. D. B. Dowling has found a small exposure of Tar sands on Firebag River, eighteen miles east of the Athabasca River.

thinner than usual, but this is probably due to the upper part having been removed by denudation.

Steep Bank River, which enters the Athabasca twenty-one miles below the Forks, was ascended for about ten miles on foot. Tar sands, overlaid by the lower part of the Clearwater shale, were exposed all the distance. Steep Bank River.

A trip was made from the Forks up the Clearwater River to the mouth of Pembina River, and thence up the latter stream for some miles, until the water became too shallow to continue the traverse.

The Clearwater, below Pembina River, winds along a great valley two miles wide and from 300 to 400 feet deep, which looks much older than the valley of the main river above the junction. Three miles above the Forks an exposure of Tar sands was observed, and three miles further up, Devonian limestones appear at the surface and recur at intervals all the way up. The limestones are similar in character to those on the Athabasca and hold the same fossils. Clearwater River.

The Pembina was ascended for thirteen miles in a straight line. Its valley is deep and gorge-like and affords many good sections. For some miles above its mouth Devonian limestones holding *Atrypa reticularis*, *Spirifera inutilis* and other fossils, undulate along the edge of the water and are then replaced by the Tar sands, many sections of which, in varying states of saturation, occur at all the bends of the river. Five miles above the mouth of the Pembina a seam of lignite, four feet thick, occurs in an exposure of the Tar sands, and a short distance further on a lenticular bed of quartzite, six feet thick and 100 yards long, was observed, somewhat similar to that found on Muskeg River. Five miles further up the Tar sands are overlaid by the Clearwater shale holding some fossiliferous beds, in which were found species of *Cyprina*, *Nucula*, and a *Yoldia* like *Y. scitula*. Two miles above the last section the Tar sands, overlaid by the Clearwater shales, are again well exposed. In the valley opposite this exposure several springs of saline water, accompanied as usual by sulphuretted hydrogen gas, bubble up close to the left bank of the river. The valley was not examined above this point. Pembina River. Lignite seam. Saline springs.

The Pelican River was ascended to its source, but it afforded no exposures above the head of the portage made to overcome the rapids at its mouth. Below the portage, sections of the La Biche shales are present, but do not differ from those on the Athabasca. Pelican River.

Lesser Slave River affords a couple of small sections of La Biche shales, in one of which a specimen of *Baculites compressus* was found, but in its upper part it does not cut through the drift deposits. Lesser Slave River.

Lesser Slave Lake.

Lesser Slave Lake.

Lesser Slave Lake rests on the La Biche shales but owes its existence to an embankment of drift deposits at its eastern end. Its shores are low and often marshy, and exposures of the older rocks seldom occur. Grayish calcareous shales, holding ironstone, were noticed east

Exposures.

of the Narrows River, and sections of dark shales, holding *Baculites compressus*, occur near the eastern end of the lake, opposite Marten Mountain. A high plateau skirts the southern shores of the lake at a distance of eight or ten miles, and a small nameless stream was examined, which flows from it into the south-east corner of the lake. Sections showing beds of hard yellowish sandstone, alternating with sandy clays and sands, occur on the lower part of this stream. Some

Fossiliferous beds.

of the beds are fossiliferous, and the following species, with, others were collected :—

Protocardia borealis, Whiteaves.
Pteria Nebrascana, Meek and Hayden.
Anchura Americana, Meek and Hayden.

These beds rest on the La Biche shales, and evidently represent the

Foxhill sandstones.

Foxhill sandstone. They were found as high as 160 feet above the lake, and are overlaid by the sands, sandy clays and sandstones of the Laramie, numerous sections of which occur all along the valley and in the scarped face of the plateau. Lignite seams were observed at several

Lignite seams.

horizons, the thickest of which measured three feet, and a conspicuous bed of soft yellowish homogeneous sandstone fifty feet thick occurs at the foot of the plateau. The Laramie beds have a thickness of about 1,200 feet, but appear to be unfossiliferous throughout.

Marten Mountain.

Marten Mountain north of the lake, was examined, but no sections were found on it, although fragments of lignite and sandstone are abundant on its lower slopes. It is 1,000 feet high and must be composed largely of Laramie as the rocks in this region are practically horizontal. A loose fragment of sandstone found at its base afforded specimens of *Limnæa* and other fresh water shells.

Section on the Wabiscaw and Loon Rivers.

Wabiscaw River.

The Wabiscaw River for many miles below Lake Wabiscaw does not cut through the boulder clay. The first exposure of the older rocks noticed, occurs about nineteen miles below Pine River, nearly in line with the continuation of the Birch Mountains, and consists of light grayish soft shales, holding ironstone and calcareous nodules, similar to those overlying the Pelican sandstone on the Athabasca, and capping the Birch Mountain. Small sections of shale underlying the boulder clay again

occur at the Grand Rapids, eight miles above the mouth of Panny River, after having been concealed for a long interval. The next exposure occurs twenty-six miles further down, or about ten miles below the junctions of the Loon and Athabasca rivers, and consists of fifteen feet of soft falsely-bedded sandstone, passing into a fine conglomerate. The coloration varies from white to red. Two miles further down, the same sandstone outcrops again with an exposed thickness of thirty feet, but is here overlaid with 100 feet of dark shales holding ironstone nodules, which probably represent the Fort St. John shales. The arenaceous band below, so far as the stratigraphical evidence goes, appears to be a continuation of the Peace River sandstones. Approaching the Buffalo Head Hills, the valley of the Loon River deepens and scarped banks are more numerous. A mile above the mouth of Muddy River, a cut bank showed seventy feet of soft, grayish sandy shales, interstratified with a few beds of grayish and greenish sandstone and ironstone. A number of fossils were collected from this section, among which are *Desmoceras affine*, var. *glabrum*, a species first described by Mr. Whiteaves from Peace River, *Hoplites Canadensis*, Whiteaves*, found also in the lower part of the Peace River sandstones on Peace River; casts of a *Trigonia*, a *Mactra*, an *Axinœa*, and a *Lunatia*.

Exposures on Wabiscaw River.

Valley deepens.

Fossils.

Below the mouth of Muddy River, Loon River breaks through the lower slopes of the Buffalo Head Hills, and has cut out for some miles a deep narrow gorge with banks 400 feet high in places, chiefly composed of a succession of land-slips. Dark and grayish shales, usually in a soft and plastic condition, are exposed all along this stretch. The shales are sandy in places and include thin beds of gray and greenish limestone and layers of calcareous and ferruginous nodules. Fossils were found at several points, and the collection, besides those enumerated above, includes a *Yoldia* like *Y. Evansi*, which is indistinguishable from the one obtained from the lower part of the Peace River sandstones on Peace River and from the Clearwater shale on the Athabasca, a *Teredo* boring into fossil wood, a *Lima*, and a *Pecten*.

Narrow gorge.

After passing the Buffalo Head Hills, the valley of the Loon is greatly reduced in depth, and its banks for some miles are composed of boulder clay overlying stratified sands and gravels. In the vicinity of Bat River the shales reappear and are exposed in several places underlying the boulder clay. A mile below Bat River, specimens were found of the large *Desmoceras*, since described by Mr. Whiteaves under the name of *D. affine*. This fossil occurs in the Clearwater shale at Boiler Rapid on the Athabasca, all along Peace River, from the first

Valley reduced in depth.

Shales reappear.

* Trans. Roy. Soc. of Can., vol. X., sec. iv., 1893.

appearance of the Cretaceous above Vermilion Falls, up to Cadotte's River, and it was also found on Red River. It characterizes the lower part of the Cretaceous section in the vicinity of Peace River, and on the Athabasca the beds immediately overlying the Tar sands.

Drift-filled basin.

Three miles below Bat River the Loon enters and traverses for some miles a basin filled with glacial deposits. In this stretch the valley is about 100 feet deep and its banks show sections of boulder clay, often seventy-five feet or more in thickness. This clay is dark and very plastic, and holds numerous concretions, evidently derived like the main part of its substance from the underlying shales. It is usually underlaid and occasionally overlaid by stratified sands and gravels, and in one section was divided into two distinct divisions by a layer of well-rounded boulders.

Seventeen miles in a straight line, below Bat River, the boulder clay rises and the shales appear again above the surface. At this point they are grayish, and very soft, but hold a few hard beds of calcareous sandstone or impure limestone, and numerous variously shaped calcareous ironstone and clay nodules. Fossils were found at two points, among those collected being a *Yoldia*, and several specimens of the same large *Desmoceras* referred to above.

Exposures of shales.

The shales are exposed along the river for a distance of eight miles, measuring in a straight line. At the end of this stretch, the valley almost disappears, but small sections of boulder clay continue to be exposed almost to the mouth of the river. The boulder clay here is stained red in places, and holds beds of nearly pure red clay similar to those on Peace River, in the vicinity of Fort Vermilion.

Comparisons with Peace River section.

The Wabiscaw-Loon Cretaceous section resembles in its general features that on the Peace River, but differs from it in the less importance of the central arenaceous division. On the Loon River, thirty feet of sandstone was observed at one point, but as a rule the sandy beds alternate with much greater thicknesses of shale, and this stream appears to mark in one direction the vanishing point of the great sand bank which stretched with gradually diminishing thickness from the Rocky Mountains into the Cretaceous sea.

Section on Red River.

Valley of Red River.

The valley of Red River is very shallow, seldom exceeding 100 feet in depth, and the geological section it affords is very imperfect, as it is interrupted by long intervals, in which the river fails to cut through the drift. Limestones of Devonian age occur at its mouth, and extend up the valley for two miles in low cliffs bordering both sides of the stream. The limestone is nodular and crumbly and weathers to a light

cream colour. It is filled with corals, brachiopods and other fossils belonging to the same species as those previously enumerated as occurring at the Vermilion Falls. Above the limestone exposures, the valley shows only dark and reddish boulder clay for twenty miles. Two large gypsum boulders, probably brought hither from Peace Point on Peace River, were noticed about half-way up this stretch. Above the boulder-clay basin, dark shales representing the lower part of the Cretaceous series appear, and are exposed at intervals for eight or ten miles. The shales include limestone and calcareous nodules, and are similar in appearance and composition to those on the lower part of Loon River, and they also hold numerous specimens, in various stages of growth of the same *Desmoceras (D. affine*, Whiteaves).

Exposures in Red River valley.

Six miles above the shale occurrences, a small anticlinal brings cream-coloured Devonian limestones to the surface, holding *Atrypa reticularis* and other fossils. The limestones are only shown in one place, and the valley, for many miles above, is destitute of any exposures older than the drift. The shales appear again for a short distance near the mouth of Owl River. At this point Red River approaches within fifteen miles of the Buffalo Head Hills. Above Owl River, the Red River valley, so far as ascended, yielded no exposures of the older rocks.

Devonian limestone.

Plateaus of the District.

The rocks of the Peace-Athabasca region are everywhere practically horizontal, as the dips seldom exceed a few feet to the mile, and such highlands as exist necessarily owe their origin to differential denudation. The principal highlands are the Buffalo Head Hills, Birch Mountains and Marten Mountain.

Rocks, horizontal.

The Buffalo Head Hills may be described as a plateau of circum-denudation still lingering in the angle between the Loon and Peace rivers, and its geology is very simple. A description of the plateau is given on another page. It is 2,500 feet above the sea, and has a maximum height above the plains at its base of 1,000 feet. The escarpments are generally wooded, but good sections were found at the northern end of the plateau on a small tributary of Bear River, a feeder of the Loon. These sections show the plateau to be entirely composed of shales. The shales are of a dark colour but weather to a light gray and at a distance look almost white. They are soft and plastic and are very uniform in composition throughout. Nodules occur, but are comparatively scarce, and no fossils of any kind were obtained. As in other places, many small streams highly charged with salts of various kinds, furrow the lower slopes of the escarpment.

Buffalo Head Hills.

Plateau composed of shales.

Thickness of Cretaceous sections.

The exposures in the Buffalo Head Hills, together with those on Loon River, show that the Cretaceous section in this part of the district has an approximate thickness of 1,500 feet, all of which, with the exception of a few sandy beds about 500 feet above the base representing the horizon of the Peace River sandstones, consists essentially of shales, and is probably of Benton age. The beds above the sandstone horizon correspond to the Fort St. John shales, while those below are referred to the Loon River shales of the Peace River section.

Birch Mountain.

Birch Mountain is a name given to a great ridge situated west of the Athabasca, in the south-eastern part of the district reported on, and extending in a northerly and southerly direction nearly parallel with the course of that stream. It is nearly 100 miles long with an average width of about thirty-five miles. Its elevation above the sea is approximately 2,300 feet, and it overlooks the surrounding plains from heights ranging up to about 1,000 feet. The surface is undulating, the depressions being frequently filled with lakes, and except where cleared by forest fires, the whole ridge is densely wooded. The slopes are usually easy, and exposures, except at the southern end, are confined to the valleys of the streams.

Genetically, Birch Mountain, like the Buffalo Head Hills, is a plateau of circumdenudation, carved out of the horizontal beds of the Cretaceous, but it has been somewhat modified by glacial action. Sections were examined on Moose River, and on Steep Bank Creek, a small stream flowing into Lake Claire. At the former place, the plateau, so far as ascertained, is formed entirely of the grayish and dark shales, which on the Athabasca overlie the Pelican sandstone. No fossils were obtained from these shales on Moose River, but on the Athabasca, they contain a Pierre and Foxhill fauna above, while the lower part of the band is probably Benton.

Composition of plateau.

Rocks on Steep Bank Creek.

On Steep Bank Creek, the shales still cover the summit of the plateau, but they are underlaid by a band of yellowish and grayish sands and soft sandstone, exposures of which also crop out at various points round the northern end of the mountain. These beds are destitute of fossils, but on stratigraphical evidence, there is little doubt that they represent the continuation of the Pelican and Grand Rapids sandstones, although the Pelican shale, which separates these two on the Athabasca, is absent here. The sands contain small coaly seams, and some of the beds are blackened with bituminous matter. They have an exposed thickness of 200 feet, but the base is concealed. The Clearwater shale and the Tar sands which underlie the Grand Rapids sandstone on the Athabasca, if present here, are also hidden, as the next rocks seen in descending the river consisted of crumbling Devonian limestones, but these occur some miles from the foot of the plateau.

Swift Current Creek, a tributary of Birch River, was examined up to the foot of the Birch Mountain plateau, but no exposures were found on it, although pebbles of tar-soaked sandy shales were found on a number of the bases, and point to an occurrence of the Tar sands in the north-western part of the ridge. Swift Current Creek.

The plateau south of Lesser Slave Lake was examined only in one place, and a description of the sections obtained is given on page 40. It consists of Laramie sandstones and shales holding lignite seams, overlying 150 feet of Pierre and Foxhill beds. Marten Mountain north of Lesser Slave Lake, is probably built of similar beds, but the section, except at the base where Pierre shales are shown, is concealed. Plateau south of Lesser Slave Lake.

Sections on Peace River.

Peace River was examined from the mouth of Red River up to the Smoky River Forks. The portion of the river below Red River was traversed by Professor Macoun in 1875. Rock exposures in this stretch seldom occur, but grayish limestones interbedded with white gypsum, and holding *Strophodonta demissa* and other Devonian fossils are described as outcropping at Rapid Bouillé or Little Rapid, and extending down the river to Peace Point, a distance of fifteen miles. Below this point, no rock exposures were noticed by Macoun until Quatre Fourches River was reached, where Archæan gneisses outcrop*. Peace River. Rocks at Peace Point.

Above Red River, Devonian limestones are exposed in low cliffs along the shore to the Vermilion Falls, and for two miles beyond. The limestone is horizontal and occurs in thick evenly-stratified light grayish or cream-coloured beds alternating with softer and more argillaceous bands. The latter are often stained reddish or greenish, and are easily eroded, and the origin of the falls is due to their gradual waste, and the consequent undermining and breaking down of the heavier beds. The limestones in the vicinity of the falls, have an exposed thickness of sixty feet. They do not appear to be bituminous. Some of the beds are very fossiliferous, the following species, among others, being collected here :— Exposures at Vermilion Falls.

Cyathophyllum cæspitosum, Goldfuss.
Phillipsastræa Hennahi, Lonsdale.
Pachyphyllum Devoniense, Edwards and Haime.
Pachypora cervicornis, De Blainville.
Alveolites vallorum, Meek.
" *Rœmeri*, Billings.
Monotrypella Unjiga, Whiteaves.
Strophodonta demissa, Conrad.
" *perplana*, Conrad.

* Rep. of Prog., Geol. Surv. of Can., 1875-76, pp. 89-90.

Spirifera disjuncta, Sowerby.
Atrypa reticularis, L.
" " var. *aspera*, Schlotheim.
Rhynchonella cuboides, Sowerby.
Cryptonella Calvini, Hall.
Pterinea flabellum, Conrad.

This fauna agrees very closely in its general characters with that occurring in the Devonian limestones on the Athabasca, and indicates that the basement rocks on the two rivers, occupy a similar position in the geological scale.

Above Vermilion Falls and Rapids, the Devonian limestones disappear, and for some miles only the boulder clays and associated beds are exposed in the banks. Further up the dark shales of the Cretaceous make their appearance, and are shown in frequent exposures all the way to Fort Vermilion. The general horizontality of the Devonian limestones in the region between the Peace and the Athabasca is shown by their disappearing below the surface in ascending these streams, at almost the same height, viz., 930 feet above the sea. The contact between the Devonian and Cretaceous rocks is concealed on Peace River, but there is little doubt that the limestones are directly overlaid by shales, and that the sands soaked with tar, which occupy this position on the Athabasca are absent. The shales seen between Vermilion Falls and Fort Vermilion are of a dark colour, and are only slightly indurated. They contain occasionally, thin beds of limestone, and more frequently layers of ironstone, and calcareous concretions. The latter are often fossiliferous, specimens of *Desmoceras affine*, Whiteaves, being especially abundant although usually in a more or less fragmentary condition.

Appearance of Cretaceous.

Contact with Devonian concealed.

Between Fort Vermilion and Battle River, a distance measured in a straight line of eighty-five miles, but following the course of the river of about 150 miles, there is little change in the geology of the Peace River valley. Dark shales holding large limestone concretions, short lenticular limestone beds, nodular beds of ironstone, and occasionally a bed of sandstone, are exposed at all the bends of the river, and occasionally are shown for miles in continuous sections. The shales are uniform in composition throughout. They are very soft, almost passing into clays in places, and like the shales on the Athabasca and Saskatchewan, break away in frequent slides. Reddish ferruginous streamlets issue from the shales at almost every section, and often feed small pools lying in the hollows caused by the slides. The shales do not appear to be bituminous to any extent, but inspissated bitumen was observed at several points lining cracks in the nodules. Fossil wood is very abundant in some of the sections.

Rocks between Fort Vermilion and Battle River.

The shales are overlaid nearly everywhere by heavy sections of boulder clay, usually associated below, here as elsewhere, with stratified sands and gravels. The boulder clay for some distance above and below Fort Vermilion, shows the same red coloration as that noted in the vicinity of Red Earth Creek on the Athabasca. Boulder clay.

Three miles below Battle River, the shales are interbedded with a band of bluish, yellow-weathering, soft sandstone and sand, about seventy feet thick, which makes its first appearance in the left bank about 150 feet above the level of the river. The shales above and below the sandstone band are similar in appearance, and are apparently simply a continuation of those exposed lower down the river, but the formation is here divided by the sandy intercalation. The thickness of the shales underlying the sandstone is uncertain, but is probably in the neighbourhood of 500 feet. Shales divided by sandstone band.

Above Battle River the sandstones which may be provisionally named the Peace River sandstones, rapidly increase in thickness and appear to have a slight southerly dip, as the lower shales gradually disappear. At the great bend which Peace River describes, about fifteen miles above the mouth of Battle River, the cut banks show 100 feet of dark shales holding limestone nodules, above which comes fifty feet of bluish and yellow sandstone, followed by 100 feet of alternating sandstones and shales. The valley here is nearly 700 feet deep, but the upper part of the section is concealed. The lower band of sandstone weathers into cliffs and holds some beds resembling the green sand bed of the Clearwater shale on the Athabasca, but they are apparently not glauconitic. A number of fossils were collected from the sandstones, but they are nearly all undescribed species. Peace River sandstones. Rocks at bend above Battle River.

Five miles above the bend just referred to, the Peace River sandstones descend to the surface of the valley and the lower shale division disappears. The Peace River sandstones at this point are 230 feet thick, showing an increase in volume since first observed below Battle River of 210 feet. Part of this increase appears to be due, however, to arenaceous beds replacing the shales in the lower shale division. A section of the sandstone division shows eighty feet of yellowish sands and shales, holding numerous nodules of various kinds, and short beds of yellowish limestone, above which comes forty feet of sands and sandstones, interbedded with small lignite seams, and holding numerous fragments of fossil wood. The upper part consists of about 110 feet of alternating sands and shale, resting on which are 200 feet or more of dark shales, representing the Lower or Fort St. John shales of Dr. G. M. Dawson's Peace River section. A number of fossils were collected from the lower part of the sandstones, among which are *Callista tenuis*, and a *Yoldia* like *Yoldia Evansi*, both of which were found in the Clear- Increase in thickness of Peace River sandstones. Fossils.

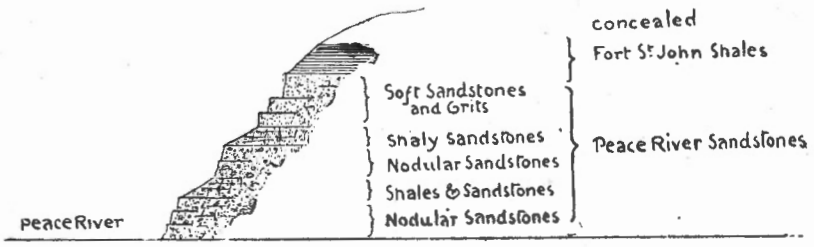
water shales on the Athabasca. Besides these, the collection includes two species of *Nucula*, a *Panopœa*, n.sp., a *Camptonectes*, a *Mactra*, a *Protocardium*, an *Axinœa*, a *Lunatia*, an *Inoceramus*, specimens of *Desmoceras affine*, and *D. affine*, var. *glabrum*, Whiteaves, *Hoplites Canadensis*, Whiteaves, and a tooth of *Ptychodus*. The Fort St. John shales hold numerous ironstone nodules, but no fossils were obtained from them. Twenty miles below Cadotte's River, the banks of the valley showed the following section, in descending order : —

	Feet.	
Dark shales (Fort St. John).....	200	
Brownish shales, with yellowish clay.....	10	Peace River sandstones.
Yellowish sands....	6	
Alternating sands and shale, with some ironstone.	70	
Yellowish sands.....	20	
Yellowish sandstone.....	8	
Yellowish sands.....	20	
Yellowish striped sands and clays, with ironstone and limestone concretions (fossiliferous).....	60	
	294	

Section at mouth of Cadotte's River.

Opposite the mouth of Cadotte's River, the Peace River sandstones consist of 100 feet of sandy shales, holding ironstone and siliceous nodules, followed by forty feet of yellowish sands studded with large sandy concretions similar to those in the Grand Rapids sandstone on the Athabasca, above which, and underlying the Fort St. John shales, comes ninety feet of yellowish sands and shales, interbedded with numerous layers of ironstone. Between Cadotte's River and Tar Island, the Peace River sandstones are well exposed in cliffs, terraces and sloping banks all along the valley.

Fig. 4



Section near Tar Island

Scale 300 Ft = 1 inch

Above Cadotte's River the Peace River sandstones become more completely arenaceous, and the lower part is filled with fantastically shaped sandy nodules, some of which are fifteen feet or more in diameter. The general appearance of this formation as developed along this part of the river, is strikingly similar to that of the Grand Rapids sandstone on the Athabasca. It consists of three sandstone divisions, which weather into steep cliffs, separated by shaly bands, forming sloping terraces. The two lower sandstone divisions are of a yellow colour and carry nodules, while the upper one often shows grayish tints, and is occasionally conglomeritic. Fossils are scarce along this part of the river, but fragments of Ammonites and other marine fossils occur in many of the nodules.

Numerous nodules.

Scarcity of fossils.

A saline spring, emitting natural gas and carrying up small quantities of tar, occurs on the boulder beach at the upper end of Tar Island, about thirty miles below the Smoky River Forks, and a short distance further down, cracked nodules, with the fractures filled with inspissated bitumen, were noticed in the right bank. A second spring is reported to occur on an island opposite the mouth of White Mud River, but this was not seen.

Saline spring.

Opposite Tar Island and for some distance above, the Peace River sandstones are shown in high cliffs on both sides of the river, but they become influenced near this point by a slight southward dip, and ascending the river they gradually decrease in height, and at length disappear just below Smoky River Forks. When last seen they consist of a few feet of soft grayish massive sandstone, marked in a peculiar manner by thin curving lines of carbonaceous shale. Two miles below the Forks the sandstones here showing an exposed thickness of twenty feet, have been grooved and fluted horizontally by river ice. At the base of this cliff, are several small springs emitting sulphuretted hydrogen gas. At the Forks the whole valley section, 700 feet in height, consists of the dark ironstone bearing shales of the Fort St. John series, crowned by a varying thickness of boulder clay and associated beds. These shales, which have overlaid the Peace River sandstones since the first appearance of the latter below Battle River, were frequently searched for fossils without result, and its fauna is still represented only by the *Inoceramus* and *Buchiceras*, or *Acanthoceras*, *cornutum* found by Dr. Selwyn, near Fort St. John, in 1875.

High cliff.

Peace River sandstones dip below the surface.

Gas springs.

Fort St. John shales.

Peace River was not examined by the writer above the Smoky River Forks, as the upper part of the river was explored by Dr. Selwyn, in 1875. The shales of the Fort St. John series are described by him, as extending up Peace River, above the Forks, for a distance of about twenty-

Peace River above the Forks.

five miles, where they are overlaid by the sandstones and shales of the Dunvegan group. The latter then occupy the valley all the way to the cañon of the Mountain of Rocks, except for some distance above and below Fort St. John, where they rise above the surface and the Fort St. John shales appear. Above the cañon of the Mountain of Rocks, Peace River enters a region of tilted beds, and the sequence of the formations becomes obscure. The Dunvegan beds have a minimum thickness at Dunvegan of 600 feet, but appear to thicken rapidly westward, and probably include the whole 2,000 feet or more of sandstones and shales, shown in the escarpments of Table Mountain. The fossils collected by Dr. Selwyn from this formation, include fresh water, brackish water and marine species, and the general character of the fauna is similar to that of the Belly River series of the Great Plains, and the Bear River beds of Wyoming.

Thickness of Dunvegan beds.

Smoky River section.

The Smoky River section above the Forks, was examined by Dr. G. M. Dawson, in 1879. Here, as on Peace River, the valley is occupied for about twenty-five miles by the Fort St. John shales. These are succeeded by 100 feet of sandstones, representing the Dunvegan group, above which comes 350 feet of shales, holding numerous fossils, most of which belong to the typical Pierre and Foxhill fauna, but Benton forms were also found. The shales are overlaid by sandstones and shales, belonging, so far as known, to the Laramie, but it is probable that here, as in the plateaus south of Lesser Slave Lake, some of the lower beds may be of Foxhill age.

GENERAL GEOLOGY.

ARCHÆAN.

Archæan area.

A small area of Archæan gneisses occurs in the north-eastern quarter of the region reported on, but they were only hastily examined. They occupy the northern shore and neighbouring islands of Lake Athabasca, and are also found in the islands of Lake Mammawee, and in the rounded knobs projecting above the delta deposits bordering Quatre Fourches River. The gneisses here have a typical Laurentian appearance. They are usually reddish, but in places are strongly and evenly banded with alternating red and dark tints. The texture varies from medium to fine-grained, and the foliation is usually distinct, the rock passing in one or two places into a mica or chlorite schist. Both hornblendic and micaceous varieties are present, but these minerals in many instances are largely replaced by chlorite. Epidote occurs in large quantities. The gneisses dip at high angles, and the strike varies from ten to twenty degrees west of north.

CAMBRIAN.

South shore of Athabasca Lake.

An examination of the southern shore of Lake Athabasca was made from the mouth of Athabasca River to near Point William. This shore, as a rule, is low, and is bordered for long distances by low bluffs, composed of recent sands and clays. At Pointe de Roche and at another point seven miles further on, the underlying rocks are exposed and consist of a granular siliceous sandstone, which, from its general character and position, probably belongs to one of the divisions of the Cambrian. For reference it may be called the "Athabasca sandstone." No fossils were found in it, nor was its contact with the overlying or underlying rocks observed. This sandstone is usually coarsely granular in texture, but passes occasionally into a fine-grained conglomerate. Its colour varies from white to dull red. Its bedding planes have been obliterated, but its general horizontal attitude is betrayed by the textural differences. It is cut by two systems of jointage planes, and in weathering, breaks into huge blocks, some of which contain several hundred cubic feet of material.

Athabasca sandstone.

Numerous fragments, some of large size, of a mottled red and green fine-grained sandstone, somewhat similar in appearance to that found at Sault Ste. Marie, were noticed strewn along the track, but were not found *in situ*.

The Athabasca sandstone apparently extends all along the southern shore of Lake Athabasca, as specimens brought by Mr. Cochrane, in 1882, from the east end of the lake, cannot be distinguished in appearance from those collected at Pointe de Roche and neighbouring localities. Its extension southwards, has not as yet been approximately determined. On the north its junction with the Archæan is concealed beneath the waters of Lake Athabasca.

DEVONIAN.

Devonian limestone.

Devonian limestones crop out from beneath the Cretaceous, along the northern part of the district. On the Athabasca they rise to the surface at Crooked Rapid, and occupy the bottom of the valley down to a point about ten miles below Calumet River, except in a few places where they are carried below the surface by synclinal folds.

Distribution of limestone.

Below this point they are covered by recent deposits, and their junction with the underlying rocks is concealed. From the Athabasca, the Devonian limestone extends in a broad band round the southern end of Birch Mountains, and across Lake Claire to Peace River, and up the latter stream to a point two miles above Vermilion Falls.

Dip of limestone.

The Devonian limestones on the Peace and Athabasca rivers have a general northerly dip of three or four feet to the mile, and are also affected in some places by a series of small subordinate folds, few of which, however, succeed in bringing into view more than the upper 100 feet of the formation.

Characters of Devonian limestone.

The limestone is very uniform in character throughout the district. It is grayish or light yellowish in colour, and is evenly stratified, the beds ranging in thickness from two inches to several feet. It is usually more or less argillaceous, and in places passes into a calcareous shale.

Bituminous beds.

The purer beds are often nodular and crumbly, but resist denudation more successfully than the shaly varieties, and now frequently form long horizontal lines of relief, running across the faces of the exposures. Some of the beds are bituminous, but seldom to an important degree, and the sources of the oils which have saturated the overlying Cretaceous sands must occur beneath the exposed part of the formation. That the oils have risen from below, is shown by the cracks and fissures lined with bituminous matter which occur in the limestone in various parts of the district, and through which the liquid has evidently escaped.

Absence of formations between Devonian and Cretaceous.

The Devonian limestone is apparently succeeded conformably by the Cretaceous, and with the possible exception of a thin bed of conglomerate of limited extent, which occurs below Crooked Rapid on the Athabasca, the age of which is doubtful, the vast interval of time which separated the two formations, is, so far as observed, unrepresented, either by deposition or erosion. This can hardly be explained, except on the assumption that the formation during all this period, was buried far from land in the depths of some abyssal ocean, as the only other alternative, viz., that its surface represents a former base level of erosion, is, in view of the remarkable persistency of the upper beds, scarcely credible.

Fossils.

Lists of the Devonian fossils collected are given in the description of the Athabasca and Peace River sections.

Cretaceous.

Range of Cretaceous.

The Cretaceous section in the Peace-Athabasca country includes beds ranging in age from the Laramie to the Dakota, but the lithological succession of the various divisions, differs from that which obtains on the Great Plains, and also varies in different parts of the district. This feature of the formation, together with the further fact that most of the fossils collected are new to science, and therefore useless for the purpose of correlating the beds here with known horizons elsewhere, makes it difficult to classify the different terranes in a satisfactory manner, and also renders necessary the provisional use of some

Difficulty in classification.

new names. The following illustration shows the succession of the various divisions of the Cretaceous on the two rivers, and also their ages, so far as the stratigraphical and palæontological evidence at hand admits :

Athabasca River Section.		*Peace River Section.*
Laramie.	Laramie.	Wapiti River sandstones.
Foxhill sandstone. La Biche shales (upper part.)	Montana.	Foxhill sandstone. Smoky River shales.
Unrepresented.		Dunvegan sandstone.
La Biche shales (lower part.) Pelican sandstone. Pelican shale. Grand Rapids sandstone. Clearwater shale.	Colorado.	Fort St. John shales. Peace River sandstones. Loon River shales.
Tar sands.	Dakota.	Unrepresented.

Laramie.—The Laramie occurs in the southern part of the district, and is well exposed in the plateaus south of Lesser Slave Lake. The north-eastern boundary of this formation crosses the Saskatchewan in Long. 112° 30′ and runs in a north-westerly direction, crossing the Athabasca near the mouth of the Pembina, to the east end of Lesser Slave Lake. From this point it bends to the west, and extends in a sinuous line along the foot of the plateaus south of the lake, and thence in a westerly direction to Smoky River, beyond which its course, as yet, is only a matter of conjecture. An outlier of Laramie forms the upper part of Marten Mountain north of the east end of Lesser Slave Lake, and probably caps the highlands extending eastward from this elevation towards Pelican Mountain. Exposures of Laramie.

In the plateaus south of Lesser Slave Lake, the Laramie has a minimum thickness of 1,000 feet. It is practically horizontal and consists of yellowish and grayish flaggy and massive sandstones, often holding large nodules, alternating with grayish and dark clays and shales. Thin ironstone beds occur frequently throughout the section, and several seams of lignite were seen, the largest of which is three feet thick, but is of inferior quality. Fragments of fossil plants occur in some of the sandstones, but no determinable fossils of any kind were obtained. Character of beds. No fossils obtained.

Montana.—This formation on the Athabasca and its tributaries is represented by about fifty feet of alternating sandstones and shales, exposures of which occur along the lower slopes of the Laramie plateaus south of Lesser Slave Lake, and by the upper part (about 700 feet) of the La Biche shales of Lesser Slave River and the Athabasca. The exact junction between the Montana and the Colorado was not definitely Beds of Montana age south of Lesser Slave Lake.

ascertained owing to the scarcity of fossils, and to the fact that the La Biche shales pass downwards from the Montana into the Colorado without any structural break or lithological change of any kind.

Fossils.

The fossils collected from the Montana on the Athabasca and on Lesser Slave Lake and River include :—

Pteria Nebrascana, Meek and Hayden.
Tancredia Americana " "
Protocardia borealis, Whiteaves.
Lunatia concinna, Hall and Meek.
Anchura Americana, Meek and Hayden.
Baculites compressus, Say.

Montana beds on Peace River.

In the Peace River section the Montana is represented by the Upper or Smoky River shales, and possibly by the lower part of the Wapiti River sandstones. These occur south of the district now reported on, but were examined and described by Dr. G. M. Dawson in 1879.* The Smoky River shales are the equivalents of the Upper or Pierre portions of the La Biche shales of the Athabasca sections. They are 200 feet thick, and are described as dark grayish or bluish-black, thin-bedded shales, holding beds of ironstone and in some places large ferro-calcareous nodules. The fossils obtained from the Smoky River shales belong chiefly to the typical Pierre and Fox-hill fauna, and includes such well-known fossils as *Pteria linguiformis*, *P. Nebrascana*, *Nucula cancellata*, *Liopistha undata*, &c., but besides these, specimens of *Scaphites ventricosus*, a typical Benton species were also found.

Dunvegan beds.

Dunvegan Group.—This name has been applied to a series of sandstones and shales, which are extensively developed along the Peace River valley, from about fifteen miles above the Smoky River Forks, up to the Cañon of the Mountain of Rocks. This part of the river was not visited during the present exploration, but was examined by Dr. Selwyn in 1875, and a description of the formation is given in the Report of Progress, Geological Survey of Canada, 1875–76. In 1879 the lower part of Smoky River was examined by Dr. G. M. Dawson, and the Dunvegan beds were found on it, underlying the Smoky River shales (Pierre), but in greatly diminished volume.†

Character of Dunvegan beds.

The character and age of the Dunvegan beds are fully discussed by Dr. Dawson in the report just mentioned, and but little additional information has since been obtained. They consist of grayish and yellowish flaggy and massive sandstones, often false-bedded and ripple-

* Report of Progress, Geological Survey of Canada, 1879-80, Part B, page 122.
† Report of Progress, Geological Survey of Canada, 1879-80, Part B, pages 116-122.

marked, alternating with grayish and dark shales, usually more or less arenaceous, and holding small beds of ironstone and thin seams of lignite. The thickness of the formation rapidly increases going westward towards the mountains, from 100 feet on Smoky River to 600 feet or more at Dunvegan, and nearly 2,000 feet at Table Mountain. The Dunvegan beds have not been detected east of Smoky River, and probably die away soon after crossing that stream, and they are not represented, so far as known, on the Athabasca.

Increase in thickness going west.

The fauna of the Dunvegan formation is remarkable for its varied character, as it contains fresh water shells like *Vivipara* and *Corbicula*, brackish water shells like *Corbula* and *Ostræa*, and such a strictly marine genus as *Inoceramus*. This assemblage of fossils, together with the general character of the beds, evidences estuarine conditions and deposition on an oscillating surface.

Fauna of Dunvegan beds.

The Dunvegan formation occupies nearly the same position stratigraphically, as the Belly River series of Assiniboia and Alberta, and may possibly be a continuation of it, but it differs in containing marine fossils, the fauna of the latter so far as known, being confined to fresh and brackish water species. It is also closely allied by its fauna to the Bear River formation of Wyoming, lately described by White and Stanton*. Two of the most characteristic species of the Bear River beds, *Corbula pyriformis* and *Corbicula Durkeii* occur in the Dunvegan formation, and most of the genera are alike. The position of the two formations in the Cretaceous is, however, different, as the Bear River beds are placed by the above writers below the Colorado, while the Dunvegan series overlies that formation.

Position in Cretaceous.

Colorado.—The beds assigned to the Colorado on Peace River are about 1,500 feet thick, and include in descending order, the Fort St. John shales, the Peace River sandstones, and the Loon River shales. The Fort St. John shales are exposed in the Peace River valley for some miles above and below Fort St. John and extend up Pine River nearly to the Forks. They are brought up here by a low anticlinal and disappear in descending Peace River near the mouth of Pine River north, and do not appear again until a point twenty-four miles above the Smoky River Forks is reached. Below this point they are exposed in the banks of the valley all the way to Battle River and beyond, and still further north form the upper part of the Buffalo Head Hills plateau. The Fort St. John shales have a minimum thickness of 700 feet, and consist throughout of brownish and dark grayish to black shales holding calcareous nodules, and in places a notable quantity of ironstone in nodules, lenticular beds and sheets. They are very unfossiliferous,

Colorado beds on Peace River.

Character of Fort St. John shales.

* American Journal of Science, vol. XLIII., p. 91.

as with the exception of a few fish scales, no specimens were found in the numerous sections examined, from the Smoky River Forks northwards. In their outcrop near Fort St. John a species of *Inoceramus*, and *Buchiceras cornutum*, which is most probably an *Acanthoceras* allied to *A. Woolgari*, were found by Dr. Selwyn in 1875.

Characters of Peace River sandstones.

The Peace River sandstones underlie the Fort St. John shales, and appear from beneath the latter in descending the river, immediately below the Smoky River Forks, and are then exposed in the banks of the valley down to about three or four miles below Battle River. Exposures are confined entirely to the valley, as the slight southerly dip by which they are affected for some miles below the forks, fails to bring them to the surface of the plateau, and further down they become almost horizontal. The Peace River sandstones consist of heavy massive beds of yellowish and grayish soft coarse sandstones, alternating with bands of thin-bedded sandstones and shales. The massive beds have an occasional thickness of fifty feet or more, and weather into a series of steep cliffs separated by sloping terraces cut out of the shaly bands. Lignite seams occur occasionally, and hard sandstone concretions ranging from a few inches to ten or fifteen feet in diameter form a prominent feature of the formation. In descending Peace River, the Peace River sandstones become more argillaceous, decrease gradually in thickness and at length disappear a few miles below the mouth of Battle River. They occur along Loon River for some miles, nearly due east from the mouth of Battle River, but in diminished volume, and the exposures here mark approximately the northern limits of the formation in this longitude.

Fossils.

Fossils were found throughout the Peace River sandstones, but occur most abundantly near the base of the mountain. The fauna differs from that of the Dunvegan group in being strictly marine. (See list pp. 47-48.)

Loon River shales.

The Loon River shales, the lowest division of the Colorado or Peace River, consist of about 400 feet of dark grayish to nearly black, soft shales, holding calcareous and ironstone nodules, interstratified with occasional beds of sandstone, impure limestone, and ironstone. Fossil wood was found in considerable quantities, scattered through this formation, and a lignite seam is said to exist some miles above Fort Vermilion, but was not seen. The Loon River shales appear in descending Peace River, about twenty miles above Battle River, and are exposed on the banks of the valley nearly all the way down to the Vermilion Falls. They also occur on the lower part of Loon River, and on Red River. They alternate above with Peace River sandstone, and below appear to rest directly on the

Devonian limestones, although the contact was nowhere seen. The fossils collected from the Loon River shales consist of numerous specimens of *Desmoceras affine*, Whiteaves, *D. affine*, var. *glabrum*, Whiteaves, and *Hoplites Canadensis*, Whiteaves.

Colorado terranes on the Athabasca.

The Colorado, in the parallel Athabasca section, resembles in its general features that on Peace River, but differs in detail. It includes, according to present evidence, the lower part of the La Biche shales, the Pelican sandstone and shale, the Grand Rapids sandstone, and the Clearwater shale in all about 930 feet of strata.

La Biche shales.

The lower part of the La Biche shales corresponds in a general way with the Fort St. John shales. They consist of soft dark grayish to black clay shales, differing in no respect lithologically from those forming the upper part of the formation, but have been separated from them on fossil evidence. The upper part of the La Biche shales holds a characteristic Pierre and Foxhill fauna, while in the lower part *Ostræa congesta*, *Desmoceras Athabascense*, Whiteaves, and *Acanthoceras Woolgari*, Mantell, occur. The La Biche shales are succeeded in descending order by the Pelican sandstone and shale, and the Grand Rapids sandstone, the probable equivalents of the Peace River sandstone. The Pelican sandstone is forty feet thick, and consists of a massive bed of soft grayish sandstone, which becomes hemitiferous above in some places. No fossils were obtained from it. The Pelican shale is ninety feet thick, and is argillaceous throughout. It alternates above with the Pelican sandstone, and appears to die out toward the northwest, as the thickness on Moose River is only a few feet, and it was not recognized at all on the north end of the Birch Mountain. The Grand Rapids sandstone is 300 feet thick, and is composed of massive cliff-forming beds of yellowish and grayish sandstone, separated by bands of thinly-bedded sandstones and shales. Lignite seams appear in places, and large, rounded sandstone concretions occur so abundantly in some of the beds, that they form a considerable portion of the substance of the formation. Fragments of Ammonites and other marine shells were found in the Grand Rapids sandstone, but no specimens perfect enough for determination were obtained.

Pelican sandstone and shale.

Grand Rapids sandstone.

Clearwater shale.

The Clearwater shale, the lowest division of the Colorado on the Athabasca, holds a considerable proportion of sandstone interstratified in thin beds with the shales, and also a green sand bed, which is probably glauconitic. Mr. Ferrier, Lithologist to the Survey, reports on this rock as follows :—"After a careful examination of this section and comparing it with a series of typical glauconitic rocks from the Tertiary of various foreign localities, I can find no difference in character between it and them. The mineral agrees in all its characters

Glauconitic bed.

with typical glauconite. Zirkel states* that the mineral, glauconite, is only singlè refracting. This must be an error, as the glauconite in all the slides examined was decidedly double refracting, but in weak colours. It has a slight resemblance to some varieties of Serpentine." Ironstone in nodules and beds is also present, and fossil wood occurs occasionally. The Clearwater shale has an average thickness of 275 feet, and occupies approximately the same stratigraphical position as the Loon River shale on Peace River, and the lower part of the Peace River sandstone. A number of fossils were collected from it, lists of which are given on pp. 31-32. The following list by Mr. Whiteaves includes all the fossils collected from the various subdivisions of the Colorado. As some of the species are undescribed, only the generic names of these can be given.

Character of Clearwater shale.

PELECYPODA.

Lima sp.
Pecten sp.
Camptonectes sp.
Modiola, allied to *M. tenuisculpta*, Whiteaves.
Nucula (*Acila*) sp.
Yoldia, like *Y. Evansi*, Meek and Hayden.
Trigonia sp.
Protocardium sp.
Callista tenuis, Hall and Meek.
Goniomya sp.
Mactra (*Cymbophora*) sp.
Teredo sp.

GASTEROPODA.

Lunatia sp.
Cinulia sp.

CEPHALOPODA.

Desmoceras affine, Whiteaves.
" " var. *glabrum*.
Desmoceras Athabascense, Whiteaves.
Hoplites McConnelli "
Acanthoceras Woolgari, Mantell.

Dakota age of Tar sands.

Dakota.—The Tar sands underlying the Clearwater shale have been assigned to the Dakota, entirely on lithological and stratigraphical evidence, as no fossils were obtained from them. They rest on the Devonian limestones, and occur in the same position as the sands of undoubted Dakota age, which outcrop along the eastern edge of the

* "Die mikroskopische Beschaffenheit der Mineralien und Gesteine," Leipzig, 1873, p. 487.

R. G. McConnell, Photo , 1890.

VIEW ON ATHABASCA RIVER.
SHOWING TAR SANDS OVERLYING DEVONIAN LIMESTONES.

Cretaceous in Manitoba, and south of the International Boundary in Minnesota. They consist of an almost homogeneous mass of tar-cemented sands, ranging in texture from a coarse silt to a grit, and vary in thickness, where fully exposed, from 140 to 220 feet. They contain occasional thin beds of ironstone, and in two places lenticular beds of quartzite were noticed. Fragments of fossil wood occur throughout the formation. The Tar sands occur along the Athabasca valley from Boiler Rapid to a point about nine miles below the mouth of Calumet River, a distance of about ninety miles. West of the Athabasca they are soon concealed by the overlying divisions of the Cretaceous, but are exposed for some miles along the valleys of the tributary streams. They were not found on Peace River. East of the Athabasca they occur in heavy sections on the Clearwater, Pembina and High-bank rivers, but on Muskeg and Firebag rivers the sections are small, and the greater part of the material in this district has evidently been planed away by glacial action.

Character of Tar sands.

Glacial Geology.

Boulder clays and the stratified sands and gravels by which they are usually accompanied, mantle the greater part of the region dealt with in the present report, so heavily and universally, as to conceal the older rocks nearly everywhere, except in the deep valleys of the main drainage channels, and along the escarpments of some of the plateaus. The glacial deposits have not been distributed uniformly, as in some of the old pre-glacial depressions they attain a thickness of 200 feet or more, while on the ridges they become greatly attenuated, and in some places the boulder clay disappears and the superficial deposits are represented only by the modified drift. Their influence in levelling the country has, however, been destroyed to some extent by irregularities in their own deposition, resulting in the production of the rolling type of country which prevails throughout a large part of the region. Another feature directly due to the unequal distribution of the glacial deposits is the number of small lakes and ponds inclosed in shallow land-locked basins in the drift, which are met with throughout the district, and which occur so frequently in some localities as to cover a considerable proportion of the surface. The present lakes and ponds represent only a part of those which originally existed, as many of them have become filled up with sphagnum and converted into muskegs and marshes.

Distribution of glacial deposits.

The glacial beds are very uniform in character, and will only require a brief description. On the Athabasca, boulder clays of the ordinary type, usually underlaid by stratified sands and gravels

Glacial beds on the Athabasca.

of the age of the Saskatchewan gravels, are met with, capping most of the sections between the mouth of Lesser Slave River and the Pelican, but from the latter point to the Forks, they were seldom observed, and the glacial deposits are represented chiefly by a thick bed of gravel and boulders of all ages, piled confusedly together, accompanied in some places by sands and clays. Below the Forks the glacial beds increase in importance, and from Calumet River to the delta, they form the principal feature in the geology of the Athabasca valley. They consist in this portion of the valley, of boulder clays, underlaid by stratified sands, and overlaid by a bed of coarse sand and pebbles. The lower sands are never fully exhibited, but show an exposed thickness in different sections of from thirty to 100 feet. They are unconsolidated, and in some places are interstratified with beds of gravel and layers of rolled sandy nodules, cemented by tar. The sands are characterized in many of the sections by a peculiar reddish colour, but in other places yellowish and brownish tints prevail. They are exposed in numerous sections on both sides of the valley, nearly to the head of the delta.

Glacial beds well represented below the Forks.

Red boulder clay.

The boulder clay is divided by a difference in coloration into two parts. The lower division is characterized by a distinct reddish tint, while the colour of the upper part is usually a dark gray. The line between the two boulder clays, while often indistinct, is sometimes clearly drawn, and in one place, a short distance below the mouth of Firebag River, they are separated by stratified sands. The section at this point in ascending order, consists of :—

	Feet.
Soft sands, holding layers of sandy tar nodules....	50
Red boulder clay.....	20
Sands, similar to those below boulder clay.....	20
Dark boulder clay.....	2
Sands and gravels, partly concealed.....	15
	107

Section below Firebag River.

A mile below the last section, the glacial deposits consist of sixty feet of yellowish and brownish sands, overlaid by twenty feet of reddish clay, holding scratched and polished boulders, above which comes ten to fifteen feet of coarse sands and gravels, part of which is saturated with tar. The red boulder clay is well exposed in the vicinity of Red Earth Creek, and was traced down the river to a point about ten miles below Pointe aux Trembles.

Beds overlying boulder clay.

The boulder clay is overlaid in most places by sands and gravel and pebble beds, a notable feature of which is the amount of tar they con-

tain. The tar in these beds is not distributed uniformly like that in the Tar sands of the Cretaceous, but occurs in irregular patches, from a few feet to 200 feet in length, and from a few inches to five or six feet in thickness. The tarry patches, as a rule, immediately underlie the surface, and are confined to the coarse beds. The tar is in a soft condition, and the percentage is as high as in the most saturated portions of the Tar sands of the Cretaceous. The tar in these beds is mixed with fragments of lignite and shale, and appears to have been derived from the Tar sands of the Cretaceous and transported to its present position in some way not fully understood. It has not ascended from below, as no trace of it was observed in the underlying beds, and the compact boulder clays, when present, would necessarily stop its upward flow. Tarry masses of sand and gravel occur at intervals, underlying the surface down to a point about twelve miles below Pointe aux Trembles. Below this point the cut banks show only stratified sands, interbedded in places with layers of rolled tar nodules. Tar in glacial beds.

The stratified sands and gravels, both below and above the boulder clay in the lower part of the Athabasca valley, are evidently lacustrine in origin and were doubtless deposited along the southern margin of the greatly extended Lake Athabasca of the Glacial Period. The upper sands extend down to and form largely the present shores of the lake, except when they are covered by the more recent delta deposits. Origin of stratified beds.

The Athabasca, in the lower thirty miles of its course cuts through its own delta, and beds of this age, although partly the product of Peace River, extend west of the Quatre Fourches River to Peace River and beyond, and underlie the wide plain west of Lake Athabasca, on which are situated the separated portions of the lake known as Lakes Claire and Mammawee, together with numerous other nameless sheets of water. Delta deposits.

In the plains between the Athabasca River and Birch Mountain, and on the eastern slopes and summit of the latter, the boulder clay, as shown by the Moose River section, attains an exceptional development, in some places being fully seventy-five feet thick. The lower sands and gravels appear to be absent here, but stratified gravels were found in one exposure alternating in thin beds with the boulder clay. West and south-west from the Birch Mountains, the rolling plains stretching towards Lesser Slave Lake and Peace River, are everywhere drift-covered but full sections are seldom seen, except near the mouths of the streams flowing into the two trunk rivers, as owing to the immature condition of the drainage system, the valleys are seldom excavated sufficiently deep to reach the older rocks, and in most cases they are only a few feet deep. Glacial beds on eastern slopes of Birch Mountain. Immature drainage system.

Boulder clay in Peace Valley.

In the deep valley of Peace River, boulder clays often associated below with stratified beds, are found overlying the older rocks in most of the sections examined. In the upper part of the valley the boulder clay is of the normal type, but for some miles above Fort Vermilion, down to the Vermilion Falls, and up the Red and Loon Rivers for a considerable distance above their mouths, reddish clays are intermixed in patches and bands with the ordinary boulder clay. The reddish clays are occasionally pure, but as a rule they carry boulders, are more or less arenaceous, and are only distinguished from the associated clays by their colour.

Red clays.

Direction of movement of Great Glacier.

The red boulder clay affords a means of tracing the general direction of movement of the Great Glacier, superior even to that afforded by glacial striæ, as the latter are apt to be deflected locally by the contours of the country. On the Athabasca these clays are found, from above Red Earth Creek down to a point about ten miles below Pointe aux Trembles, below which the boulder clay is covered by more recent deposits. On Peace River the red boulder clay occurs on the lower parts of the Red and Loon Rivers, and along the Peace River from the mouth of Red River up to Fort Vermilion and beyond. A line running 12° N. of W. from Pointe aux Trembles to the mouth of the Loon on Peace River, would pass through the centre of the red boulder clay belt. The glacier travelling along this line must have moved up the eastern slope and over the summit (1,500 feet) of Birch Mountain. That it did so, is further shown by masses of Tar sands occurring in the drift on the summit of this plateau, which could only have been derived from the exposures in the Athabasca valley, many hundreds of feet lower down. The nearly easterly movement of the glacier west of Athabasca and Great Slave Lakes, taken in connection with the southerly movement south of Lake Athabasca, and its northerly movement on the Mackenzie, shows that the ice must have radiated from a centre situated somewhere between the eastern ends of these two lakes and Hudson Bay.

Distribution of red boulder clay.

Economic Geology.

Gold on Peace River.

Gold.—Gold was found in many of the bars along Peace River, and in several places in sufficient quantities to deserve attention. Three miles above the mouth of Battle River, a large bar nearly a mile long, on the left bank, was examined, from which we obtained fifteen to twenty *colours* of fine gold, by washing a few handsful of the mixed gravel and sand in an ordinary frying pan. We tried the bar at several points, and always with the same result. A small stream descends from the plateau on the opposite side of the river, and by

leading its waters across the river, which is here about 1,000 feet wide, the bar might be easily and inexpensively worked on a large scale. Twelve miles further up the river, another bar was examined, which yielded from twenty to forty *colours*, when washed in the same way. Numerous other bars occur in this portion of the river, which would probably give as good results as those examined.

Cause of deposition of gold.

The presence of fine gold in some quantity in the bars above the mouth of Battle River is probably due to the diminution in the strength of the Peace River current which takes place here, and its consequent loss of transporting power. The same fact is shown in the gradual substitution of sand bars for gravel bars which occur at the same point.

Besides the gold on Peace River, two *colours* were also washed out of a bar on Loon River, an eastern tributary of the Peace.

Distribution of clay ironstone.

Iron.—Clay ironstone in nodules and thin beds, is of universal occurrence in the Cretaceous shales of the region, but is especially abundant in some of the outcrops of the Fort St. John shales on Peace River, between Battle River and the mouth of Smoky River. The ironstone here, owing to the rapid erosion of the soft shales has been silted out, and in many places forms thick accumulations at the foot of the cliffs lining the valley, some of which may prove to be of economic value. The Pelican sandstone on the Athabasca is usually capped with a bed of hemitiferous sandstone varying in thickness from a few inches to four or five feet. A specimen of this rock was examined in the laboratory of the Geological Survey, and found to contain 12·4 per cent of metallic iron.

Hemitiferous sandstone.

Lignite.

Lignite.—Lignite was found in the Peace River sandstones on the Peace River in several places, but in seams too small to be workable. It also occurs in the plateaus south of Lesser Slave Lake. In one section at the latter place, four seams ranging in thickness from one to four feet, besides a number of smaller ones were found, distributed through about 1,000 feet of sandstones and shales. Drift lignite was also found in Marten River near the base of Marten Mountain, but it was not traced to its source. On the Athabasca, the Grand Rapids sandstone is lignitiferous, some of the seams being from four to five feet thick, but the quality is usually inferior. Several small seams also occur imbedded in the Tar sands.

Mineral springs.

Salt.—Mineral springs holding considerable percentages of sodic-chloride occur on the Athabasca at La Saline, twenty-eight miles below the Forks, and about two miles above the mouth of Red Earth Creek (see p. 36). Samples of the water have been analysed in the Survey laboratory by Mr. Wait, with the following result.

Grains of saline constituents in one imperial gallon—at 60° F.

	Red Earth Creek.	La Saline.
Chloride of potassium	4·89	121·87
" sodium	860·28	4,475·69
" magnesium		77·25
Sulphate of lime	228·10	394·12
" magnesia	43·21	85·05
Total	1,136·48	5,153·98
Specific gravity at 60° F.	1·012	1·052

Saline springs of small volume also occur on the Pembina River and at Tar Island on Peace River.

Gypsum at Peace Point.

Gypsum.—Gypsum is deposited in small quantities by the mineral springs at La Saline, and it also occurs on Peace River between Bouillé Rapid and Peace Point, where beds ten to fifteen feet in thickness are said to exist. Blocks of gypsum several feet in diameter were found on Peace River above its confluence with Loon River, and on Red River, a few miles above its mouth. They have probably been derived from the Peace Point exposures, and carried up the valley of the Peace River by ice during the Glacial Period.

Gas springs on the Athabasca.

Natural Gas.—The most important natural gas spring in the district occurs on the Athabasca at the mouth of Little Buffalo River. The gas here forces its way up from the Tar sands, through 250 feet of the Clearwater shales and issues from the surface in numerous small jets distributed over an area, fifty feet or more in diameter. Some of the jets burn steadily when lighted, until extinguished by heavy rains or strong wind, and afford sufficient heat to cook a camp meal. A second spring was noticed on the left bank of the Athabasca about thirteen miles below the mouth of the Pelican River. The volume of gas escaping here is less than at the mouth of Little Buffalo River, and in order to reach the surface it is obliged to penetrate 570 feet of shales and sandstone which here overlie the Tar sands. Escaping jets of gas were also noted at several points further up the river, but these were mostly small, and may possibly be due to decaying vegetable matter. On Peace River natural gas issues in small quantities from the Tar spring on Tar Island. The natural gas springs have less value in themselves at present, than in the indications they afford of the existence of petroleum beneath.

Gas spring on Tar Island.

Age of Tar sands.

Bitumen.—The Tar sands, the principal bitumen bearing formation of the district, are described in a preceding part of the report. This unique formation is of Dakota age, and constitutes in this region

the basal member of the Cretaceous series. It rests unconformably on the Devonian, and is exposed overlying the latter along the valley of the Athabasca for a distance of ninety miles. Lithologically it may be described as a soft sandstone, the cementing material of which is a bitumen or inspissated petroleum derived from the subjacent limestones. The boundaries of the Tar sands were only precisely defined at a few points, but they were estimated to have a minimum distribution of fully 1,000 square miles, where either completely uncovered, or buried beneath a part of the overlying Clearwater shale on the highlands, and exposed in the river valleys. They vary in thickness where the section is complete, from 140 to 225 feet. The bitumen is unequally distributed through the sands, in a few places merely staining the grains, but in most of the sections examined it is present in sufficient quantity to render the whole mass more or less plastic. The following calculation, which is extracted from the Summary Report for 1890, although it can only be regarded as an approximation, yet will serve to give some idea of the enormous outpouring of bituminous substances which has taken place in this region.

Distribution of Tar sands.

"An analysis by Mr. Hoffmann of a specimen collected some years ago by Dr. Bell, gave by weight :—

Bitumen	12·42
Water (mechanically mixed)	5·85
Siliceous sands	81·73

"A cubic foot of the bituminous sand rock weighs, according to Mr. Hoffmann, 117·5 lbs. This figure multiplied by the percentage of bitumen 12·42 gives 14·59 lbs. as the amount of bitumen present in a cubic foot, or $\frac{14 \cdot 59}{63 \cdot 7} = 22 \cdot 9$ per cent in bulk. Taking the thickness at 150 feet, and assuming the distribution as given above at 1,000 square miles, the bituminous sands in sight amount to 28·40 cubic miles. Of this mass, if the preceding analysis is taken as an average, although it is probably rather high 22·9 per cent in bulk, or 6·50 cubic miles is bitumen. The amount of petroleum which must have issued from the underlying limestones to produce 6·50 cubic miles, or by weight approximately 4,700,000,000 tons of bitumen, cannot now be estimated, as the conditions of oxidation and the original composition of the oil is unknown. It must, however, have been many times greater than the present supply of bitumen."

Amount of bitumen.

The commercial value of the Tar sands themselves, as exposed at the surface, is at present uncertain, but the abundance of the material, and the high percentage of bitumen which it contains, makes it probable that it may, in the future, be profitably utilized for various purposes, when this region is reached by railways. Among the uses to which

Commercial value of Tar sands.

it is adapted, may be mentioned roofing, paving, insulating electric wires, and it might also be mixed with the lignite which occurs in the neighbourhood, and pressed into briquettes for fuel.

Probability of finding oil.

The Tar sands evidence an upwelling of petroleum to the surface unequalled elsewhere in the world, but the more volatile and valuable constituents of the oil have long since disappeared, and the rocks from which it issued are probably exhausted as the flow has ceased. In the extension of the Tar sands under cover the conditions are different, and it is here that oils of economic value should be sought. In ascending the Athabasca, the Tar sands are overlaid at Boiler Rapid by a cover of shales sufficient to prevent the oil from rising to the surface, and in ascending the river, this cover gradually thickens. The geological attitude of the shales is not the most favourable, as the beds dip away from the outcrop at the rate of five to ten feet to the mile, and it is possible that a part, or even the whole of the oil may have flowed northwards and eastwards through the sands, and escaped where these come to the surface. It is unlikely however, that all the oil has escaped in this manner, as small anticlinals in the covering beds are almost certain to exist, and a differential hardening of the beds themselves may serve to inclose reservoirs or inverted basins of large capacity. It is also possible that the sands at their outcrop, may by the deposition of tarry substances be plugged tightly enough to prevent further egress. Favourable indications of the presence of oil in the vicinity of the Athabasca, are also afforded by the existence of the natural gas springs referred to on a previous page.

Drilling desirable.

The question of the continuity of the Tar sands and their petroliferous character under cover, can, however, only be settled in a decided manner by boring, and it is highly desirable that drilling operations should be undertaken for this purpose. At the mouth of Pelican River the Tar sands are probably covered by about 700 feet of strata, and this amount increases as the river is ascended. At the Athabasca Landing, if the formation extends to that point, it probably lies at a depth of from 1,200 to 1,500 feet below the surface, but the distance of the Landing from the outcrop of the Tar sands, and the variability in the thickness of the Cretaceous formations make it impossible to give more than a rough estimate.

Indications of oil on Peace River and other places.

Indications of the presence of oil in the district is not confined to the Tar sands, as on Peace River and Lesser Slave Lake inspissated bitumen was found in a number of places lining cracks in nodules, and at Tar Island in Peace River, small quantities of tar are brought to the surface by a spring. Tar springs are also reported from several

other points, but their existence lacks verification. North of this district tar occurs at intervals in the Devonian limestones exposed along the valleys of Slave River and the Mackenzie, all the way to the Arctic Ocean.

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

NORTH - WESTERN MANITOBA

WITH PORTIONS OF THE ADJACENT DISTRICTS OF

ASSINIBOIA AND SASKATCHEWAN

BY

J. B. TYRRELL, M.A., B.Sc., F.G.S.,

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1892

To Alfred R. C. Selwyn, C.M.G., LL.D., F.R.S., &c.,

Director and Deputy Head,

Geological Survey of Canada.

Sir,—I beg to present herewith my report on North-western Manitoba, and portions of the adjacent Districts of Assiniboia and Saskatchewan, accompanied by two copies of a map on the scale of eight miles to one inch, one showing the geology of the region, and the other the distribution and character of the forests.

The collections made during the course of the exploration have for the most part been described in other reports and papers. For gratuitous assistance in the description of these collections we are indebted to Dr. D. Rüst, of Hanover, Germany; Dr. H. A. Nicholson, of Aberdeen, Scotland; Prof. T. Rupert Jones, of London, England; Sir William Dawson, Prof. D. P. Penhallow and Prof. B. J. Harrington, of McGill College, Montreal.

We are also indebted to the various officers of the Hudson's Bay Company for much assistance rendered during the course of the exploration, but especially to Mr. David Armitt, of Manitoba House, who did everything in his power to promote the welfare of the expedition.

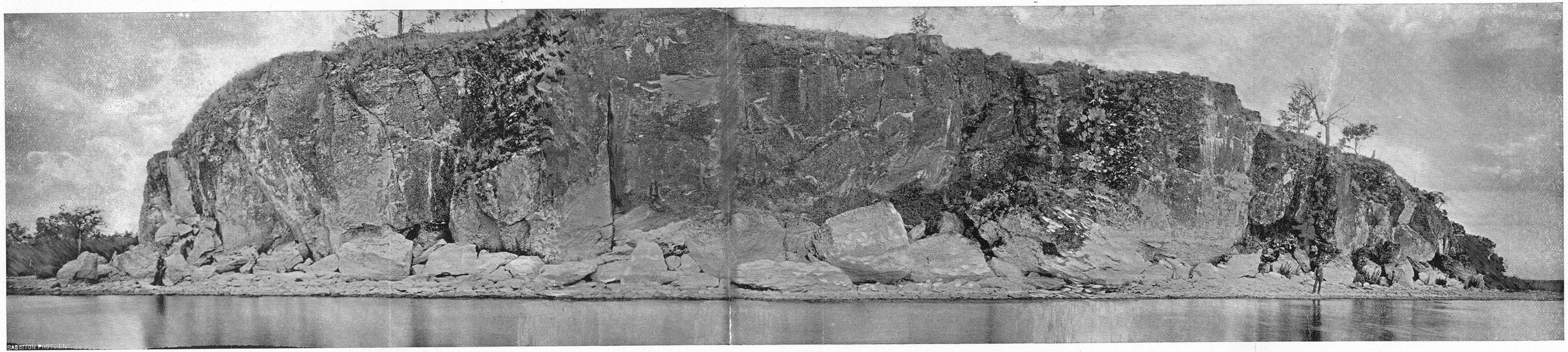
I have the honour to be, sir,

Your obedient servant,

J. B. TYRRELL.

Geological Survey Office, 6th June, 1892.

NOTE.—The bearings throughout this report are given with reference to the true meridian.



J. B. Tyrrell, Photo., July 25, 1889.

CLIFF OF MIDDLE DEVONIAN DOLOMITE (STRINGOCEPHALUS ZONE)
ON AN ISLAND NORTH OF WHITEAVES POINT, DAWSON BAY, LAKE WINNIPEGOSIS. Lat. 52° 51′ 40″ N., Long. 100° 40′ W.

This document was produced by scanning the original publication.

Ce document est le produit d'une numérisation par balayage de la publication originale.

NORTH-WESTERN MANITOBA

WITH PORTIONS OF THE DISTRICTS OF

ASSINIBOIA AND SASKATCHEWAN

INTRODUCTION.

Date of exploration.

The present report, with the accompanying maps, is the result of explorations carried out during the summers of 1887 and 1889, and portions of those of 1888 and 1890.

Preliminary report.

On account of the magnificent resources of this country in dairying, lumbering and agriculture, and also on account of the long continued ill-health of the writer caused by an attack of typhoid fever contracted in the northern part of Lake Manitoba, it was thought advisable to publish a preliminary description of the region in the Annual Report Geological Survey, vol. III., in which a few of its main characteristics were commented on.

Assistance.

Throughout the progress of the survey, Mr. D. B. Dowling, B.A.Sc., has acted continuously as my assistant and has performed a considerable portion of the topographical work that it was found absolutely necessary to prosecute in order to designate intelligently the geological features of this hitherto almost unknown region. To him is also due the credit for any excellence that the maps possess from a cartographical stand-point. The projection was laid down by Mr. Scott Barlow, chief draughtsman, and the proofs were carefully inspected by him.

Contour lines

In the preparation of the map, it has been found much more satisfactory to represent differences of elevation by contour lines, rather than by hachuring as has been customary up to the present in the maps published by this department, since by this method the character of the escarpment running north-north-westward through the province of Manitoba can be beautifully brought out. On the other hand, it has been impossible thus to represent many of the steep, but comparatively low slopes.

Maps.

As a basis for the preparation of the present map the surveys made by the Dominion Lands Branch of the Department of the Interior have been used wherever practicable. These include surveys of townships and township outlines in the southern portion, all of which are marked in full lines; the western boundary of the province of Manitoba as far north as the north side of township 36; a meridian township outline between ranges 18 and 19 on the First System of Survey, run on the ice across Lake Winnipegosis to Cedar Lake; a traverse survey of Lake Manitoba (corrected by transverse lines at several points); a traverse survey of Lake Winnipegosis from Meadow Portage around the west shore to the mouth of Overflowing River, and surveys of Shoal River, Swan Lake, and Swan and Overflowing Rivers for a few miles above their mouths; a survey of the Saskatchewan River (corrected for longitude by connecting it with the meridian line running southward across Lake Winnipegosis). The surveys of the old line of the Canadian Pacific Railway have been of much value, especially in furnishing reliable bases of elevation. The Manitoba and North-western Railway has furnished similar information for the south-west corner of the sheet. Besides these lines, surveys of Waterhen River, and Meadow and Mossy Portages were made in connection with the Canadian Pacific survey. Indian reserves have been incorporated throughout, as well as several surveys of timber limits in the northern portion of the Duck Mountains.

The following statement of the surveys performed during the course of the present exploration is essentially an abridgement from the Summary Reports of the Director in the "Annual Reports" of the Geological Survey Department, vols. III. and IV.

Exploration, 1887.

Starting from Brandon on the 15th of July, 1887, we drove northward to Strathclair, and thence made an odometer survey of the trail up the Little Saskatchewan River to its source in Lake Audet, across the summit of Riding Mountain and down the Vermilion River to Lake Dauphin. From this trail, paced surveys were made of the beds of Ochre River and Edwards Creek, the banks of these streams being either too swampy or too much obstructed by fallen timber to admit of following them even on foot.

Lake Dauphin Plain.

An odometer survey was then made northward across Wilson River to Valley River, a track survey at the same time being made of Wilson River and its vicinity. North of Valley River one of the rounded gravel ridges, known to the Indians as "Pitching Ridges," was followed, first with a buckboard and odometer, and afterwards on horseback as far as Fork River, a fairly accurate sketch-map being at the same

time made of the eastern face of Duck Mountain. Finding that progress would be very slow north of Fork River, we returned to Valley River and made an odometer survey of the cart trail leading westward along this stream, reaching Shell River through the deep glacial valley that separates the Duck from the Riding Mountain. From Shell River the trail was followed and surveyed over the high ground southward to the village of Russell, a terminus of one of the branches of the Manitoba and North-western Railway. From Russell, a similar survey was conducted across Silver, Bird Tail and Arrow Creeks to Shoal Lake, and thence to Little Saskatchewan River, returning by a more northern route to the point of starting.

Shell River.

From Russell we proceeded northward with buckboard and carts to Assessippi, on Shell River, from which point the vehicles were sent round to meet me higher up the river, while with saddle and packhorses I examined the lower part of the valley, and rejoined the carts about the south line of township 26. We then continued up Shell River to within three miles of the confluence of the north and east branches, generally in the bottom of the wide, deep valley, but sometimes where it was impossible, without great delay, to ford the stream, we were obliged to climb to the top of the bank. On the way, however, we left Shell River for a time and turned eastward on an Indian cart trail to Angling Lakes, where Coté's band of Indians have several houses in which they spend the winter, being here in the centre of their hunting grounds. From this village, then quite deserted, a track survey was made of the stream that flows southward out of the largest and most easterly of the Angling Lakes till it was found to flow into the valley that separates the Duck from the Riding Mountain. It was found to be the main branch of Valley River. Two pack trails leading northward from the Indian village were also examined, one being found to lead up the east branch of Valley River to its source, and the other to Gull Lake which belongs to the drainage area of Shell River.

Angling Lakes.

Returning to this latter river, we were obliged to leave the carts at a point three miles below the confluence of the north and east branches, and to use packhorses in continuing the survey towards the sources of some of the small streams tributary to the main river. Returning to the carts we followed and surveyed an Indian cart trail westward across Big Boggy and Little Boggy Creeks, till it joined the old Pelly cart trail at the Indian village on Coté's Reserve. We then followed and located the latter trail northward to Fort Pelly, where we arrived on the 22nd of September.

Swan River.

Having here obtained sufficient supplies to last till the end of the season, we followed a cart trail to the north-east, keeping south of Swan River for about forty miles, or till we reached the "Square Plain," making an odometer survey throughout the distance. I, however, branched off from this trail, and with packhorses followed a trail up Rolling River, till the stream became very small and was flowing in a shallow valley through a country that appeared to be one interminable swamp. As the country was impassable for horses, I returned and made a paced survey down the bed of the stream to a short distance below the crossing of the old location of the Canadian Pacific Railway, where the river again flows in a defined but winding channel through a marshy, level tract of country.

Duck Mountain.

Returning to Square Plain, Swan River was crossed and followed on its northern bank down to the mouth of Oak Creek, where the carts were again left, and with pack and saddle horses a track survey was made around the north end of Duck Mountain, following, during part of the distance, conspicuous gravel ridges that extend along the eastern face of the escarpment, at least as far north as the valley of Swan River. In returning, the north-east point of the Duck Mountain was crossed, and also the head-waters of North and South Duck Rivers and Pine River. Then passing around the north end of Big Lake, in which Rolling River takes its rise, the head of Favell River was reached. This river was then followed on a northward course to near its junction with Rolling River, whence we returned to the carts at the mouth of Oak Creek.

While I was engaged as above described, Mr. Dowling was making pace and track surveys of Swan River and of the country lying north of it in the vicinity of the camp.

Swan River Trail.

Below Oak Creek an odometer survey was made of the trail down to Swan Lake, and the river was followed on foot in many places, where there was any possibility of exposures of the underlying rocks being met with. From Swan Lake the party returned to Fort Pelly by the old Hudson Bay Company's cart trail on the north side of Swan River, at the same time making an examination of the southern face of Thunder Hill.

The village of Russell was reached and the season's work completed on the seventh of November.

Barometer readings.

Readings were taken regularly three times a day from a mercurial barometer, and numerous intermediate readings were taken from two aneroids. These were compared with readings taken from a standard mercurial at Minnedosa, the height of the cistern of which is 1,689 feet. Known points were also taken along the old Canadian Pacific

railway survey line, and barometer readings at these points were compared with simultaneous readings at many surrounding places.

Exploration, 1888.

On the 13th of June, 1888, I left Winnipeg for Portage la Prairie, where Mr. W. R. Baker, General Superintendent of the Manitoba and North-western Railway, kindly ordered a railway velocipede to be placed at my disposal. With its assistance all the cuttings on the railway between Minnedosa and Langenburg were examined, as well as the material thrown out of the wells at and between the different stations.

Returning from Minnedosa to Westbourne we paddled down White Mud River to Totogen, and from there coasted along the west side of Lake Manitoba to Manitoba House. The east side of the lake was next examined from Manitoba House to Fairford, and the Fairford River was descended to its mouth in Lake St. Martin.

Lake St. Martin.

A survey was made of this latter lake by Mr. Dowling with a compass and floating boat-log, while the writer travelled on foot into the wooded country to the west of the lake for the purpose of examining and locating a reported deposit of gypsum, after which a careful geological examination was made of the shores of the lake itself.

Returning to Lake Manitoba, its north shore was examined, and any outlying islands were surveyed, as far as the mouth of Waterhen River, and this river was explored up to Waterhen Lake.

From Waterhen Lake the writer returned to Manitoba House, and the next eighteen days were spent in company with Mr. J. F. Whiteaves, Palæontologist of the Geological Survey Department, in making a full collection of fossils from the exposures of Devonian rocks around the shores of Lake Manitoba.

Lake Winnipegosis.

In the mean time, Mr. Dowling surveyed the east shore of Lake Winnipegosis with a compass and micrometer as far as Mossy Portage, and the north shore with a transit and micrometer from the meridian outline near Mossy Portage to the mouth of Overflowing River, there connecting with the traverse of the west side of the lake made by the Dominion Lands Branch of the Department of the Interior two years before.

He next surveyed with compass and micrometer the Overflowing River for thirty-seven miles up from its mouth, the Red Deer River up to the lake, which was found to have an area of a hundred square miles, and the river for twenty-two miles above the lake. He also connected the final point of the Dominion Lands survey of the Swan River with the chain survey of the higher parts of the river on the south-east side of two Indian reserves now abandoned. He also made a survey of many of the islands in Lake Winnipegosis.

Exploration, 1889.

In the spring of 1889 the rivers St. Martin (Little Saskatchewan) and Fairford were ascended from Lake Winnipeg to Lake Manitoba, and Manitoba House was reached on the evening of the 8th of June.

From Manitoba House the lake was crossed to Crane River Narrows, where lines were run to locate some islands more exactly, and to connect the surveys of the opposite sides of the lake. The Waterhen River was ascended to Lake Winnipegosis and the south shore of this lake examined to the mouth of Mossy River, and at the same time a survey was made of Snake Island, and the other islands in its vicinity.

Mossy River.

A micrometer and compass survey was made of Mossy River, and the shores of Lake Dauphin were run in with the floating boat-log.

Lake Winnipegosis.

From Mossy River, the shore of Lake Winnipegosis was closely followed and examined to the mouth of Red Deer River and surveys were made of all the adjoining islands. Shoal River was then ascended to Swan Lake, and surveys were made of the islands in this lake.

Porcupine Mountain.

From the west side of Swan Lake an examination was undertaken along the foot of the Porcupine Mountain to Kematch River where a good section of the Niobrara and Benton beds was obtained; meanwhile Mr. Dowling crossed to Bell River, and ascended it to the summit of the mountain, also obtaining a section of the Cretaceous shale and the overlying drift. North of Porcupine Mountain Red Deer River was ascended in canoes to Red Deer Lake. There, horses were obtained from a small band of Indians living at the west end of the lake, and with two men I struck back to Armitt River at the foot of the mountain. From the west bank of this stream two gravel ridges were followed alternately, to near the mouth of the Etoimami River, where they merge into an extensive sandy delta-plain. An old trail was then followed down the north side of Red Deer River back to the lake.

From the mouth of Red Deer River an examination was made of the north and east shores of Lake Winnipegosis, a pace survey was made of the western Mossy Portage, while the eastern Mossy Portage was also carefully examined.

Waterhen Lake.

From Pine Creek Mr. Dowling returned with the boat to Manitoba House, stopping on the way to make a survey of Waterhen Lake with a compass and floating boat-log. The writer left Pine Creek with a horse and cart, and made an odometer survey of the trail back to a small new Indian village on one of the pitching ridges. From there the ridge was followed north to Duck River, and the deep gorge of North Pine River was discovered and examined. From the Indian village an odometer survey was made southward to the Dauphin settlement, and thence eastward through wooded country to Manitoba House.

In the early summer of 1890 a canoe traverse was made of the Assiniboine River southward from Fort Pelly to Portage la Prairie, and immediately afterwards a survey of the islands and south shore of Cedar Lake was made with a compass and floating boat-log, and the Saskatchewan River was examined from Cedar Lake down to its mouth. At the same time Mr. Dowling examined a small area, hitherto unexplored, on the eastern face of the Riding Mountain south of Lake Dauphin. Exploration, 1890.

The plateau on the summit of Porcupine Mountain was not examined, but its topography has been dotted in from plans and verbal information received from Sakewékochin, John Beardy and Peter More, three Indians living near Swan Lake who hunt and trap in that area.

During the course of the exploration the fossil fauna of western Canada has been very greatly enriched both by the discovery of new species and by the finding of many previously known species which have not before been met with on this continent. Most of these have been identified or described by Mr. J. F. Whiteaves, Palæontologist of this department. The fossil plants have been kindly determined by Sir William Dawson and Professor D. P. Penhallow, of Montreal; the Radiolaria by Dr. D. Rüst, of Hanover, Germany; the Stromatoporoids by Dr. H. A. Nicholson, of Aberdeen, Scotland; the Ostracoda by Professor T. Rupert Jones, of London, England; and a Cretaceous insect by Professor S. H. Scudder, of Cambridge, Mass., U.S. Specimens of brine from all the principal brine springs in the district were collected and have been analysed by Mr. G. Christian Hoffmann, Chemist of this department; while Professor B. J. Harrington, of Montreal, has kindly analysed the fossil resin collected on the shore of Cedar Lake. Fossils.

More than two hundred photographs have been taken of places and features of especial interest throughout the region. Photographs.

HISTORICAL SKETCH.

Secluded position.

North-western Manitoba has, up to the present time, remained comparatively unknown, for since the early part of the present century it has been off the main line of travel either to the Great Plains or to the Athabasca Region. Prior to A.D. 1806, however, the Swan and Red Deer rivers were main channels of the trade of the North-west Company with the Indians of the Plains, and a good cart trail is stated to have existed along the north bank of the latter river through what is now dense poplar forest. Also for many years after the above date Fort Pelly was one of the chief trading posts of the Hudson's Bay Company, and boats of from three to four tons burden annually descended the Swan River, carrying the furs there collected to York Factory on Hudson's Bay.

The following are among the more important recorded explorations that have been made in the region under consideration up to date :

Verendrye, 1739.

Lake Manitoba was first discovered by Chevalier de la Verendrye, who in April, 1739, was sent by his father, Sieur de la Verendrye from Fort la Reine at Portage la Prairie, to look for suitable places to construct forts on Lake des Prairies (Manitoba) and the lower portion of River Paskoiac (Saskatchewan) and to examine the northern end of Lake Winnipeg in order to intercept the trade with the English at Hudson's Bay. Two years later, in October, 1741, another party was sent by Sieur de la Verendrye, under the Chevalier's eldest brother Pierre, to build Forts Dauphin and Bourbon in the district already explored.*

David Thompson, 1797.

In September, 1797, David Thompson, the distinguished geographer of North-western America, crossed Lake Winnipeg from the mouth of Winnipeg River, ascended Dauphin (St. Martin's) River, and entered Manito (Manitoba) Lake. This lake was crossed, the goods were carried across Meadow Portage, and he proceeded to the mouth of the Little Dauphin (Mossy) River. He then traversed Lake Winnipegosis, ascended Shoal River to Swan Lake, and ascended Swan River a short distance to the old fort of the North-west Company on the broad alluvial flat on the north bank of the stream. Here he left his birch canoes and taking horses rode up the valley of Swan River to the trading post on Snake Creek, crossing on his way a wide sandy plain on which he states that "the buffalo sometimes feed in winter." From the Snake Creek Post

*Report on Canadian Archives, 1889, p. 27. Memoire du Sieur de la Verendrye, in Mémoire et Documents originaux, recueillis et publiés par Pierre Margry. Paris, 1889, pp. 591 & 594.

he turned south to the Assiniboine River, the valley of which he followed to a trading post six miles below the mouth of Little Boggy Creek. He next surveyed the upper waters of the Assiniboine River, after which he set out on his winter journey to the Mandan villages on the Missouri. Mr. Thompson's map, on the scale of about thirteen miles to the inch, is in the possession of the Crown Lands Department of the province of Ontario.*

Alex. Henry, 1800.

Alexander Henry, who was afterwards drowned at the mouth of the Columbia River in 1814, spent the winter of 1799–1800 at Fort Dauphin on the lake of the same name, and in 1804, he made a winter journey from Portage la Prairie across Lake Manitoba to Manitoba House.†

D. W. Harmon, 1800.

In the year 1800 Daniel Williams Harmon, at that time a clerk, and afterwards a partner in the North-west Company, ascended St. Martin's River, crossed Lakes Manitoba and Winnipegosis and ascended the Swan River to the company's trading post. During the winters of 1800–1804 he often travelled up the Swan River valley with a dog team. He speaks of the soil being rich, of there being a garden at the fort, and of salt springs in the vicinity from which salt was obtained.‡

Note by Sir John Richardson.

Sir John Richardson, who made several journeys up and down the Saskatchewan in the early part of the present century, states: "We obtained specimens exactly similar to those (limestone) in Lake Winnipeg from Manito-baw Lake, and were informed that it abounds much further to the southward."§

℔He also describes the Scapulæ of *Mastodon giganteus* obtained through the exertions of Dr. Rae "from Swan River (properly Swan River District) near the western side of the basin of Lake Winnipeg."

T. Simpson, 1836.

On the first of December, 1836, Thomas Simpson left Fort Garry on his famous journey to the north and crossing Lake Manitoba on the ice reached Manitoba House on the 6th. Thence he coasted the west shore of the lake to Meadow Portage, and travelled on the ice of Lake Winnipegosis to Duck Bay. At Duck Bay he struck inland by a winter trail to Swan Lake, from which he ascended the Swan River

*A Brief Narrative of the Journeys of David Thompson in North-western America by J. B. Tyrrell. Proc. Can. Inst., Vol. VI., pp. 135–160.

†Alexander Henry's Manuscript in the Parliamentary Library in Ottawa.

‡A Journal of Voyages and Travels in the Interior of North America, by Daniel Williams Harmon. Andover, 1820.

§Franklin Journey to Polar Sea. London, 4to. 1823, p. 506. Richardson's Appendix.

℔Zoology of the Voyage of H.M.S. "Herald." London, 4to. 1854, pp. 101–102 and 141–42.

valley to Fort Pelly and going by way of Fort Carlton hurried on to the Mackenzie River.

On his return journey he reached Fort Pelly on the 22nd of January, 1840, and then turned southward by the trail on the west side of the Assiniboine River.

He gives short descriptions of lakes Manitoba and Winnipegosis and mentions the manufacture of salt by "freemen" for sale to the Hudson's Bay Company.*

J. Palliser, 1857.

In October, 1857, Capt. J. Palliser, returning from Fort Carlton, travelled down the trail on the west side of the Assiniboine from Pelly to Ellice, and has left a short general description of that portion of the country.†

S. J. Dawson, 1858.

In May, 1858, Mr. S. J. Dawson left Fort Garry and crossed over to "Manitouba" Lake, on which he embarked, and thence travelled in canoes to the north-west end of "Winnipegon" Lake, crossed the Mossy Portage to Bourbon (Cedar) Lake and descended the Saskatchewan to Grand Rapids. On his return to Mossy Portage he divided the party, giving Mr. Wells, his assistant, charge of one section, while with the other section of the party he ascended the Swan River in canoes to the Pelly Crossing and descended the Assiniboine from Fort Pelly to its mouth.

He gives a description of the character of the shores of lakes Manitoba and Winnipegosis and mentions the occurrence of limestone towards the north end of the latter lake. He also notes the occurrence of mineral springs near the mouth of Swan River, from some of which salt was being made. Swan Lake, and the valley of Swan River are then glowingly described, the latter being correctly stated to be one of the most beautiful tracts of country that he had passed through. A good general description is then given of the valley of the Assiniboine from the Elbow at Fort Pelly to its mouth. He mentions having found float coal on Swan River, and that the Indians report it on Rolling River, Thunder Mountain and Red Deer River.

A. W. Wells, 1858.

Mr. A. W. Wells, who took charge of the second division of the party, measured the length and height of Mossy Portage, giving its length at four miles and eighteen chains and height of Lake Winnipegosis as four feet above Cedar Lake. From Mossy Portage he travelled southward along the west side of Lake Winnipegosis to Mossy River, which he ascended to Lake Dauphin. From Mossy

*Narrative of the Discoveries on the North Coast of America by Thomas Simpson, London. 8vo. 1843, pp. 31-36.

†The Journals, Detailed Reports and Observations relative to the Exploration, &c., by Capt. J. Palliser. London, folio, 1863, pp. 59-60

River he travelled by the north end of Lake Manitoba, whence he descended by St. Martin's River to Lake Winnipeg. He mentions the salt springs on Lake Winnipegosis and the occurrence of limestone on Mossy River and Snake Island, the former poor and the latter rich in included organic remains.

After reaching Fort Garry, Mr. Dawson and his assistant proceeded to examine the country between Red River and Lake Superior.

Attached to Mr. Dawson's report is a letter from Mr. E. Billings, dated 21st February, 1859, inclosing others from Messrs. Meek and Hayden, J. W. Dawson and J. R. Jones. This letter states that the fossils collected show the existence of Cretaceous rocks in the Canadian North-west, a fact which had been previously recognized by Dr. Hector in 1857, but which had not yet been made public. The first inclosure identifies the Cretaceous fossils, the second inclosure fossil woods and lignite, and the third a Palæozoic Ostracod.*

H. Y. Hind, 1858.

On the 13th of September, 1858, Professor H. Y. Hind accompanied by Mr. John Fleming as assistant entered Manitoba Lake from St. Martin's River. Crossing this lake, they ascended Waterhen River to Lake Winnipegosis and sailed to the mouth of Mossy River, calling at Snake Island and the salt works on the way. Mossy River was ascended with some difficulty and camp was pitched on the south shore of Dauphin Lake, at what was considered the nearest point to Riding Mountain. From the 9th to the 12th of October was spent in ascending the escarpment of Riding Mountain and descending again to the lake, whence Mr. Hind crossed by land on horseback to Manitoba House, while Mr. Fleming went round by the Waterhen River with the boat. While waiting at Manitoba House for Mr. Fleming, Mr. Hind examined the Devonian rocks on Manitoba Island.

From Manitoba House they crossed the lake to Oak Point, whence they returned to Fort Garry.

The report of this expedition contains records of many interesting geological observations, among which is the first notice of the occurence of Devonian strata east of the Manitoba escarpment.

John Fleming, 1858.

In August of the same year, Mr. Fleming had descended the Saskatchewan from Fort à la Corne to its mouth, on which trip he estimated the fall of the Grand Rapids at forty-three and a half feet.

*Papers relative to the exploration of the country between Lake Superior and the Red River Settlement, London, Govt., 1859. This report is accompanied by four maps, two of which are entitled "Sketch of Region explored between Red River and the Great Saskatchewan" and "Thompson's map showing the different tracks of the Saskatchewan and Assiniboine Exploring Expedition" in charge of Prof. H. Y. Hind.

Also the same report in Appendix No. 36 to the Seventeenth Volume of the Journals of the Legislative Assembly of the Province of Canada. Toronto, 4to. 1859.

This has been found to be an under-estimate, as the actual fall is seventy-one feet.

In July of the same year Mr. Dickinson, one of Mr. Hind's assistants, travelled from Ellice to Pelly, up the west side of the Assiniboine, and thence turning southward he followed the west side of the Little Saskatchewan, which he explored for part of its course, afterwards returning to Ellice. He makes no mention of the geology.*

Lord Southesk, 1859.

On the 9th December, 1859, Lord Southesk arrived at Fort Pelly on his return from a hunting trip to the Rocky Mountains. On the 28th of the same month he left this post in a carriole drawn by three dogs and descended the Swan River valley to Swan Lake, which he crossed on the ice, and travelled on the winter trail through the spruce forest to Duck Bay where the Hudson's Bay Company had just established a trading post. From Duck Bay he rode across the ice of Lake Winnipegosis to Meadow Portage and thence down Lake Manitoba to the mission at St. Laurent. He mentions the occurrence of salt springs, and indicates the possibility of springs in the bottom of the lake, as there are places where the ice is always dangerous.†

H. B. Smith, 1873.

In 1873, Henry B. Smith, C.E., made some explorations in this district in connection with the surveys of the Canadian Pacific Railway, with a view to determine the extent and nature of its navgable water-stretches, and the character of the barriers that separate them from each other.

"The Saskatchewan River between Cedar Lake and Winnipeg" is first briefly discussed, then "Mossy Portage between Cedar Lake and Winnipegosis" is described, and a plan and section of it are given. The two lakes are stated to have the same elevation, and the highest point of the portage is a quarter of a mile from Lake Winnipegosis, with an elevation of 93·14 feet above Cedar Lake. The approaches to the portage are also described. "Waterhen River, between Lakes Winnipegosis and Manitoba," is next considered, and a plan and section of the river are given. "Meadow Portage, between lakes Winnipegosis and Manitoba," is stated to have a length of one mile and three-quarters (given in the plan as 1 mile 57 chains 20 links), and the difference in level of the two lakes is stated as 18·73 feet, the greatest elevation being ten feet above Lake Winnipegosis. The approaches to this portage are also described. "Partridge Crop and

*Reports of Progress, together with a Preliminary and General Report on the Assiniboine and Saskatchewan Exploring Expedition by Henry Youle Hind, M.A. Appendix No. 36 to the Journals of the Legislative Assembly. Toronto. 4to. 1859.

†Saskatchewan and the Rocky Mountains, by Earl of Southesk. Edinburgh. 8vo. 1875.

Dauphin (St. Martin's) rivers, between lakes Manitoba and Winnipeg" are next discussed, and their depth and breadth given in several places.*

In the summer of 1874, Dr. R. Bell, of the Canadian Geological Survey, travelled with carts from Fort Garry to Fort Pelly, going by way of Fort Ellice and the trail on the west side of the Assiniboine River. From Fort Pelly he examined the eastern trail southward to Big Boggy Creek, and the valleys of Big Boggy Creek and Shell River in parts of their course. Returning to Fort Pelly he rode down the Swan River valley on the trail north of the river to a point four miles above the mouth of Rolling River where he found the pyritiferous sandstone that has since been determined as representing a horizon about the top of the Dakota formation. Returning again to Fort Pelly he embarked in a skiff on the Assiniboine and followed its windings as far as Fort Ellice. From Fort Ellice he crossed to the south end of Lake Manitoba and proceeded up the west side of the lake to the Narrows, and thence across to Fairford at the discharge of the lake. From Fairford he descended the Fairford and St. Martin's (Little Saskatchewan) rivers to Lake Winnipeg. R. Bell, 1874.

Throughout this distance exposures of Cretaceous shales were noted on the banks of the Assiniboine, and Devonian limestones at two places on Lake Manitoba, but no fossils were collected in either case.†

Dr. J. W. Spencer, acting as Dr. Bell's assistant in 1874, examined the lower portion of Shell River, and descended Swan River in a small boat from the Pelly crossing to its mouth, branching off in one place to climb to the top of Thunder Hill. From the mouth of Swan River he crossed Swan, Winnipegosis and Manitoba lakes to Oak Point, whence he returned to Fort Garry. J. W. Spencer, 1874.

In the Swan River valley, and on the face of Thunder Hill and Porcupine Mountain Cretaceous beds were observed, and specimens collected from the former locality were determined by Dr. George M. Dawson, on the evidence of the contained fossil foraminifera, to be of Niobrara age. Devonian rocks were also noticed on the shores of the various lakes passed through, and some typical fossils were collected from them or from loose masses of rock in their vicinity.‡

*Memorandum on the portages and streams between Lakes Winnipeg, Manitoba, Winnipegosis and the River Saskatchewan at Cedar Lake. From reports of surveys made by Henry B. Smith, C.E., in 1873. Appendix O. C.P.R. Report, 1874, pp. 259–262, with maps and profiles on sheet No. 11, Ottawa, 1874.

†Report on the country west of Lakes Manitoba and Winnipegosis by Robert Bell, C.E., F.G.S. Geol. Survey of Canada, Rept. of Prog., 1874–75, pp. 24–56. Montreal, 1876.

‡Report on the country between the Upper Assiniboine River and Lakes Winnipegosis and Manitoba by Joseph William Spencer, B. Ap. Sc. Geol. Survey of Canada, Rept. of Prog., 1874–75, pp. 57–70. Montreal, 1876.

G. C. Cunningham, 1874.

In the summer and autumn of 1874, Granville C. Cunningham located the old Canadian Pacific Railway line from Mossy River to the crossing of Snake Creek, around the north-east angle of the Duck Mountain. He gives a short, but clear description of the character of the country passed through, mentioning the occurrence of gravel ridges in several places.*

Swan River bore, 1875.

In the summer of 1875 Mr. Fairbank, of Petrolea, under contract with the Geological Survey of Canada, sank a bore-hole in the valley of Swan River close to the old Mounted Police barracks. A depth of 501 feet was reached, and the rocks throughout were found to be of Cretaceous age.†

J. Macoun, 1881.

In June, 1881, Prof. John Macoun, now of the Geological Survey Department, sailed northward across Lake Manitoba, ascended Waterhen River, and traversed the whole length of Lake Winnipegosis, reaching Shoal River House on the seventh of July. Here he built a boat with which he ascended Red Deer River to the forks, turned southward into Etoimami River and ascended it and Little Swan River to a marsh in the bottom of a valley. Making his way through this marsh he came on Swan River which he descended to the Mounted Police barracks at the mouth of Snake Creek, which he reached fifty-one days after leaving the mouth of Red Deer River. From here he made short excursions into the adjoining hills to the north-east and south-east. From Fort Pelly he descended the Assiniboine to Fort Ellice, whence he returned east.

The year was one of very high water, and much of the country immediately adjoining the lakes was flooded. He mentions the occurrence of limestone on lakes Manitoba and Winnipegosis, and especially notices the great fertility of the soil.

The salt springs are discussed at some length and a list is given of a number of places where they are to be found. On Red Deer River he records the occurrence of outcrops of fossiliferous limestone below Red Deer Lake and sandstone above it. The consideration of the extent and character of the forests in this valley is not the least interesting part of his report.‡

T. Guerin, 1881.

In the same summer, Thomas Guerin, C.E., was sent by the Department of Public Works to find out the cause of the abnormal rise of

*Report on an Exploratory Survey between Lake Winnipegosis and Livingstone during the summer and autumn of 1874 by Granville C. Cunningham. Appendix L. C. P. R., Rep., 1877, pp. 185-188. Ottawa, 1877.

†Boring made on Swan River, near Fort Pelly, in 1875. Alfred R. C. Selwyn. Geol. Survey of Canada, Rept. of Prog., 1875-76, pp. 292-3. Montreal, 1877.

‡Report on Exploration by Prof. John Macoun, M.A., F.L.S. Ann. Rep., Dept. of Interior, 1881, Pt. I., pp. 67-88. Ottawa, 1882.

the water in Manitoba and St. Martin's lakes during that and the preceding year, and if possible to devise some means of lowering the water and keeping it at its normal level. He found that a band of limestone stretched across the head of the Fairford River. The White Mud, Waterhen, Fairford and St. Martin's (Little Saskatchewan) rivers were measured and cross sections were made, and the total amount of water discharged by each of them at that time was calculated.*

D. L. surveys.

Several surveys have been made by the Dominion Lands Branch of the Department of Interior, among which the most important are the following:

In the winter of 1878, Wm. Wagner made a transit and chain traverse of Lake Manitoba.

In the winter of 1880, Wm. Pearce, D.L.S., ran the meridian township outline between ranges 18 and 19 in the old system of survey on the ice across Winnipegosis and Cedar lakes.

In the summer of 1887, J. I. Dufresne, D.L.S.; made a survey with transit and micrometer of the south and west shores of Lake Winnipegosis, and of Shoal River and Swan Lake. In his report he gives generally the character of any timber seen, and the positions of a number of outcrops of limestone.†

Previous reports on the work of this exploration.

As a result of the present exploration, the following reports and papers have already been published:

Harrington, B. J.—On the so-called Amber of Cedar Lake, North Saskatchewan, Canada. Am. Jour. Sci., Vol. 42 (Oct., 1891), pp. 332–5.

Jones, Prof. T. Rupert.—On some Ostracoda from the Cambro-Silurian, Silurian and Devonian rocks. Geol. Sur. Can., Contribs. to Can. Micro-Pal., Part III., with 3 plates. Montreal, 1891.

Nicholson, H. Alleyne.—On some new or imperfectly known species of Stromatoporoids. Ann. & Mag. N. Hist., ser. 6, Vol. VII. (Apl., 1891,) pp. 309–328, with 2 plates.

Dawson, Sir William, and Prof. D. P. Penhallow.—On the Pleistocene Flora of Canada. Bull. Geol. Soc. Am., Vol. I. (1890) pp. 311–334.

Rüst, Dr. D.—Radiolaria from the Pierre Formation of Northwestern Manitoba. Geol. Sur. Can., Contribs. to Can. Micro-Pal., Part IV., with 3 plates. Ottawa, 1892.

*General Report of the Minister of Public Works from 30th June, 1867, to 1st July, 1882, pp. 535–536. Ottawa, 1883.

†Exploratory Survey of Lake Winnipegosis and of Swan and Red Deer (Overflowing) Rivers. Ann. Rep. Dept. Interior, 1887, Pt. II., pp. 71–74. Ottawa, 1888.

Penhallow, D. P.—A new species of Larix from the Interglacial of Manitoba. Am. Geol., Vol. 9 (June, 1892) pp. 368–371.

Scudder, S. H.—Canadian Fossil Insects. Geol. Sur. Can., Contribs. to Can. Pal., Vol. II., pp. 30–31, with plate. Ottawa, 1892.

Whiteaves, J. F.—On some Cretaceous fossils from British Columbia, the North-west Territory and Manitoba. Geol. Sur. Can., Contribs. to Can. Pal., Vol. I., Part II., pp. 185–196, with plate. Montreal, 1889.

Whiteaves, J. F.—Descriptions of some new or previously unrecorded species of fossils from the Devonian rocks of Manitoba. Trans. Roy. Soc. Can., Vol. VIII., Sec. IV., pp. 93–110, with 7 plates. Montreal, 1891.

Whiteaves, J. F.—Descriptions of four new species of fossils from the Silurian rocks of the south-eastern portion of the District of Saskatchewan. Can. Rec. Sci., Vol. IV., Apl., 1891, pp. 293–303, with plate.

Whiteaves, J. F.—The Fossils of the Devonian rocks of the islands, shores or immediate vicinity of Lakes Manitoba and Winnipegosis. Geol. Sur. Can., Contribs. to Can. Pal., Vol. I., Part IV., with 15 plates. Ottawa, 1892.

Hoffmann, G. Christian.—Chemical Contributions to the Geology of Canada. Geol. Sur. Can., Ann. Rep., N.S., Vol. IV., 1888–9. Part R., 1890, p. 6 R.

Hoffmann, G. Christian.—Chemical Contributions to the Geology of Canada. Geol. Sur. Can., Ann. Rep., N.S., Vol. V., 1889–90–91. Part R., 1892, pp. 26–37.

Tyrrell, J. B.—Short account of the work done in the Duck and Riding Mountains in 1887. Ann. Rep., Dept. of Int., 1887. Part III., pp. 11–14. Ottawa, 1888.

Tyrrell, J. B.—Short account of the examinations of Lakes Manitoba and St. Martin. Ann. Rep., Dept. of Int., 1888. Part III., pp. 12–14. Ottawa, 1889.

Tyrrell, J. B.—Short account of the examinations of Lake Winnipegosis and vicinity. Ann. Rep., Dept. of Int., 1889. Part III., pp. 12–18. Ottawa, 1890.

Tyrrell, J. B.—Short account of the Assiniboine and Lower Saskatchewan Rivers. Sum. Rep., Geol. Sur. Dept., 1890, pp. 19–26. Ottawa, 1891.

Tyrrell, J. B.—Notes to accompany a preliminary map of Duck and Riding Mountains in North-western Manitoba. Geol. Sur. Can., Ann. Rep. N.S., Vol. III., 1887–8. Pt. E. Montreal, 1888.

Tyrrell, J. B.—Gypsum Deposits in Northern Manitoba. Can. Rec. Sci. (Apl., 1889), Vol. III., pp. 353–360.

Tyrrell, J. B.—Post-Tertiary Deposits of Manitoba and the adjoining Territories of North-western Canada. Bull. Geol. Soc. Am., Vol. I., Apl., 1890, pp. 395–410.

Tyrrell, J. B.—Foraminifera and Radiolaria from the Cretaceous of Manitoba. Trans. Roy. Soc. Can., Vol. VIII., 1890, Sec. IV., pp. 111–115.

Tyrrell, J. B.—The Cretaceous of Manitoba. Am. Jour. Sci., Vol. XL., 3rd Ser., Sept., 1890, pp. 227–232.

Tyrrell, J. B.—Pleistocene of the Winnipeg Basin. Am. Geol., Vol. VII., July, 1891, pp. 19-28.

Tyrrell, J. B.—Three deep Wells in Manitoba. Trans. Roy. Soc Can., Vol. IX., 1891, Sec. IV., pp. 91-104.

PHYSICAL GEOGRAPHY.

GENERAL FEATURES.

Position and area.

The map accompanying this report covers an area lying between latitudes 50° 47′ and 53° 19′ 30″ north, and longitudes 98° 40′ and 101° 56′ 30″ west, measured along its southern margin, and thus incloses about 25,300 square miles. Of this area 15,600 square miles are within the province of Manitoba; 5,600 square miles are in the district of Saskatchewan, and 1,500 are within the district of Assiniboia. About 4,000 square miles in the north-eastern and north-western portions of this region are as yet unexplored, so that the total area mapped and described in the following report slightly exceeds 21,000 square miles. At the commencement of the exploration it was intended to confine the work to the country lying south of the Saskatchewan River, and the main portion of the report is written with this impression in view; but on account of the uncertainty in which the exact taxonomic position of the rocks on the east side of Lake Winnipegosis was then left it was found necessary to extend the exploration to Cedar Lake and the lower stretches of the Saskatchewan, east of that lake, and a brief description of the geology of this water-stretch which has been so often travelled, but was yet so imperfectly known, has been incorporated.

Lacustral plain.

The general character of the surface is remarkably simple and is well shown by the contour lines on the accompanying map. The eastern two-thirds of the district is a lightly undulating plain sloping gently to the bottom of Lake Winnipeg. The depressions in the surface of this great plain are filled with shallow bodies of water with more or less irregular confines, and their waters are more or less rily from the presence of suspended clayey matter degraded by the waves from the surrounding shores of boulder clay or alluvium. These lakes are connected by short rapid streams, generally navigable for canoes, and with the exception of Swan and Red Deer lakes are chiefly fed by streams running from the face of the Manitoba escarpment.

Manitoba escarpment.

This escarpment is the most prominent geographical feature of the whole region. It rises from the lacustral plain, at first by a very gentle incline which gradually becomes steeper, till in the more typical places it reaches an almost abrupt declivity of several hundred feet. From the top of this escarpment, if a favourable place be chosen, not too much obstructed by forest growth, a far-reaching view may be had of

the vast plain stretching apparently from beneath the feet of the observer to the almost level horizon.

Table land. West of the brow of the escarpment lies the rugged table land of the Riding, Duck and Porcupine Mountains, often still rising for several hundred feet to extreme heights of more than two thousand seven hundred feet above the sea, or two thousand feet above the surface of Lake Winnipeg, and then declining gradually towards the south-west. This table land is generally densely wooded and travel over it is necessarily slow and difficult, but wherever examined, its summit near the edge of the escarpment was found to consist of irregular boulder-covered hills, wooded with small pine and spruce, while farther west extensive level tracts were found clothed with large spruce, and still further west it is trenched by deep valleys carrying small tributary streams down to the Assiniboine River.

Valleys. Both to the south and north of Porcupine Mountain the table land is cut through by large and very ancient valleys at present drained by Swan and Red Deer rivers, valleys that have evidently been formed by streams that flowed eastward into the great river that ran between the face of the escarpment and the Archæan plain east of Lake Winnipeg.

In the south-westerly part of the district the slope is towards the valley of the Assiniboine, and the country gradually changes from a thick forest, through partly wooded country, to open prairie.

The drainage of the whole surface finds its way into Lake Winnipeg, and thence by the Nelson River to Hudson Bay; but it discharges into Lake Winnipeg by three distinct and widely separated channels, viz., the Saskatchewan, the St. Martin's or Little Saskatchewan, and the Red rivers.

Across the north-east corner of this district the Saskatchewan carries the snow-waters of the Rocky Mountains to Lake Winnipeg, but no tributaries of any size join it here.

St. Martin's River. St. Martin's River empties into Sturgeon Bay on the south-west side of Lake Winnipeg, one hundred miles south-east of the mouth of the Saskatchewan, and carries with it the drainage of the greater part of this area. It is the channel of overflow of lakes St. Martin and Manitoba, and the chief tributary of this latter lake is the Waterhen River flowing from Waterhen Lake and Lake Winnipegosis. This lake is the collecting basin for the water draining the eastern face of the Manitoba escarpment, and those portions of the plains tributary to the Swan and Red Deer rivers.

Assiniboine River. The south-western corner of the district is drained by the Assiniboine which enters it from the west at Fort Pelly. It immediately

turns sharply to the S.S.E., and flowing for nearly eighty miles, leaves it just east of the western boundary of Manitoba. In this distance it receives the White Sand and other tributaries from the west, and the Little Boggy, Big Boggy and Shell rivers from the east, carrying off the drainage of the greater portion of the summit plateau of the Duck Mountain.

Adaptabilities of the country.

The adaptabilities of the country are very varied, and will be discussed at greater length in succeeding pages of the report, when the different areas are considered in detail; but it may be stated that the slope extending from the foot of the more abrupt escarpment to the western shores of Lakes Manitoba and Winnipegosis and the valleys of Swan and Red Deer rivers is eminently fitted for mixed farming. It is well supplied with water, though much of it needs to be drained. It is also for the most part underlaid by a clay soil derived from the degradation of the soft limestones and shales of the Cretaceous beds to the west, and is greatly enriched by the abundance of phosphatic material supplied by large deposits of fish remains included in these beds. In the immediate vicinity of the large lakes and on their eastern side the amount of alluvium is comparatively very small, but doubtless much of the calcareous boulder-clay with which the country is covered would be found to yield profitable harvests of the more hardy roots and cereals.

The country west of the escarpment in this part of Manitoba will probably never be a very successful wheat-raising district, but the hardier cereals can be grown with the assurance of an abundant crop, and the country is eminently suited to the raising of cattle for dairying purposes, for rich nutritious grass covers the surface everywhere except in the dense forest.

Natural products.

Much fine timber is growing on the remoter parts of the mountains, but a very large amount of spruce has during late years been destroyed by forest fires.

The manufacture of salt could readily be carried on, especially in the vicinity of Dawson Bay, where the natural brine springs are much more copious than elsewhere.

The lakes abound in food-fish, and with careful fishing can be made to yield a large and constant supply. Much large game is still to be found. Moose are plentiful throughout the wooded tracts everywhere; caribou are especially numerous on the east side of Lake Winnipegosis, and a few elk are still to be found between Riding Mountain and lakes Manitoba and Winnipegosis. The black bear wanders along the streams and by the lakes. Other fur-bearing

animals common to Manitoba and the North-west are taken by the hunters in greater or less abundance.

Climate.

The climate is remarkably clear and beautiful. In June and July, the prevalent winds are from the south, ushering in warm days accompanied by frequent heavy showers of rain, while later in the year westerly and north-westerly winds prevail accompanied by drier weather.

Frost.

Frost generally occurs in the early part of June and the latter part of August on the high lands west of the Manitoba escarpment, but the country to the east of this line enjoys a greater interval between the frost periods.

Table of temperature and rainfall.

The following table has been kindly prepared by Prof. C. Carpmael, Director of the Canadian Meteorological Service, and shows the temperature and rainfall better and clearer than any extended discussion would do. It is prepared for Minnedosa which is situated in a wide valley on the edge of the escarpment, on the eastern side of range 18, and thirty-five miles south of the limit of the accompanying map, and Russell at the terminus of the Manitoba and North-western Railway. The observing station at Minnedosa has an elevation of 1,689 feet above the sea, and that at Russell an elevation of about 1,830 feet. This latter is the only place in the district at which meteorological observations are at present taken, but the record is doubtless essentially correct for the country north at least to the Swan River valley, while the daily range in summer on the lacustral plain is certainly less than on the higher table land, and there is thus less probability of erratic frost.

STATISTICS of Temperature and Precipitation at Minnedosa, Manitoba, Latitude North 51° 10′, Longitude West, 99° 48′, height above sea, 1,665 feet.

BY PROF. C. CARPMAEL.

AVERAGE MONTHLY TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1881	.....	.....	.....	.....	.....	.....	65·25	61·35	47·24	30·22	12·26	9·78	.....
1882	— 2·54	6·67	8·63	28·62	47·55	57·19	60·93	64·69	53·66	38 19	18·29	2·80	32·06
1883	—15·38	7·01	5·86	30·96	44·40	57·71	58·19	57·85	47·93	33·59	12·18	—0·42	28·32
1884	— 7·63	—10·76	10·52	31·97	50·83	62·07	56·81	58·05	46·52	36·34	18·23	—4 80	29·01
1885	—12·20	— 6·87	11·77	34·09	46·70	55·68	60·48	54·08	49·02	34·97	24·94	10·16	30·24
1886	—14·43	1·23	13·75	38·98	52·09	60·70	66·76	59·50	44·70	41·07	16·12	—1·15	31·61
1887	—13·45	— 7·96	11·75	34·16	53·13	60·98	62·17	56·61	50·55	31·13	17·12	0·31	29·71
1888	—11·55	1·18	3·94	28·98	44·28	58·97	62·37	55·89	47·08	35·08	18·30	12·28	29·54
1889	4·92	— 4·06	24·82	40·47	48·76	62·50	63·36	62·18	45·75	35·08	19·78	7·59	34·26
1890	—11·52	— 8·64	7·70	35·82	42·10	65·18	65·36	57·41	45·06	38·26	.....	.....	.....
Average	— 9·31	— 2·73	10·97	33·78	47·77	60·11	62·17	58·76	47·75	35·39	17·47	4·06	30·52

AVERAGE MONTHLY MAXIMUM.

1881	.....	.....	28·9	42·2	65·6	68·2	76·9	71·6	56·9	38·7	20·3	19·9	.....
1882	7·3	18·0	19·6	38·6	59·9	69·2	72·3	76·4	66·3	47·2	26·1	13·3	.....
1883	— 4·3	5·3	17·0	42·4	57·8	69·8	70·8	69·4	61·7	41·0	21·6	9·4	.....
1884	3·1	— 1·0	20·8	41·8	65 8	74·2	74·8	71·8	58·6	47·2	25.9	3·5	.....
1885	— 3·2	— 0·4	22·6	45·1	59·6	68·2	72·1	67·7	64·6	46·1	31·8	21·0	.....
1886	— 4·8	13·8	26·0	51·4	65·2	73·9	79·6	75·8	59·7	54·2	27·8	8·1	.....
1887	— 1·1	3·8	24·5	47·1	67·0	71·9	74·0	70·1	65·8	43·9	28·7	10·0	.....
1888	— 2·5	9·8	15·2	39·8	57·4	69·4	74·7	72·4	66·4	48·9	31·9	24·8	.....
1889	19·0	12·2	40·4	56·6	64·1	77·5	77·7	79·8	62·7	52·8	35·2	20·3	.....
1890	2·2	6·1	22·5	49·9	55·2	77·2	78·2	71·3	62·3	50·2	.....	.....	.....
Average	1·7	7·5	23·7	45·5	61·8	71·9	75·1	72·6	62·5	47·0	27·7	14·5	.....

AVERAGE MONTHLY MINIMUM AND MEAN DAILY RANGE.

1881	.....	.....	.....	.....	.....	.....	53·6	51·1	37·6	21·7	4·2	0·4	.....
1882	—12·3	— 4·7	— 2·4	18·7	35·2	45·2	49·5	52·9	41·0	29·2	10·5	— 7·7	.....
1883	—26·6	—16·0	— 7·7	21·1	30·1	44·1	45·1	44·8	35·2	24·6	0·1	—12·7	.....
1884	—21·5	—25·0	— 1·2	21·0	34·8	49·5	44·0	45·6	36·0	25·4	6·2	—20·0	.....
1885	—25 2	—20·6	— 1·3	22·1	33·2	41·6	48·2	41·3	33·8	23·7	16·4	— 5·1	.....
1886	—26·9	—13·6	— 0·2	26·5	35·7	44·0	51·1	44·3	31·2	28·8	3·2	—13·2	.....
1887	—29·4	—21·3	— 2·0	20·9	39·1	47·4	47·8	42·5	36·5	18·5	5·0	—10·2	.....
1888	—23·7	—13·5	— 8·8	18·5	28 7	45·5	49·0	42·2	36·2	28·8	11·1	3·4	.....
1889	— 6·0	—15·2	15·3	28·3	34·4	44·8	48·9	46·9	35·9	26·0	10·5	— 3·7	.....
1890	—20·7	—18·7	— 3·9	24·9	29·1	50·5	50·0	43·6	34·7	31·8	.....	.....	.....
Average	—21·4	—16·3	— 1·4	22·6	33·4	45·8	48·7	45·5	35·8	25·9	7·5	— 7·6	.....
Mean Daily Range	23·1	23·8	25·1	22·9	28·4	26·1	26·4	27·1	26·7	21·1	20·2	22·1	24·42

HIGHEST TEMPERATURE REGISTERED.

1881	35·8	27·4	40·8	76·0	78·0	82·8	86·5	85·6	74·5	59·7	45·6	36·4	86·5
1882	28·1	38·5	42·8	48·6	78·7	81·8	84·8	86·6	82·0	63·7	41 0	31·7	86·6
1883	28·5	37·9	36·6	68·0	72·3	91·8	81·8	78·8	77·8	56·2	44·8	36·3	91·8
1884	19·9	28·7	43·8	64·2	82·0	88·0	77·3	85·0	69·6	72·8	49·7	41·6	88·0
1885	27·5	41·8	40·2	63·3	76·8	83·3	88·2	82·0	82·3	69·8	44·8	37·9	88·2
1886	19·9	44·6	47·6	76·3	83·8	88·0	92·0	102·6	82·8	82·4	63·2	38·8	102·6
1887	21·7	21·7	47·6	79·8	90 0	86·3	89·8	82·8	83·8	67·2	66·5	33·6	90·0
1888	35 9	38·4	36·9	66·1	73·2	93·8	84·3	84·3	82·8	75·8	47·3	37·9	93·8
1889	35·4	39·8	66·2	79·8	81·3	98·8	88 8	92·7	93·3	81·1	57·7	34·9	98·8
1890	28·4	35·4	35·7	69·8	68·8	87·3	94·3	90·4	87·1	82·8	56·2	.....	94·3
Average	28·1	35·4	43·8	69·2	78·5	88·2	86·8	87·1	81·6	71·2	51·7	36·6	92·1

STATISTICS of Temperature and Precipitation at Minnedosa, Manitoba, &c.—*Continued.*

LOWEST TEMPERATURE REGISTERED.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1881	.....	.....	.....	.....	.....	.....	41·2	40·8	24·9	4·3	— 26·9	— 29·2	.....
1882	— 39·2	— 38·5	— 26·0	— 10·2	20·6	33·4	38·4	33·2	22·6	21·2	— 6·2	— 33·2	— 39·2
1883	— 50·2	— 43·2	— 30·4	0·0	16·8	29·2	37·7	31·2	5·8	10·9	— 28·2	— 43·2	— 56·2
1884	— 48·8	— 40·8	— 35·2	8·9	18·3	35·0	32·7	31·0	23·6	0·6	— 31·4	— 46·7	— 48·8
1885	— 43 4	— 48·0	— 29·2	— 7·2	12·4	24·4	37·3	24·5	21·6	11·9	1·3	— 25·2	— 48·0
1886	— 52·2	— 48·7	— 24·7	— 14·7	14·3	26·0	37·0	24·5	11·7	11·9	— 23·6	— 39·5	— 52·2
1887	— 43·5	— 43·0	— 37·0	— 4·2	24·0	27·8	35·8	27·6	14·9	— 11·4	— 37·0	— 43·0	— 43·5
1888	— 44·5	— 50·6	— 28·8	— 4·2	14·9	22·5	38·5	38·5	15 4	14·9	— 11·4	— 14·0	— 50·6
1889	— 34·3	— 52·2	— 12·4	11·4	20·0	33·5	36·5	32·0	19·0	1·8	— 7·8	— 26·1	— 52·2
1890	— 39·0	— 46·0	— 33·3	— 2·9	14·9	36·8	40·0	27·5	22·0	20·0	— 1·2	.....	— 46·0
Average	— 43·9	— 45·7	— 28·6	— 2·6	17·4	29·8	37·5	31·1	18·1	8·6	— 17·2	— 33 3	— 47·9

RAINFALL IN INCHES.

	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1881	0·00	0·00	0·00	0·14	4·25	7·85	3·03	1·14	4·64	1·14	0·00	0·00	22·19
1882	·00	·00	·00	1·89	1·11	2·47	3·24	1·45	0·80	4·85	0·00	·00	15·81
1883	·00	·00	·00	0·14	0·88	2·03	1·38	1·63	0·30	1·82	0·00	·00	8·18
1884	·00	·00	·00	0·26	0·27	3·30	3·17	3·76	2·94	1·15	0·03	·00	14·88
1885	·00	R.	·00	1·05	2·44	3·01	2·26	1·90	0·46	0·11	0·10	·00	11·33
1886	·00	·00	·00	1·16	1·63	1·25	1·88	0·76	0·84	1·04	0·00	R.	8·56
1887	·00	·00	·00	0·10	2·24	6·95	1·89	1·53	1·15	0·30	0·02	·00	14·18
1888	·00	·00	·00	0·01	0·64	3·68	4·59	1·27	0·27	0·59	0·00	·00	11·05
1889	·00	·00	0·14	0·52	1·74	0·94	1·50	1·80	0·98	0·22	0·40	·00	8·24
1890	·00	·00	·00	0·47	1·56	4 72	2·72	3·81	1·90	1·41	.....	.....	16·59
Average	·00	R.	0·01	0·57	1·68	3·62	2·57	1·90	1·43	1·26	0·06	R.	13·10

SNOW, IN INCHES, AND TOTAL PRECIPITATION.

1881	1·5	27.0	8·0	8·0	0	0	0	0	0	10·0	14·6	2·0	71·1
1882	14·5	9·0	12·0	4·5	*	0	0	0	0	4·0	14·1	6·0	64·1
1883	4·0	5·7	8·5	11·5	*	0	0	0	*	*	4·5	18·5	52·7
1884	6·8	5·7	10·0	9·9	0	0	0	0	0	6·2	7·6	6·2	52·4
1885	2·8	5·4	9·6	8·8	1·5	0	0	0	0	5·0	1·3	10·8	45·2
1886	5·1	5·0	4·0	9·4	*	0	0	0	0·5	1·1	4·1	1·4	30·6
1887	4·9	5·0	2·1	8·3	1·0	0·5	0	0	0	1·3	8·5	8·2	39·8
1888	4·8	2·5	10·0	10·1	0·7	0	0	0	0	8·4	4·0	4·5	45·0
1889	10·4	5·1	0·9	1·7	*	0	0	0	*	0·6	4·9	12·3	35·9
1890	3·3	23·0	2·3	1·4	3·3	0	0	0	*	2·2	.....	.....	35·5
Average	5·8	9·3	6·7	7·4	0·7	*	.....	.....	*	3·9	7·1	7·8	48·7
Total rain and melted snow	0·58	0·93	0·68	1·31	1·75	3·62	2·57	1·90	1·43	1·65	0·77	0·78	17·97

NUMBER OF DAYS OF RAIN.

1881	0	0	0	5	15	16	11	14	18	4	1	0	84
1882	0	0	0	3	10	10	9	6	2	9	0	0	49
1883	0	0	0	1	6	15	13	7	3	10	0	0	55
1884	0	0	0	4	2	9	17	12	17	4	1	0	66
1885	0	1	0	8	10	9	18	15	5	3	1	0	70
1886	0	0	0	7	13	15	12	11	9	6	0	1	74
1887	0	0	0	4	12	15	13	12	11	3	2	0	72
1888	0	0	0	3	8	12	15	10	10	9	0	0	67
1889	0	0	4	6	13	9	5	4	9	3	1	0	54
1890	0	0	0	5	14	14	13	14	12	16	0	0	88
Average	0	R.	R.	5	10	12	13	10	10	7	1	R.	68

NUMBER OF DAYS OF SNOW.

1881	4	16	6	5	0	0	0	0	0	5	11	5	52
1882	9	3	5	5	1	0	0	0	0	2	9	6	40
1883	4	3	3	3	1	0	0	0	1	5	12	7	39
1884	10	9	7	9	0	0	0	0	0	7	7	10	59
1885	8	7	13	8	4	0	0	0	0	6	5	13	64
1886	13	12	14	2	2	0	0	0	1	1	8	4	57
1887	10	12	9	5	3	1	0	0	0	7	9	12	68
1888	10	9	12	7	2	0	0	0	0	6	9	6	61
1889	13	7	5	2	1	0	0	0	1	2	7	9	47
1890	8	12	12	3	5	0	0	0	1	2	0	0	0
Average	9	9	9	5	2	*	0	0	*	4	9	8	55

STATISTICS of Temperature and Precipitation at Russell, Manitoba, Latitude North 50° 42′, Longitude West 101° 20′, height above sea 1,830 feet.

BY PROF. C. CARPMAEL.

AVERAGE MONTHLY TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1883	.....	.....	.....	.....	.....	.....	.....	.....	48·00	32·60	11·90	— 2·80	.....
1884	— 9·35	—10·74	9·40	32 22	53·35	62·07	58·33	59·34	46·20	35·87	16·38	— 9·24	28·65
1885	—13·67	— 7·70	13·01	34·66	48·32	57·06	61·07	55·08	48·54	33·69	24·54	8·33	30·24
1886	—18·16	0·94	11·99	38·80	51·74	60·06	66·93	59·70	44·85	40·27	14·79	— 4·38	30·63
1887	—15·82	—11·71	11·42	34·56	52·51	59·80	62·17	57·53	49·98	31·41	16·35	— 2·30	28·83
1888	—14·46	— 4·77	1·89	28·51	45·01	58·89	62·07	55·44	50·36	36·99	17·50	16·72	29·51
1889	4·87	— 2·67	24·86	41·48	48·04	59·82	60·57	63·20	46·29	36·32	19·87	4·17	33·90
1890	—14·94	—11·33	6·07	33·86	40·79	62·77	61·18	55·74	46·80	38·47	.....	.....	.....
Average	—11·65	— 6·85	11·23	34·87	48·52	60·09	61·76	58·00	47·63	35·70	17·33	1·50	29·84

AVERAGE MONTHLY MAXIMUM.

1883	.....	.....	.....	.....	.....	.....	.....	.....	63·5	40·8	21·5	6·4	.....
1884	1·7	— 1·5	20·4	41·4	67·2	73·8	68·7	72·4	56·9	46·7	24·1	0·0	.....
1885	— 4·9	2·4	21·1	44·3	60·5	69·2	71·4	67·9	64·6	46·5	32·2	18·5	.....
1886	9·1	13·0	23·6	50·2	64·9	72 8	80·3	74·7	59·6	53·6	27·8	5·2	.....
1887	— 4·4	0·8	22·2	46·3	66·3	70·9	74·0	70·8	64·4	44·4	28·6	7·9	.....
1888	— 4·9	8 0	12·6	37·5	57·9	70·3	72·6	71·0	64·8	45·9	27·4	21·2	.....
1889	14·9	11·4	36·6	54·7	62·0	75·4	75·5	79·2	61 4	51·6	31·8	15·5	.....
1890	— 5·1	1·2	15·5	44·5	52·3	75:7	75·4	68·4	60·8	48·2	.....	.....	.....
Average	0·9	5·0	21·7	45·6	61·6	72·6	74·0	72·1	62·0	47·2	27·6	10·7	.....

AVERAGE MONTHLY MINIMUM AND MEAN DAILY RANGE.

1883	.....	.....	.....	.....	.....	.....	.....	.....	32·5	25·3	0·7	— 12·5	.....
1884	— 20·7	— 23·7	— 0·9	21·3	37·0	49·2	45·1	46·0	35·8	24·2	7·2	— 16·5	.....
1885	— 24·9	— 17·7	0·1	24·0	34·0	42·1	49·3	42·3	33·7	23·6	16·9	— 4·1	.....
1886	— 27·9	— 12·3	0·1	25·7	36·1	45·6	50·8	44·3	30 4	28·4	3·2	— 13·9	.....
1887	— 26·6	— 23·1	2·1	23·0	37·7	46·4	44·2	44·3	36·0	18·4	4·5	— 12·6	.....
1888	— 24·7	— 15·4	— 10·0	17·9	29·5	45·1	49·0	43·2	37·1	26·9	7·5	1·1	.....
1889	— 8·4	— 17·6	11·9	27·5	32·7	42·6	46·1	46·5	32·5	24·7	5·7	— 8·3	.....
1890	— 25·6	— 25·4	— 8·9	21·7	27·8	47·9	48·2	43·1	33·7	30·6	.....	.....	.....
Average	— 22·7	— 19·3	— 0·8	23·0	33·5	45·6	47·5	44·2	34·0	25 3	6·5	— 9·5	.....
Mean Daily Range	23·6	24·3	22·5	22·6	28·1	27·0	26·5	24·9	28·0	21·9	21·1	20·2	24·22

HIGHEST TEMPERATURE REGISTERED.

1883	.....	.....	.....	.....	.....	.....	.....	.....	81·5	63·5	47·0	38·0	.....
1884	29·5	35·0	41·0	65·0	89·5	92·5	80·5	89·5	72·5	73·5	45·0	40·0	92·5
1885	25·0	37·0	37·0	66 0	79·0	89·0	86·5	81·0	81·0	73·0	45·0	34·0	89·0
1886	19·0	43·5	40·5	75·5	85·5	88·0	95·0	103·7	87·0	81·0	57·5	34·9	103·7
1887	20·0	22·5	41·5	78·5	92·5	82·5	88·0	83·5	80·5	80·5	61·0	38·0	92·5
1888	33·0	39·0	36·0	62·0	76·0	94·0	81·5	86 5	78·0	77·5	46·5	41·0	94·0
1889	30·0	41·5	63·0	74·5	75·5	101·0	90·0	93·0	88·0	80·0	54·5	30·0	101·0
1890	25·0	33·0	31·0	65·0	70·5	90·0	92·0	86·5	85·5	79·0	.....	.....	92·0
Average	25·9	35·9	41·4	69·5	81·2	91·0	87·6	89·1	81·7	76·0	50·9	36·6	95·0

LOWEST TEMPERATURE REGISTERED.

1883	.....	.....	.....	.....	.....	.....	.....	.....	8·7	9·5	— 32·0	— 42·5	.....
1884	— 48·0	— 43·0	— 30·0	1·0	19·0	37·5	30·5	33·5	26·0	— 4·0	— 31·5	— 45·0	— 48·0
1885	— 44·0	— 44·0	— 25·5	5·0	12·5	25·0	35·5	27·5	25·0	5·0	2·0	— 21·5	— 44·0
1886	— 49·0	— 43·0	— 23·0	— 9·0	22·0	32·0	35·5	31·0	13 5	12·0	— 21·5	— 33·2	— 49·0
1887	— 43·5	— 46·0	— 31·0	— 4·0	22·0	28·5	35·0	31·5	21·0	— 11·0	— 34·5	— 30·0	— 46·0
1888	— 47·5	— 49·5	— 30·0	— 7·5	11·5	27·0	38·5	24·5	23·0	11·5	— 21·5	— 17·0	— 49·5
1889	— 32·0	— 49·0	— 15·5	16·5	19·0	34·5	34·0	31·5	18·0	6·0	— 21·0	— 27·5	— 49·0
1890	— 39·5	— 50 0	— 35·0	— 1·5	18·0	37·0	37·0	30·0	18·5	19·5	.....	.....	— 50·0
Average	— 43·4	— 46·4	— 27·1	0·1	17·7	31·6	35·1	29·9	19·2	6·1	— 22·9	— 31·0	— 47·9

STATISTICS of Temperature and Precipitation at Russell, Manitoba.—*Continued.*

RAINFALL IN INCHES.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1883	0·00	0·00	R.	0·00	2·70	2·30	1·63	1·94	0·65	2·30	0·00	0·00	11·52
1884	0·00	0·00	0·00	·28	0·30	3·42	1·90	1·35	2·11	0·55	0·02	0·00	9·93
1885	0·00	0·00	R.	·80	1·05	6·86	4·03	2·57	0·30	R.	0·00	0·00	15·61
1886	0·00	R.	0·00	·69	1·70	2·32	1·95	1·64	0·42	1·70	R.	0·25	10·67
1887	0·00	0·00	0·00	·10	2·31	5·99	2·51	2·85	2·18	0·20	R.	0·00	16·14
1888	0 00	0·00	0·00	·06	0·50	6·25	4·25	1·98	0·52	0·21	0·00	0·00	13·77
1889	0·00	R.	0·27	·12	1·21	0·52	1·60	0·68	0·92	0·02	R.	0·00	5·34
1890	0·00	0·00	0·00	·78	1·59	2·03	2·54	4.82	2·01	1·82	.....	.....	15·59
Average	0·00	0 00	0·03	0·35	1·42	3·71	2·55	2.23	1·14	0·85	R.	0·04	12·32

SNOW IN INCHES AND TOTAL PRECIPITATION.

	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1883	.....	.....	.....	.....	.....	.....	.....	.....	0	0·5	8·7	5·9	
1884	5·5	10·0	10·0	3·0	0	0	0	0	0	5·5	5·5	9·3	48·8
1885	2·5	4·0	7·0	18·6	2·5	0	0	0	0	8·5	1·5	9·5	54·1
1886	5·0	6·8	11·5	6·0	1·0	0	0	0	0	1·0	4·0	2·0	37·3
1887	5·3	7·3	4·0	5·3	*	0	0	0	0	3·0	6·3	13·5	44·7
1888	5·5	8·5	17·5	8·5	0 5	0	0	0	0	9·5	5·5	4·0	59·5
1889	5·5	5·3	0·5	3·0	2·0	0	0	0	0·5	*	3·5	12·0	32·3
1890	4·5	15·5	8·3	1·5	6·0	0	0	0	5·0	1·8	.....	.....	42·6
Average	4·7	8·2	8·4	6·6	1·7	0	0	0	0·8	4·3	5·0	8·2	47·9
Total rain and melted snow	0·47	0·82	0·87	1·01	1·59	3·71	2·55	2·23	1·22	1·28	0·50	0 86	17·11

NUMBER OF DAYS OF RAIN.

1883	0	0	1	0	9	15	13	9	4	11	0	0	62
1884	0	0	0	5	2	14	17	12	18	5	1	0	74
1885	0	0	1	6	10	13	16	14	7	3	0	0	70
1886	0	1	0	5	8	7	9	9	9	5	1	2	56
1887	0	0	0	4	15	14	11	10	7	2	2	0	65
1888	0	0	0	2	7	11	9	6	11	3	0	0	49
1889	0	1	2	7	9	7	13	5	8	4	1	0	57
1890	0	0	0	7	13	14	14	12	11	8	.....	.....	79
Average	0	0	1	4	9	12	13	10	9	5	1	R	64

NUMBER OF DAYS OF SNOW.

1883	.....	.....	.....	.....	.....	.....	.....	.....	0	1	10	9	.....
1884	14	10	10	3	0	0	0	0	0	5	9	9	60
1885	7	9	14	8	2	0	0	0	0	9	6	13	68
1886	14	9	15	3	4	0	0	0	0	3	7	6	61
1887	11	12	9	5	1	0	0	0	0	10	10	14	72
1888	8	8	12	5	2	0	0	0	0	3	5	7	50
1889	10	4	2	2	1	0	0	0	1	2	7	9	38
1890	6	8	8	4	9	0	0	0	2	5	.....	.....	.....
Average	10	9	10	4	3	0	0	0	*	5	8	10	59

THE LACUSTRAL PLAIN.

This plain presents a slightly undulating surface which extends from the foot of the Manitoba escarpment to the east shore of Lake Winnipeg. It is thinly covered with alluvial or glacial deposits, through which the underlying limestones occasionally project and form islands or cliffs on the lakes, or more or less conspicuous hills inland. The depressions in the surface of this plain are filled with lakes that vary much in size and contour. The following are the most important of these embraced within the scope of this report :—

Manitoba, Ebb and Flow, Partridge Crop, Winnipegosis, Waterhen, Swan, Pelican, Red Deer, Cedar and Cross Lakes, together with a number of small lakes in the totally unexplored region east of Lake Winnipegosis. The plain can be best described in connection with the larger bodies of water on its surface.

LAKE MANITOBA.

Position. Lake Manitoba lies between latitudes 50° 11′ and 51° 48′ north, and longitudes 97° 56′ and 99° 35′ west, extending in a general direction N. 25° W.

Altitude. Its mean altitude above the sea is 810 feet, as shown by the profiles of the original location of the Canadian Pacific Railway. This railway survey line was run in the winter of 1874–75, and the difference between high and low water at Sifton Narrows, where the line crossed the lake, is given in the profile at two feet. The high water in Lake Manitoba is given by the same profile as ninety-nine feet above the level of the ice crossing of Red River, near the village of West Selkirk, or eighty-eight feet above the level of the water mark of the freshet of 1852. This latter point is given by J. H. Rowan, C.E.,* one of the engineers of the old location, at 16·55 feet above the mean level of the water in Lake Winnipeg. The height of Lake Winnipeg is 710 feet above the sea, and therefore the high water at the Narrows of Lake Manitoba as determined in the winter of 1874–75 is 104·55 feet above Lake Winnipeg or 814·55 feet above the sea. The low water is put at only two feet below high water, which is much less than it should be, since in 1881, Mr. Guerin† found the lake to be six feet above its normal low water level. As 1874 and 1875 were years of rather high water, four and a half feet may be taken from the high water mark then observed, thus giving 810

* The Red River, by James H. Rowan. Transaction 13, Man. Hist. & Sci. Soc., Winnipeg, 1874.

† Public Works Report, 1867–1882.

feet as the mean height of the lake as stated above. This agrees closely with the height given by Mr. Upham* for the mean altitude of the same lake.

Extent.

The lake has a total length of 119 miles, and is divided into two parts by a strait known as "The Narrows" which, to distinguish it from other places with the same local appellation, might be known as "Sifton Narrows," from Mr. Sifton who has kept a trading store at this place for some years. The channel here contracts to a width of 2,650 feet with a maximum depth of fifteen feet. This strait divides the lake into two distinct portions differing widely in their physical features. The southern portion is sixty-three miles long, and twenty-nine miles wide in its widest part, and has generally a moderately even regular contour, with very few islands, except immediately south of Sifton Narrows. The shore line of this portion amounts to 160 miles and its total area to 1,039 square miles.

Southern portion.

Northern portion.

The lake north of the Narrows is very different from that to the south. It is cut by long stony points into deep bays, and while the total length is only fifty-six miles, the length of shore line is 375 miles, and the total area is only 672 square miles. The greatest depth found in this northern portion is twenty-one feet six inches, and the average depth of the middle of the lake east of Crane River Narrows is about sixteen feet. The southern expansion of the lake is reported to have about the same general depth. The mean depth of the lake may therefore be assumed at twelve feet, and as its total area is 1,711 square miles, its total capacity is about 572,399,308,800 cubic feet.

Rise and fall of water.

The only considerable streams flowing into the lake are White Mud River at its south end, and Waterhen River at its north end. These were measured by Thomas Guerin in the summer of 1881, and were found to be then discharging respectively 1,425 and 13,930 cubic feet of water per second, while at the same time the Fairford River was discharging from the lake 14,833 cubic feet per second. This would leave a surplus in the lake, to be removed by evaporation, of 522 cubic feet a second or 45,100,800 cubic feet a day, and other small tributaries would probably bring this surplus up to 60,000,000 cubic feet a day, or only ·01 of an inch over the whole surface of the lake. By consulting the table of rainfall given above, it will be seen that the mean rainfall for the three months of June, July and August is 8·09 inches, or ·088 inches a day, and this added to the ·01 inch obtained above would give ·098 inch a day as the mean daily evaporation from the

* Report of Exploration of the Glacial Lake Agassiz in Manitoba by Warren Upham. Geol. Surv. of Can. Ann. Rept., Vol. IV., p. 155 E.

surface of this lake. It is not improbable, however, that the surplus water left in the lake is greater than that given above, and Mr. Guerin's experiments at Fairford on evaporation would appear to indicate that this was the case, as for the month of August, 1881, he found that the amount of water evaporated from a shallow vessel was about 5¼ inches. In that year also the channels of the above named three rivers were filled well up to their brims, while in 1888 and 1889 the water was low and there was a drop of several feet from the brink of the channel to the surface of the stream.

Periods of high and low water.

Periods of high and low water occur at apparently long and irregular intervals, and are caused by excessive rainfall and excessive drought. In general, however, the lakes may be said to oscillate about a foot above or below the normal. In 1880 the lake was very high, whereas in 1889 it was very low. In 1858 Professor Hind* states that the water was two feet above its lowest level, that in 1852 there was a period of very high water, previous to which for a long time the water had been very low. In 1826 there was another period of high water, anterior to which there would appear to be as yet no very definite published record.

Wind.

The winds have a very marked effect on the height of the water at any particular place on the shore of this, or of the adjoining shallow lakes. With a wind blowing from the north-west or south-east, the water is driven towards the opposite end of the lake, and the lake being so shallow, the undertow is not able to form a continuous current beneath the surface. The water, blown forward by the wind, can return only by a series of interrupted undercurrents which are incapable of preventing it from being piled up at the extremity of the lake towards which the wind is blowing.

Temperature

On account of the shallowness of the water, its temperature is comparatively high during the summer months, and this large body of warm water exerts a very great influence in reducing the daily range of temperature and thus preventing summer frosts.

On page 47, will be found a list of observations on the temperature of the water of Lake Winnipegosis during the summer and autumn of 1889, and it is probable that the temperature of Lake Manitoba will average slightly higher.

Record of the freezing and thawing of the lake.

The lake annually freezes over, but no exact records have up to the present been systematically kept of the date in the autumn when it first becomes covered with ice, or of the date in the spring when the ice breaks up and again opens the lake for navigation.

* Report on the Assiniboine and Saskatchewan Exploring Expedition. 4to. Toronto, 1859, p. 102.

Record of the freezing and thawing of the lake.

The following extracts have been taken from the "Journal of Occurrences" kept at the Hudson's Bay Company's Post of Manitoba House, on the west side of the lake, and are published with the permission of Mr. Joseph Wrigley, Commissioner of the Company:

Oct. 23, 1881. Ice all disappeared.

Nov. 3, 1881. Lake frozen about the shores.

" 10, 1881. Lake frozen fast as far as the eye can see.

May 13, 1882. The lake is now open in places along the shore.

" 16, 1882. Ice moved a little north.

" 17, 1882. Ice breaking up rapidly.

" 18, 1882. Ice drifting north, large spaces of open water to be seen in every direction.

May 20, 1882. No ice to be seen as far as the eye can reach, so that it may be said *the lake is now open.*

May 22, 1882. Small boat passed en route to Totogen.

" 17, 1883. Ice seems to be much broken up, and open water is to be seen in many places.

May 18, 1883. The wind veering to the north in the afternoon, the ice began to break up and drift to the south, so that at 6 p.m. the bay was clear.

May 19, 1883. No ice is to be seen, so that navigation is open.

Nov. 1, 1883. Ice forming rapidly along the shores.

" 5, 1883. Boat passed to Totogen.

" 6, 1883. Froze hard last night, so that the lake opposite is nearly all frozen over. Outer lake, except bays, still open.

Nov. 7, 1883. Outer lake open.

" 9, 1883. Beyond the village the lake is still open.

" 10, 1883. The lake is to-day, as far as the eye can reach, all fast with ice.

May 12, 1884. Ice moved a few yards southward to-day.

" 16, 1884. Spaces of open water to be seen on east shore.

" 17, 1884. N.-E. wind cleared the bay of ice.

" 19, 1884. No ice to be seen.

Oct. 27, 1884. All the lake closed in with ice as far as the eye can see.

May 13, 1885. Open patches of water to be seen.

" 16, 1885. Ice moving about.

" 18, 1885. Lake clear of ice.

Nov. 1, 1885. Ice to be seen on the bay this morning, a thin skim covering the whole bay.

Nov. 2, 1885. The whole lake, as far as can be seen, frozen over.

" 7, 1885. The lake found to be still open on the other side.

Record of the freezing and thawing of the lake—*Con.*

April 30, 1886. Open water to be seen right across to Sugar Island.
May 6, 1886. Schooner passed to Totogen.
Nov. 5, 1886. Thin skim of ice over portions of the bay.
" 16, 1886. Lake all frozen over.
May 7, 1887. Ice moved a little.
" 14, 1887. The lake clear of ice.

The following information was obtained from Mr. McKay, J.P., who has lived by Lake Manitoba for many years.

For the opening of the lake :

In 1889. April 18th, the earliest known.

In 1866. May 20th, the latest known.

The average would be from the 10th to the 15th of May.

The lake frozen over :

In 1883. October 18th, the earliest date known in thirty years.

In 1874. November 13th, the latest date known in thirty years.

In 1871. Commenced to freeze on October 24th, but was not frozen over till November 2nd.

The average date of the closing of York boat navigation is about October 28th.

The water in the lake throughout the summer is slightly milky, from the presence of fine clayey material in suspension, which is stirred up by storms from the low shores and the soft, shallow bottom.

Shores and Islands.

Southern expansion of lake.

The southern expansion of the lake lies almost entirely beyond the limit of the accompanying map, but its western side was examined when proceeding from Westbourne, where the expedition started in 1888, and was found to be composed very largely of a low sand or gravel beach behind a soft clay shore studded with boulders. Behind the beach is a level country, often marshy, extending back to a forest of poplar or spruce. At Manitoba House the shore is higher, sloping up to a gravel ridge in a narrow belt of timber.

Manitoba House.

The Hudson's Bay Company's trading post of Manitoba House is beautifully situated on this slope, and looks out over a narrow streak of water towards some islands thickly wooded with poplar and maple, to which the Indians annually resort in the spring to boil down the sap of the latter tree for sugar.

Mr. David Armitt, who was in charge of the trading post in 1889, informed me that the present house was built by Ewan Macdonald in 1870, and that the house which was being built by Mr. McKenzie in 1858, when the place was visited by Mr. H. Y. Hind, was about 300 yards further south, where the ruins can still be seen.

Between Manitoba House and Sifton Narrows, the shores, both of the islands and the mainland, are low, and usually protected by a shingle beach of irregular, waterworn limestone pebbles, behind which stretch woods of poplar, willow, and occasionally ash-leaved maple. One point, north of the creek into Ebb and Flow Lake, is composed of Archæan boulders, and other parts of the shore are low and marshy.

Sifton Narrows.

On the west side of Sifton Narrows, is the Indian agency, and a trading store kept by Mr. Sifton. A quarter of a mile south from this store, in the extreme south-west corner of section 22, township 24, range 10, west of the Principal Meridian, is the site of some old buildings which, the Indians informed me, were formerly a trading post of the Hudson's Bay Company. Nothing now remains but a small chimney-mound and three hollows in the midst of a grove of willows, between which and the edge of the lake is a grassy meadow 120 yards wide, and level to near the edge of the water, where it is bounded by a gravel ridge. To the west the land is still level, but covered with small poplar, mixed with a few small ash and elm.

North of the Indian agency the shore is at first soft, but it soon becomes skirted by a gravel bar which extends to an outcrop of compact Devonian limestone.

Manitoba Island.

To the east of this rock outcrop, and at the north end of the strait, is Manitoba Island, with an area of about 160 acres, and rising from fifteen to twenty feet above the water. Its interior is either wooded with poplar and birch, or is open and grassy, or covered with underbrush of amelanchier and choke cherry. On the shores elm is also growing to a large size. While the east and west sides of the island slope more or less gradually to the water, the north side presents an abrupt cliff of limestone twelve feet high, from the foot of which a talus of limestone gravel fifty feet wide slopes to the lake. The limestone is very compact and resonant, and when the waves beat against this beach and throw these resounding pebbles one on another, the roaring sound will undoubtedly be produced which has given rise to the superstition among the Indians that a Manito or Spirit beats a drum or otherwise makes a noise on the island. The strait past the island was therefore called Manito-wapow (*Cree*), or Manito-baw (*Ojibway*), meaning the Strait of the Spirit or Manito.

Horseshoe Harbour.

At the west end of the cliff the gravel beach runs out into deep water, and incloses a beautiful little harbour, known as Horseshoe Harbour, where the small freighting boats can find shelter on their way up and down the lake.

Following the east side of the lake northward from Manitoba Island the shore line is indented by deep marshy bays, surrounded by low

country, either marshy or wooded with poplar and some spruce, while the points, which are also not more than a few feet above the water, are generally guarded by a wall of Laurentian boulders. Point Richard is of this character, and off it are some small bare islands, consisting of bars of sand and small limestone gravel scattered over with large boulders of gneiss and cream-coloured limestone. To the northward lies Reed Island, wooded in the interior and apparently surrounded by a white sandy beach.

Point Richard

Dog-hung Bay

East of Reed Island is a deep rounded bay, known as Dog-hung Bay, extending beyond the eastern confines of the map. The prominent points in this bay are all composed of boulders piled in an even slope to a height of six or eight feet above the lake, while between the points is a beach of rounded limestone gravel, on which is growing a narrow belt of poplar, elm and oak. Behind the points are often small ponds, and in rear of the whole beach is an extensive open marsh, stretching back to a forest of poplar and spruce. A belt of low land is said to extend north-eastward from this bay towards Lake St. Martin, and in years of very high water this belt is entirely overflowed.

North of Dog-hung Bay, the shore maintains precisely the same character to Elm Point, which is itself a ridge or spit of limestone gravel without boulders, projecting out into the deep water of the lake, and overhung by a number of fine elm trees. North of this point the shore is more regular, without so many boulders on the points, and for a considerable stretch the drier wooded country comes to the edge of the lake, but boulders are backed up against it in a close wall. Then limestone cliffs begin to make their appearance, and continue for a couple of miles along the shore, rising at their highest point to twenty-two feet above the water. The bottom of these cliffs is hollowed out into fantastic shapes, and on their summit is a lovely stretch of open prairie, in places overshadowed by oak trees. This is one of the most charming camping places on the lake.

Steep Rock Point.

Low Island.

Off the cliff is a small wooded island, composed of flat-lying limestone and boulder clay.

From the neighbourhood of these limestone cliffs, to the mouth of Fairford River, the shore is low, and generally bordered by a gravel ridge.

Fairford River.

Fairford or Partridge Crop River discharges Lake Manitoba through Partridge Crop Lake into Lake St. Martin, and this in its turn is discharged by St. Martin or Little Saskatchewan River into Lake Winnipeg. It has a width of 700 to 900 feet, and a channel from ten to twenty feet deep. Where it leaves the lake it flows over a bed of flat-lying limestone, on which there is usually from two to three feet of

water, but after crossing this bar its banks are composed of hard, light gray clay, with a few boulders, till it passes the Mission and reaches the shallow expansion now largely covered by the water of Partridge Crop Lake. From this lake it again flows between clay banks, but in a shallow channel, to Lake St. Martin. It has a total length of ten miles, and a total fall, in this distance, of about fifteen feet. Most of the fall occurs in two rapids, one a short distance below Partridge Crop Lake, and the other a mile and a third in length, between Fairford Mission and Lake Manitoba. These are chiefly caused by the collection in the bed of the stream of great numbers of boulders of gneiss and limestone, washed out of the contiguous banks of boulder-clay.

On its upper portion the north bank of the river is generally thickly wooded with poplar, while the south bank shows several small clearings around comfortable log houses. Here are also situated the trading post of the Hudson's Bay Company and the Church of England mission, the former, a mile and a half, and the latter two miles and a half, from Lake Manitoba. The mission was first established on the less thickly wooded gravelly banks of the river below Partridge Crop Lake, but on account of floods the situation had to be abandoned, and the church and parsonage are now beautifully situated on a rising ground from twenty to thirty feet above the river, and overlooking, towards the south, a forest of poplar, spruce, and Banksian pine. Fairford Mission.

Returning to Lake Manitoba and proceeding northward from the mouth of Fairford River the shore as far as Davis Point is generally rather low, in some places bounded by a gravel bar, and in other places it is high enough to be wooded with poplar and birch down to the beach. In the distance tall spruce trees can occasionally be seen. The point itself is composed of thick-bedded white limestone. Davis Point.

West of Davis Point, the north shore of Portage Bay is cut by deep narrow bays separated by long points wooded with elm and poplar. These points run out in a direction a little east of south, on the same course as the glacial striation, and are composed chiefly of large boulders of Laurentian gneiss, mixed with a very few of palæozoic limestone. Portage Bay.

Paonan Peninsula, as far as it was examined, was also found to be low, and surrounded by a wall of Archæan boulders, behind which, in the more southern parts, is a marsh extending back to a poplar forest; while in its northern half the woods generally come down to the beach. Across the north end of the peninsula is a portage road 1,700 paces in length, over which the Indians often carry their canoes. At the east end of the portage, which is opposite a small island of boulders covered with a few willows, the water is very shallow, and the first few hundred yards of the portage itself are across a sloping gravel plain, extend- Paonan Peninsula.

ing from the water to the poplar woods. The western end of the portage is in a grove of oaks, at the bottom of a small bay opening to the south, the shores of which are sandy and piled with boulders.

West of Paonan Peninsula a long shallow bay runs to the northward. The north end of this bay is especially shallow, with stones projecting above the water in every direction, and banks of rushes growing off the beach. The surrounding country is wooded with small poplar, while spruce and tamarack can occasionally be seen in the distance.

Garden Island.

Garden Island, which lies just off the point west of the mouth of this bay, is a ridge of gravel and boulders, inclosing, in the northern part, a grassy and reedy marsh, and in other places drier land. It is wooded all around the shore, and, in the southern part, in the interior. On its western side a sand bar runs out towards the point of the main shore. The island is said to have derived its name from the fact that Indians of the Crane River band used to grow crops of potatoes here year after year.

Crane River Narrows.

West of Garden Island Point, two long points extend southward towards the opposite shore, contracting the lake in one place to less than a mile and a half in width, and from these points extend boulder-reefs, in places piled up into little islands, on which a few willows may be growing. Thus this strait is shallow and much obstructed by boulders, so that, in low water, it is difficult to find a channel through it four feet in depth. The boulders are almost all of granite or mica-schist, while many of the pebbles on the shore are of white palæozoic limestone.

Low shore.

Between Elm Point, the most westerly of the two points above mentioned, and the mouth of Waterhen River, the shore is all composed of sand or boulders, and, like the north shore of the lake elsewhere, without any sign of fixed rock. The boulders at and near the points are piled in steep walls six to eight feet in height, and behind these walls are often groves of large elms and maples.

From the mouth of Waterhen River southward for a few miles the shore was not closely examined, but it appeared to be low, and

Twin Islands.

without special interest. Off the mouth of the river lie the Twin Islands, two low islands thickly wooded with poplar and elm, with a few spruce in the interior. The islands are surrounded by a beach of gravel or boulders about seven feet high, and are connected by a bar of limestone gravel half a mile long, which rises five feet above the water and has an average width of 100 feet. At the north end of this bar is a large, cairn-like heap of boulders piled up by the ice.

South of Twin Islands another similar island, wooded with poplar and ash, lies close to the shore, and is connected with it by a very similar bar of sand and fine gravel more than half a mile long, rising in some places not more than a foot above the water, and averaging only about thirty-five feet in width.

From the end of this bar to Onion Point the shore is low and sandy or scattered with boulders, but at the point itself a cliff of limestone, eight feet in height at its highest point, looks out in a north-westerly direction over the lake. On the top of the rock is a little oak-surrounded prairie, similar to that at Steep Rock Point already referred to, but not quite so large or open. Onion Point.

The next two prominent points are composed of limestone, and the shores of the bays are thickly wooded with poplar. At Little Sandy Point there is a pile of rounded granite boulders, and just to the eastward is a high spit of sand and small rounded limestone gravel, at which the York boats usually stop on their way up the lakes, as the water is here moderately deep up to the shore. Little Sandy Point.

From Little Sandy Point to the limestone cliff at Monroe Point the shore is generally low, and more or less thickly wooded with poplar. East of Monroe Point a small brook, known as Crane River, enters the lake from the south, but it appears to carry very little water. It is quite stagnant for about a mile from the lake, to a point where there is a small Indian village, composed of a few log houses tenanted only in winter. Crane River.

The east shore of Crane Bay is generally piled with boulders, while the extreme point is a high ridge of boulders extending out into the lake, on the end of which a few elms, maples and willows have grown. A quarter of a mile to the south, this ridge divides; the branches run back and include a marsh about a mile in length and a quarter of a mile in width. The other points south of Crane River Narrows are also composed largely of boulders, and the bays between them are shallow and marshy.

South of Crane River Narrows the shore assumes a much more even character, since the lake here extends for twenty-five miles in the direction of the general glaciation of the country, and therefore no drumlin-ridges of boulders extend out at right angles to the shore. As a rule, the water is moderately deep to within a short distance of the land. The beach in some places runs back to a ridge of boulders, but it generally consists of a bar of limestone gravel in front of a wide, level marsh, behind which are groves of poplar. It was reported that the country to the west, and for a considerable distance inland, is made up entirely of alternating bands of marsh and poplar woods extending in Even shore.

a north and south direction. The best known harbour on this shore is at Big Sandy Point, which is a spit of sand and limestone gravel running out into deep water, just south of some low cliffs of white limestone. The harbour is not a good one, being open to the north-east wind, but the deep water close to the gravel beach makes it a convenient place to land.

Big Sandy Point.

Near the southern end of this portion of the lake are three islands, two of them being merely piles of boulders quite bare of vegetation, while the third and largest is low and generally marshy, but bears a few bushes, and is surrounded by bars of gravel and calcareous sand, with boulders of gneiss on the points. The most westerly of the small stony islands was visited on the 4th of August, 1888, and was found to be black with great numbers of cormorants (*Phalacrocorax dilophus*), young and old, this being their principal breeding place in the lake. North-east of these islands, and at the south-eastern extremity of this stretch of open water, the lake is again shallow and contracted, the space between the point of Paonan Peninsula and the opposite shore being largely taken up by Cherry Island. The water in the main channel to the south of this island is not more than seven feet deep, while to the north of it a depth of three feet is all that was found throughout.

Cormorants.

Cherry Island possesses a little harbour on its north-east side where the brigades of freighting boats belonging to the Hudson's Bay Company, coming from various parts of this district, used to wait for each other before proceeding on their annual trip to York Factory. The name Paonan, now given to the peninsula to the north, is said to be an Ojibway word meaning "Waiting place," and was originally applied to this harbour. The harbour is a little horse-shoe-shaped bay, open to the north and north-east, but obstructed at its mouth by a sandy bar. The water within this bar is from four to five feet deep up to the beach of sand and gravel, which rises six feet above the water. Behind the beach is a narrow sandy plain, behind which is a thin row of elm, oak, maple and cherry. The centre of the island is a marsh covered with tall reeds, while most of the rest of the shore is surrounded by reeds or boulder-bars running out a considerable distance into the lake. Riding Mountain can be distinctly seen from this island as a clear blue line in the south-west.

Cherry Island.

South of Cherry Island the west side of the lake to the Narrows is low, and without any sign of the underlying rock, but is composed of a ridge of gravel or boulders, lying on an original floor of boulder-clay, which has been first shoved up by the ice, and then assorted by the waves and currents. Many examples of

West shore north of Narrows.

the result of the shoving of spring or floating ice were seen in 1889 in the little mounds of clay and gravel near the water's edge on the gently sloping shore just in front of the ridge of boulders; and the gravel hook at the "Bluff Harbour" is an excellent example of the way in which this ice-shoved material is assorted by waves and currents, the finer pebbles being carried along into deeper water. Bluff Harbour.

WATERHEN RIVER AND LAKE.

Waterhen River flows from Lake Winnipegosis into the north-western extremity of Lake Manitoba, touching the south end of Waterhen Lake about the middle of its course. Its Indian name, *Sin-gip-siew-sibi*, is given to it on account of the presence here of the western grebe (*Podiceps occidentalis*, Ojibway *Sin-gip-siew*), which breeds on the lake and river in quite large numbers. Name

The river was examined and surveyed by Henry B. Smith, C.E., in 1873, and the following are some of his notes in reference to it:— Description by H. B. Smith.

"The total distance by this river between the above lakes (Winnipegosis and Manitoba) is thirty miles, and the difference of level 18·73 feet. After traversing a long reach of Lake Winnipegosis, the Waterhen River is entered, flowing in a north-easterly direction between low marshy banks, with a current of three miles an hour over a muddy bottom; its average width is about 500 to 600 feet and depth five to six feet; the difference of level on this section, known as the 'North Branch,' is about six feet.

"Waterhen Lake is now reached, a very shallow sheet of water, filled with boulders lying on a stiff clay bottom, and so close together that no channel can be found; the average depth (in the channel) in July, 1872, was only three feet.

"Leaving Waterhen Lake the river flows at an average rate of from three to four miles an hour in a southerly direction to the 'Forks.' The depth varies from three and a half to seventeen feet, and the channel is in many places obstructed by large boulders, so as to interfere seriously with navigation.

"The average width of this portion of the river is about 500 feet, the bottom is stony as far as the 'Forks,' where it becomes muddy."*

In 1881 Thos. Guerin, C.E., examined the river for the purpose of determining the amount of water discharged by it, and reports as fol- Volume discharge.

*Memorandum on the portages and streams between Lakes Winnipeg, Manitoba, &c. From reports on surveys made by Henry B. Smith, C.E., in 1873. C. P. R. Report, Ottawa, 1874, p. 260, with map and section.

lows :—"About five miles above its junction with the lake (Manitoba) a suitable place was found for examining it. Here the river was 444 feet wide; its maximum depth was twelve feet, and the quantity of water passing in it was 13,930 cubic feet per second. From a watermark visible on its banks it was ascertained that the river had fallen $1\frac{65}{100}$ feet from its highest stage during the previous spring. When it was at that stage, the quantity of water passing in it was 18,642 cubic feet per second."*

River banks. In the upper parts of the river the banks are low, and generally skirted with reeds, though near Lake Winnipegosis the reeds are varied with grassy banks and occasional gravel beaches. At its mouth into Waterhen Lake the river is almost filled with rushes, and through them there is a narrow, rapid stream.

Another channel, to the east of the one usually travelled, is said to exist, but it was not examined.

In the lower part of the river are a number of islands, most of which are surrounded by rushes, and capped in the centre by groves of poplar. The banks are generally from three to eight feet in height, grassy on the face, but on top covered with the burnt remains of a forest of poplar and birch and small oak. Boulders of gneiss are scattered over the surface.

The river empties into Lake Manitoba by several channels, all of which wind through a low wide marsh for several miles.

Waterhen Lake. Waterhen Lake was examined by Mr. Dowling, who states that it is twenty-four miles long, with a width of five miles, a shore line of sixty miles, an area of forty-four square miles, and an elevation above the sea of 822 feet. It is very shallow, the depth in the centre being about six feet. The south-east side of the lake is thickly strewn with large boulders, but further to the north they are not so prevalent, though the beach is still low and sloping, partaking very much of the character of the east shore of Lake Winnipegosis north of Birch Island. The western shore is generally low and muddy, and often indefinite, being bounded by a wide bank of rushes. None of the underlying rocks were anywhere seen.

LAKE WINNIPEGOSIS.

Position. Lake Winnipegosis is a long, curved lake, lying between north latitudes 51° 34′ and 53° 11′, and west longitudes 99° 37′ and 101° 6′.

Extent. Its greatest length in a direction N. 30° W. from Meadow Portage to

*Report on Lake Manitoba overflow, by Thomas Guerin. Report of the Minister of Public Works, 1867-1882, p. 541, Ottawa, 1883.

the mouth of Overflowing River, but across a long stretch of land, is one hundred and twenty-two miles; its greatest width, north of Fox Point, is seventeen miles and a half. It has a shore line of 570 miles, an area, exclusive of islands, of 2,000 square miles, while its islands have an aggregate area of ninety-six square miles. Its greatest ascertained depth is thirty-eight feet, off the north-east point of Birch Island, and its mean altitude is eighteen feet above Lake Manitoba, or 828 feet above the sea. This height is the approximate mean of two measurements made respectively by H. B. Smith, C.E.,* in 1873, and George A. Bayne, C.E.,† in 1889, the former finding a difference of level of 18·73 feet between the two lakes, and the latter a difference of 17·4 feet measured across Meadow Portage, when the water had been calm for some time.

Clearer water

The water in this lake is clearer than that in either Lakes Winnipeg or Manitoba, and, as was stated in referring to the latter lake, it is warmed by the sun's rays in summer, and as it does not cool rapidly, it exerts a great influence in equalizing the diurnal temperature of the country in its vicinity, and thus preventing the occurrence of summer frosts.

Water temperature.

The following table will show the temperatures of the surface of the lake and vicinity during the summer of 1889, the observations having been generally taken in open water, some distance from land :—

WATER TEMPERATURE.

Date.	Time.	Temperature.	Remarks.
		°	
July 13.....	.....	62 Fahr.	In Lake Winnipegosis.
14.....	9.05 a. m.	66	
15.....	8.00 a. m.	64	
16.....	8.20 a. m.	65	
18.....	7.40 a. m.	64	
19.....	1 40 p. m.	66	
20.....	8.35 a. m.	65	
21.....	8.45 a. m.	63	
22.....	3.15 p. m.	67	
23.....	11.30 a. m.	68	
24.....	11.30 a. m.	70	
25.....	7.00 a. m.	67	
29.....	10.15 a. m.	70	
31.....	12.00	70	
Aug. 3.....	9.00 a. m.	62	
6.....	8.00 a. m.	66	
7.....	3.30 p. m.	66	

*Memorandum on the portages and streams, &c., by Henry B. Smith, C. E., C.P.R. Report, 1874, p. 260.

†Letter from George A. Bayne, C.E., of Winnipeg, dated Dec. 26, 1890.

WATER TEMPERATURE—*Concluded.*

Water temperature—*Con.*

Date.	Time.	Temperature.	Remarks.
		°	
Aug. 8	7.20 a. m.	63	
9	10.00	65	
10		66	In Red Deer River.
13		68	do do
14	6.15 a. m.	70	do do
14	10.50 a. m.	71	In Lake Winnipegosis.
15	9.00 a. m.	69	
17	7.45 a. m.	68	
18	9.00 a. m.	68	In mouth of Shoal River.
22	1.00 p. m.	69	In Swan Lake.
27	5.00 p. m.	69	do
31	12.30 p. m.	65	do
Sept. 1	1.50 p. m.	65	do
2	7.20 a. m.	57	do
3	2.00 p. m.	59	do
6	5.30 p. m.	56	In Lake Winnipegosis.
7	1.30 p. m.	56	
8	9.00 a. m.	56	
21	10.00 a. m.	48	
22	9.30 a. m.	49	
25	9.30 a. m.	44	
26	8.30 a. m.	46½	
27	2.30 p. m.	47½	
28	11.00 a. m.	45	
Oct. 1	9.00 a. m.	41½	
3	9.30 a. m.	41	
5	8.30 a. m.	41½	
6	11.45 a. m.	41	
7	8.15 a. m.	41½	
10		42	
12		43	
14		42	In Waterhen Lake.
19		40	In Lake Manitoba.
22			Ice around the shore.

Ice.

The lake annually freezes over with a thickness of from two to three feet of ice, and, as far as could be learned, the dates of the opening and closing of navigation are about the same as those given for Lake Manitoba on pages 37 and 38.

Shores and Islands.

The following brief description of the shores and islands of the lake refers to the summer of 1889 unless otherwise stated.

Beginning at the south-eastern corner of the lake and proceeding northward, the shore is generally composed of a ridge of sand and gravel faced with scattered boulders, behind which is a marsh or low meadow from a quarter of a mile to a mile in width. East of the marsh or meadow is a light gravel ridge, on which are growing oak, willow and poplar, inclosing here and there small grassy swamps.

The Meadow Portage, between Lake Winnipegosis and Lake Manitoba, has its western termination in a little bay in this long coast meadow. The shore of this bay is free from boulders, and is a good landing place for canoes and small boats, but a number of stony reefs lie a short distance out in the shallow water. From the shore the portage road runs east across the level meadow for a quarter of a mile to a belt of oak and poplar. Passing through this grove it skirts the north end of an extensive marsh, passing here and there through clumps of trees, till a belt of poplar woods about a quarter of a mile wide is reached. Beyond this another swamp a third of a mile wide is crossed, and then the road enters a poplar forest stretching down to Lake Manitoba. Within this forest and about a mile and a third from Lake Winnipegosis is a low ridge, stated by H. B. Smith on his profile,* to be eleven feet above Lake Winnipegosis, or 29·72 feet above Lake Manitoba. Mr. Bayne informs me that the shortest distance between the two lakes is 9,400 feet. The land consists of a light gray, almost white, calcareous clay, holding many irregular pebbles of limestone. Very few boulders are lying on the surface, except at a point about two hundred yards east of the ridge last mentioned, where they are rather numerous. Meadow Portage.

The country maintains the same character throughout to the head of Waterhen River. The old trading post of the Hudson's Bay Company was situated on this shore, near the head of the river, but a few years ago it was moved down the river to a point just below Waterhen Lake.

From the head of Waterhen River to Point Brabant the east shore was examined by Mr. Dowling, and the following description is from his notes:— Waterhen River to Point Brabant.

The west side of the bay from which Waterhen River flows is very similar to the east side, being generally bounded by a beach of sand or gravel, behind which is a low flat meadow, extending back to a burnt forest of poplar and spruce. At a point half way down the side of the bay several small saline ponds lie behind the gravel beach, and at Salt Point there is a drier meadow, on which are the remains of several old houses. From this point a reef of boulders extends into the lake towards Ermine Island, which is generally high, and wooded with maple, its northern extremity extending into a gravel bar. Long Island, lying further southward within the bay, is low, and generally lightly covered with scrub. West of Salt Point the shore runs northward into a long marshy bay, to the west of which again is a low Salt Point.

*Memorandum on the Portages and Streams and C.P.R. Reports, 1874. Sheet 11

unwooded point, from which bars of granite boulders extend southward into the lake.

Turning northward up the east side of the main portion of the lake, the shore is generally low, with a few small boulders lying on scattered broken fragments of limestone. The timber, chiefly burnt poplar, first touches the beach two miles north of this point. Some of the bays are shallow, while the points are built up of large boulders, with deep water off them. Four miles and a half north of the point fixed rock was seen for the first time since entering the lake. Four miles and a half further north a small island lies off the shore wooded with poplar, elm and willow, while the land to the east is wooded with poplar, elm and a few oak trees.

Rock exposure.

At Net Point there is another low exposure of bedded limestone; but the rest of the shore all the way to Point Brabant is low and more or less closely piled with a ridge of boulders.

Point Brabant.

At Point Brabant a limestone cliff extends for about a mile along the shore, rising at its highest point to about forty feet above the water. A long sloping gravel beach reaches from the foot of the almost vertical cliff to the edge of the water, and on this beach, and under the shelter of the cliff, a line of wide-spreading elms is growing. A similar row of trees may be seen in front of many of the other cliffs by this lake, indicating clearly that its waves are not at present cutting them, but that they were formed when the lake stood a few feet above its present level, when the ridge along the top of the Meadow Portage was also formed, and when consequently lakes Winnipegosis and Manitoba were joined into one great sheet of water which extended to the south and east over large areas in the province.

Old shore-cliff.

North of Point Brabant.

For five miles north from Point Brabant the shore is often protected by a sloping wall of boulders, behind which is a higher ridge of boulders wooded with elm. At the end of the above distance is a low cliff of limestone, north-east of which and a short distance back from the lake, is a hill of limestone rising by an easy slope from the edge of the water to a height of sixty feet, and strewn with dead birch, spruce and poplar. Its summit is slightly rolling parallel to the shore, and is covered with pebbles and rounded cobbles, while its western face is strewn with large masses, some possibly in place, of heavily-bedded dolomitic limestone.

Wade Point.

From this hill to Wade Point, a distance of seven miles, the shore is everywhere low, and generally bounded by a wall of Archæan boulders, and wooded with elms, behind which is a country clothed with poplar and some spruce. Gun Island is a mass of these boulders ten

feet in height, and is connected with the shore by a long bar of similar boulders, which stood a foot above the surface of the lake during the period of low water in 1889.

Change in character of shore.

North of Wade Point the character of the east shore changes considerably, and granite boulders, which form so prominent a feature of the beach to the south of it, are much less numerous, the boulder-strewn tract crossing the lake and continuing up the west side of Birch Island. The water to the south of Hunter's Island is everywhere shallow, and the shores slope very gradually into the lake. Boulders of gneiss are thickly scattered on the most southerly points. Elsewhere the beach is composed chiefly of more or less irregular fragments of limestone, which in most cases, as on the north side of Island Z, are probably derived from immediately underlying rock. North-east of Hunter's Island the beach is a belt, fifty to seventy-five yards in width, between the woods and the water, the upper part grass-grown, the lower part bare of vegetation, and scattered with debris, chiefly of moderately thin-bedded limestone with an occasional boulder of gneiss, all bedded in a soft light gray sandy clay.

Limestone hill.

In latitude 52° 23′ a hill of limestone, thirty-five feet in height, rises to the south of a shallow bay, and on its side sloping towards the lake is an old beach of rounded limestone gravel of the age of the Meadow Portage ridge.

Point Laronde.

From this hill northward to Point Laronde the shore is very monotonous, being everywhere very low, and composed of sandy clay irregularly strewn with fragments of limestone, and a few boulders of granite. The water off the shore is shallow, and stony bars project above its surface. The larger islands close to the shore are low, and wooded with spruce and poplar; their eastern sides are generally soft and marly, while their western sides are flat, like the main shore.

Hill Island.

Further out in the lake several wooded islands lie in the channel between Birch Island and the shore; the most conspicuous and interesting of these is Hill Island, the northern one of the group. It rises about forty feet above the water, and at its northern end, hidden among poplar and spruce trees, is a half-buried cliff of limestone, at the foot of this cliff is a terrace strewn with boulders down to fifteen feet above the water, below which the beach is composed of a sloping pavement of granite boulders from twelve to eighteen inches in diameter. On the east side of the island is another cliff, but it consists of compact glacial till, and a beach of large boulders extends from its foot down to the lake. On top of the cliff, at heights of twelve and twenty-five feet above the water, are deposits of rounded gravel, indicating old stages in the history of the lake.

Inland the island is generally thickly wooded with spruce, birch and poplar. From the north-east and north-west corners of the island gravel bars extend northward as reefs, and from the south end a gravel spit extends southward for 250 yards beyond the limit of the woods.

The other islands to the south are mostly low, with flat shores, and inland are generally wooded with poplar and a few spruce.

Low shore.

North of Point Laronde the east shore of the lake is everywhere low and flat, being often underlaid by thin-bedded limestone dipping gently towards the west, and running for a long distance under the water. This limestone has been very generally much broken by the shoving of the ice in spring, and the beach is therefore strewn with angular fragments of the rock. Two miles north of the point is the mouth of the only noticeable creek emptying into the east side of Lake Winnipegosis. It is fifty feet wide and from three to six inches deep, flows swiftly among boulders, and in the autumn of 1889 was falling about two feet over the beach into the lake. An Indian canoe route is said to go up this stream and across into a chain of lakes which connect with the northern end of Waterhen Lake, providing a short way to the Hudson's Bay Company's post on the latter lake, and one on which there is not much danger of detention by storms.

Canoe route.

Country east of the lake.

The country through which this route passes, and the whole of the region lying between Lakes Winnipegosis and Winnipeg, is described by Alexander Monroe, the Hudson's Bay Company's trader at Waterhen River, as a great flat-lying area, dotted with many small lakes, and traversed from south to north by a high ridge covered with Banksian pine, reaching as far as the Grand Rapids on the Saskatchewan.

Islands and points of boulders.

The islands off the shore are generally capped by a ridge of granite boulders, and the whole shore bears evidence of having been moulded to some extent by the ice of the glacial period, for the points run out into the lake parallel to the direction of the glacial striation, while behind them are shallow bays extending back into long, narrow marshes. On the low, flat beach are also many evidences of the shoving of the ice in spring. Boulders are lying on the soft clay, and grooves in which they have been pushed along extend from them towards the water. One large boulder of dark gray gneiss had a groove behind it seventy-four paces, at least, in length; thirty-four paces straight, then a bend and twenty paces straight, and then another bend and twenty more paces straight, to beneath the surface of the water.

Long Point.

At the north end of the bay east of Long Point, and again north of the bay to the west of the same point, a high wooded ridge rises back

from the shore, and the north shore of the lake follows the foot of this ridge in a moderately even line to the mouth of Swamp Creek. The shore of the latter bay is low and marshy, and a number of rills of dark brown water are flowing into its western side from a dense spruce swamp. The beach is of fine hard quartz sand, and is generally skirted with rushes.

Even shore

West of this bay, the beach for a short distance descends into shallow water, and then for more than thirty miles it maintains a very constant character. It is generally about 150 feet wide, with a gentle slope between the water and the edge of the woods, while the water, even close to the shore, is of considerable depth. The beach, which is probably the most beautiful anywhere on the lake, is partly overgrown with grass, and is composed of sandy clay, in which cobbles and pebbles of white limestone are embedded, many of them but little water-worn and showing well-marked glacial striæ. Large boulders of gneiss are comparatively rare.

Towards the eastern end of this part of the shore the gentle slope between the edge of the grass and the water shows many evidences of ice shoving, both in little heaps of gravel piled on the beach, and deep furrows ploughed in the mud.

Wooded shore

Behind the open shore is a forest of white and black poplar, mingled, in the distance, with birch and spruce. In this forest a hill rises by a gentle incline to a height of from sixty to ninety feet, and though its face is thickly overgrown with vegetation, some small boulders and cobbles, similar to those on the beach, can be seen lying on it here and there.

Old beaches and terraces.

While none of the older rocks are exposed in place on this shore, there are on the southern slope of the above-mentioned wooded ridge several terraces and ancient gravel beaches which are of considerable interest. The most conspicuous of these terraces extends along the face of the ridge at a height of from twenty to thirty feet above the water. One of the localities at which it is best shown is four miles south-east of the Western Mossy Portage. It is here scarped, and is seen to be composed almost exclusively of flattened, disc-shaped, water-worn pebbles of white limestone, with a few of dolomite, and a few others of granite, most of which still show traces of glacial striæ. The pebbles are embedded in a scanty matrix of white, slightly clayey sand. The summit of the terrace is twenty-seven feet above the lake and consists of three gravel ridges, all of about the same height, and all parallel to the shore, separated by narrow troughs, the trough behind the third ridge being ten feet deep, back of which the main hill rises with a gentle slope. These probably repre-

sent the remains of an ancient gravel spit which projected into the lake in the era of the Meadow Portage ridge, and the long gravel islands opposite this part of the shore, and now a mile and a quarter out in the lake, possibly also represent fragments of the same ancient spit.

Four miles west of the Eastern Mossy Portage, the woods have been burnt for a short distance, and two terraces are seen, one about the height of the last, and one very conspicuous, at a height of from fifty to sixty feet above the lake.

Eastern Mossy Portage.

The Eastern Mossy Portage, called by the Saulteux Indians *Kak-is-tét-i-nak*, The Man Ridge, starts from Lake Winnipegosis near the middle of this open stretch of shore line, and runs northward for a distance of about four miles to a shallow bay on the south side of Cedar Lake. It was first surveyed and levelled about the end of May, 1858, by Mr. A. W. Wells, acting as assistant to Mr. S. J. Dawson, who found that its total length was four miles and eighteen chains, and that Lake Winnipegosis was four feet higher than Cedar Lake, which was very low at the time.*

Surveys.

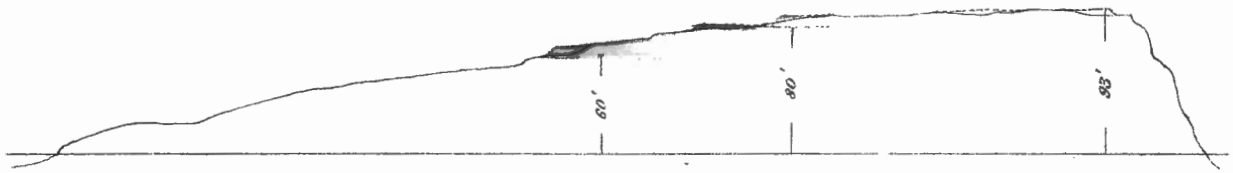
It was afterwards surveyed and levelled by Mr. Henry B. Smith, C.E., in 1873, and is described with a plan and section in his report as follows:—"The level of these lakes may be assumed to be equal. Starting from a fine open bay on Cedar Lake, with a bottom composed of mud and sand, sloping off gradually to a depth of six feet at a distance of 660 feet from the shore, the portage for three-quarters of a mile, passes over a corduroy road through a very soft muskeg or swamp, to a fine hard ridge of land, along which the Hudson's Bay Company have built their waggon road.

"The total length in a straight line between the lakes is nearly four miles. Travelling in a southerly direction from Cedar Lake the land rises gradually to a height of 93·14 feet at a point only one-quarter of a mile from the shore of Winnipegosis, then descends suddenly to its beach. Winnipegosis here presents a wide surface, affording no natural protection to boats from the heavy storms which are so frequent in these parts. The bottom of the lake, composed of limestone gravel, slopes away gradually to a depth of six feet at 200 feet from the shore."†

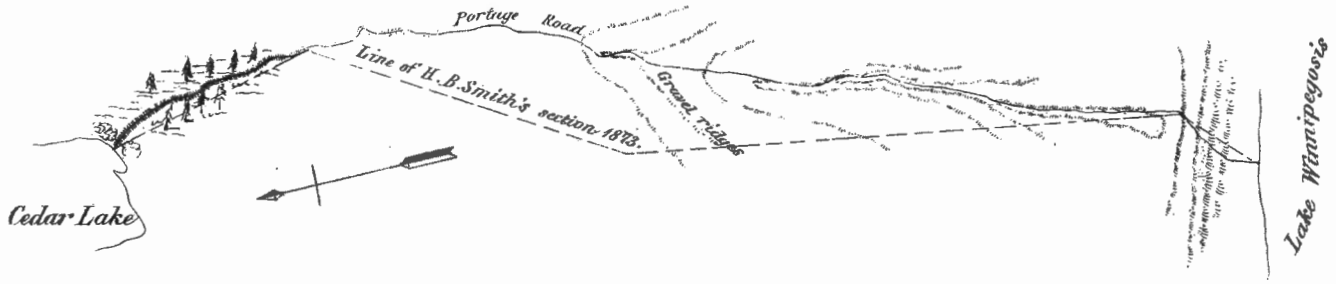
In the winter of 1880 Wm. Pearce, D.L.S., ran a survey line between the two lakes, crossing the portage a mile and a half from Lake

*Papers relative to the exploration of the country between Lake Superior and the Red River Settlement, London, Govt., 1859.

†Memorandum on the portages and streams, &c., by Henry B. Smith, C.E. C.P.R. Report, 1874, pp. 260-1.



Horizontal Scale: 50 Chains to an inch.
Vertical Scale: 120 feet to an inch.



Plan and Elevation of Mossy Portage between Cedar Lake and Lake Winnipegosis
From a survey by D.B.Dowling in 1891.

Winnipegosis; in September, 1889, it was examined by the writer, and lastly, in July, 1891, it was levelled by Mr. D. B. Dowling, who found the highest point on the trail ninety-three feet above Lake Winnipegosis, and this lake nine inches above Cedar Lake. The accompanying plan and elevation are from his surveys.

Description of Portage.

Starting from Lake Winnipegosis, the portage runs from the water over the beach-ridge, and immediately begins to ascend the hill, the top of which is reached on the third step at a height of ninety-three feet, where the ground is found to consist of water-worn discoidal limestone gravel. From this point it strikes northward along the top of a gravel ridge, which is at first wooded with spruce and then for a mile and a quarter with little else but Banksian pine, the land on either side being ten feet lower, and wooded with spruce and tamarack. The ridge throughout this distance is 100 to 200 feet wide, and consists of round or discoidal limestone gravel. It slopes lightly to the east, where in places there is a low subsidiary ridge, and as a rule descends somewhat more abruptly towards the west. In the woods to the east two other parallel and lower ridges were found, consisting of rounded limestone gravel, rising three or four feet above the surrounding country, and thickly wooded with spruce and poplar. The country is very wet, and covered with small spruce, tamarack and a few cedar, beneath which Indian tea (*Ledum latifolium*) and pitcher plant (*Sarracenia purpurea*) are growing in great abundance. In the above distance the portage ridge has declined from ninety-three to eighty-nine feet. It now drops slightly, and for the next quarter of a mile has an altitude of from eighty-two to eighty feet. Small spruce here begin to crowd in towards the trail from either side, Banksian pine becomes scarce, and some cedar trees are noticeable in the swamps both to the east and west. The ridge now has the general appearance of becoming more diffuse, but Mr. Dowling recognized branching gravel ridges at altitudes of sixty and seventy feet, the latter extending as a gravel spit into the angle of the former, which is at the same level as the high terrace along the north shore of Lake Winnipegosis. North of this gravel ridge, which is two miles and a third from the shore of the last named lake, the road still continues along a belt of land somewhat higher than the surrounding country, and boulders of gneiss and limestone, chiefly the former, begin to appear. At a distance of two-thirds of a mile from Cedar Lake the ridge disappears altogether, at a height of thirty feet above the lake, and the road enters a wet swamp wooded with spruce, tamarack and cedar, across which the Hudson's Bay Company built a corduroy road of small poles, over which goods were conveyed in a waggon from lake to lake.

Gravel ridges.

Descent towards Cedar Lake.

North end.

The north end of the portage opens on the shore of Cedar Lake, rising over a ridge of light red sand with a crest six feet above the water. The bay appears to be everywhere shallow, and a small lightly-wooded island of boulders lies across its mouth.

Ancient lake beaches.

As will be seen from the above description, and the accompanying plan and elevation, the line of the portage road is along and across several ancient beaches, formed on an original ridge in the underlying till when the lake was at some of its higher stages. The top of the portage would represent the crest of an island, formed at a period when the lake was ninety-three feet above its present level, or 921 feet above the level of the sea. From this stage the water gradually declined, forming, while it was falling, two or three small beach-lines, till it reached a height of sixty feet above Winnipegosis, or 888 feet above the sea, when a strong ridge was formed, well shown both north and south of the higher portions of the portage, as well as in other places, showing that the lake stood at this level for a considerable period. From this latter level the water fell rapidly to a height of from twenty to thirty feet above Lake Winnipegosis, or about 850 feet above the sea, so that no beaches were formed on the portage ridge between these two elevations; but at the latter, a gravel ridge extends along the face of the hill on the south side of the portage, while towards its north end the country, at about the same elevation, descends into a cedar swamp which slopes toward Cedar Lake.

Later history of the lake.

This portage, therefore, furnishes a very interesting and concise history of Lake Winnipegosis in several of its later stages.

Western Mossy Portage.

The Western Mossy Portage, called by the Indians *Muskegónigá* or the Mossy Portage, is used chiefly in winter by the Indians with dog trains. A paced survey was made of it by Mr. Dowling in 1889, and altitudes were determined by two aneroids. It starts from the open shore of Lake Winnipegosis, opposite Shannon Island, and ascends rapidly through woods of white and black poplar to a height of sixty feet, and then by a much more gentle incline through spruce and poplar to a total height of seventy-five feet at a distance of three-quarters of a mile from the lake. From here it slopes gently through a mossy swamp to the south-west angle of Cedar Lake near the mouth of a small creek; the fore part of the distance being thickly wooded with small spruce, and the latter part with scattered tamarack.

The total length of the portage is about four miles and a quarter.

Depth of water.

In Lake Winnipegosis a depth of eighteen feet can be obtained a short distance from the shore, while in Cedar Lake the water is so shallow for a long distance from the end of the portage that it is difficult to get to the land with a light canoe.

Swamp Creek empties into the lake at the edge of a very extensive marsh, and south of this marsh a forest of spruce and poplar stands close to the shore, skirted by a narrow belt of grass growing on sand, pebbles and boulders. In front of this is a bare strip of sand and pebbles fifty feet in width, which shows many evidences of ice-shoving in troughs cut in the sand, and pebbles shoved back into little mounds. Swamp Creek

All the way to the mouth of Overflowing River the shore is flat and uninteresting, the water off it being in places so shallow that it is difficult for a canoe drawing six inches to get within a quarter of a mile of land. It consists of a soft clayey sand, in which are imbedded, so as to completely cover the sand, pebbles of gneiss and fragments of limestone and dolomite. Behind this flat shore is a ridge of boulders of gneiss and limestone, raised to about the general level of the surrounding country, which, except at the prominent points, is wooded to within a short distance of the water.

Overflowing River is a small stream said to rise in Leaf Lake, just on the western side of the map. It flows first north-eastward and then south-eastward to its mouth at the north-western extremity of Lake Winnipegosis. Here it is 200 feet wide, with brownish water, in which, in September, 1889, there was no perceptible current. The shore adjoining it is low, with an open saline flat covered with grass and the red salt plant (*Salicornia herbacea*) to the north, and a forest of poplar and spruce to the south. Three-quarters of a mile up the river, the bank is abrupt and twelve feet in height, and a rapid is encountered with a fall of about three feet, where the water flows over a bed of boulders of gneiss and broken fragments of hard compact limestone. At the above date it was almost dry, but in August, 1888, Mr. Dowling ascended the stream with two large canoes for a distance of thirty-seven miles. He gives the following description of its characters :— Overflowing River.

"At the first rapid a cut-bank on the south-east side shows six feet of stratified sand and gravel; at the next bend the bank is twelve feet high, and is composed of light gray clay, with a few striated pebbles; while at the end of two miles the banks have risen to a height of twenty feet. In this distance there are eight rapids of varying length, the uppermost and largest one having a fall of more than four feet, and they all seem to be caused by accumulations of boulders washed from the clay of the banks. Throughout this distance the timber on both sides of the stream is mostly fire-killed. Rapids.

"Above the eighth rapid the river turns slightly more to the westward, still flowing through burnt country. The banks descend to an average height of about eight feet. The stream, though crooked, is deep,

and for six miles has a uniform current of about one mile an hour, and then, with a slight bend for a mile towards the north-west, it falls in the above distance down three small rapids. At the upper one of the series a dark yellow limestone was recognized in the bed of the stream.

"The next westerly bend opens to the view a fine straight stretch of river at least a mile in length, with a mean width of 300 feet, and apparently very deep. On either side is a narrow fringe of spruce and tamarack, behind which is a tamarack swamp.

Swamp and poplar forest.

"Above this straight portion of its course the river flows through a narrow strip of poplar woods, and then, coming from the northward for a distance of six miles, it winds in a very tortuous channel of twice the above length through a belt of mossy bog, which extends towards the north-east and south-west, and has an approximate width of three miles in a south-easterly and north-westerly direction. Ash, elm, poplar and willow occasionally overhang the stream.

Tributaries.

"Two small tributaries join the Overflowing River in this part of its course, one coming from the south-west through the middle of the bog, and the other from the north-east, draining a lake which can be seen from the extreme north-easterly bend of the river, and the shores of which appeared to be generally low and marshy.

"The river now turns sharply to the west, and for seven miles maintains the same tortuous character, but towards the end of this distance a current becomes appreciable, and the points of land included in the bends gradually become thickly wooded, till at last it leaves the bog and again enters the forest, when the banks suddenly rise to a height of at least twenty feet, and descend in a gravel-covered slope to the water. Above this the river was ascended for two miles, but was found to be very shallow, and to have a strong current with a succession of small rapids, in which there was hardly enough water to float an empty canoe. The surrounding forest consists of large poplar, mixed with birch and some spruce of moderate size."

Higher gravel banks and strong current

From the mouth of Overflowing River southward and eastward to Macoun Point the shore is for the most part grassy, sloping gently to the water, and in places fringed with rushes. Just within the edge of the woods a ridge, apparently composed of gravel, runs parallel with the beach. About the middle of the distance, or six miles from the mouth of the river, a long bare diffuse point extends into the lake. It is composed chiefly of sand and limestone gravel, but the end, which is a little higher than the rest, is piled round with Archæan boulders.

Macoun Point.

Macoun Point is wooded with a beautiful grove of large elms. Around the grove is a beach of rounded limestone gravel, and in front

of and a little below this beach is a line of boulders of gneiss and limestone, some of which show glacial striæ. From the foot of this line of boulders the shore extends with a very gentle slope to the edge of the water, and is strewn with angular fragments of porous dolomite broken from the parent rock beneath, and shoved over it by flow ice. The rock here seen in place is the first met with on the shore since leaving Ami Island at the north-east corner of the lake.

Dawson Bay.

From Macoun Point southward to the mouth of Red Deer River the shore is very irregular, and the more prominent headlands are formed of cliffs of light gray limestone. The shores of the bays are low and composed of clayey sand or broken pebbles, and are commonly margined with rushes. At the bottom of the deepest bay is a bare saline area around some salt springs, and this again is surrounded by the usual growth of thin wiry grass. These salt springs are the most northern that were observed on the west side of the lake.

Red Deer River.

Red Deer River flows into the west side of Dawson Bay just north of a small club-shaped peninsula, terminating in a low wooded point underlain by white dolomitic limestone. The channel at its mouth is from three to twelve feet deep, not being obstructed by bars of sand or gravel. It has a width of from 200 to 300 feet, and banks three feet high, behind which, on the north side, is a meadow covered with rich grasses and vetches. Back of this is a forest of poplar and spruce, which shows many traces of the ravages of fire.

From the mouth of Red Deer River to Whiteaves Point the shore is very irregular. In many places it consists of cliffs of Devonian limestone which have been formed when the lake was at the stage of the Meadow Portage ridge, and are now in many cases behind narrow belts of timber. These will be found more fully described on subsequent pages.

Steep Rock River.

Seven miles south of Red Deer River is a shallow bay, almost cut off from the rest of the lake by a long straight spit of rounded gravel shaded by a line of spreading elm trees; and at the bottom of the bay is the mouth of Steep Rock River. This river is said to rise in two lakes on the summit of Porcupine Mountain, and to flow down its face in a gorge that can be clearly seen from the islands in Dawson Bay. On reaching the level country it opens into a marshy lake, or wide marsh, surrounded by tall spruce and covered with cat-tail and other rushes. Through this marsh it winds with ill-defined banks, and then appears to flow from its south-east end as a shallow stony stream. In ascending or descending this river with canoes the Indians make use of a good portage path 1,650 paces in length, cut out through a forest of spruce and poplar on the north side of the river, from the

marsh to the lower end of the rapids. The river at the latter point is forty feet wide and eight inches deep, flowing with a swift current over stones and little gravel bars, and the water appears to be slightly saline. For the rest of the way to the lake it has little or no current, and the banks are wooded for a short distance, and then are low, marshy, and skirted with willows.

Bell River.

Five miles and a half south-east of the mouth of Steep Rock River, Bell River flows into the bottom of another shallow bay. This river rises on the summit of Porcupine Mountain, and flowing eastward in the bottom of a gorge in the face of the mountain turns northward and empties into the south-west corner of Dawson Bay. Its upper course is described on a subsequent page, but at its mouth it is thirty feet wide and eighteen inches deep, with a bed obstructed by large boulders of Archæan gneiss, large and small irregular fragments of Devonian limestone and a few of white Dakota sandstone.

Islands.

The islands in Dawson Bay are all well wooded, and most of them are immediately underlaid by white limestone, which often projects from among the trees in bold vertical cliffs.

Professor Macoun's description.

Prof. Macoun, who visited this lake in 1881, speaks of this portion of it as follows :*—

"The northern end of Lake Winnipegosis is filled with lovely islands, which are margined with fine drooping elms of a large size. The sail across Dawson Bay on a lovely day in July reveals more natural beauties than I ever before beheld on our inland waters. Green islands, with white sand or gravel beaches, covered with drooping elms and other fine trees, the mainland rising gradually up from the water covered with an unbroken front of tall poplars intermixing with the gloomy spruce, deep bays backed with the distant forest, and high over all the steep escarpment of Porcupine Mountain, form a picture, as seen from the lake, which has few equals in any part of the world. Point Wilkins, a bold promontory pushing out into the bay, and rising almost perpendicularly to a height of seventy (83) feet, is a prominent and beautiful object. Crossing a bay to the north of this, and rounding a low point, we entered the mouth of Red Deer River and, after ascending it a mile or more, camped at a salt spring, where the swift water commences."

Whiteaves Point.

On the east side of Dawson Bay, at Whiteaves Point, a cliff of highly fossiliferous limestone rises to a height of thirty feet above the water, but is now hidden by a belt of elms fifty feet in width at the back of the gravel beach. Off the point is a small horse-shoe shaped island,

* Report of Explorations by Professor John Macoun, M.A., F.L.S. Ann. Rept. Dept. of Interior, 1881, p. 75. Ottawa, Govt., 1882.

composed of rounded pebbles of limestone, at which boats bound down the lake usually stop to take on ballast.

North of Whiteaves Point is a wide bay, in which lie several islands wooded with elm, poplar and willow. The outermost island is a high limestone rock facing the west in white vertical or overhanging cliffs, and diminishing towards the south to a gravel spit. Those of the group at the bottom of the bay are mostly low, and composed of pebbles and irregular masses of white dolomitic limestone mingled with boulders of gneiss.

The shore opposite these islands is generally low, but rises gradually to a height of twenty-five feet within woods of large spruce and poplar, under which is a close thicket of spicated maple (*A. spicatum*). Northward to Nason Point the country, though low, continues thickly wooded, and from the edge of the woods a narrow grassy belt slopes gradually to the deep water. At the points, the beach is flat, and scattered with fragments of limestone. Nason Point.

From Nason Point, across the north end of the peninsula east of Dawson Bay, to Channel Island, the country is wooded with spruce and poplar, and between the woods and the water is a narrow, flat-lying belt of grassy and stony land. Over this the ice shoves in spring back to a ridge of large and small irregular fragments of rock. At one point, on the south-west side of Cameron Bay, a cliff of limestone thirty-seven feet high, peeping out from behind a narrow belt of small poplars, breaks the general monotony of the low-lying shore.

Many low islands lie in the channel north of this peninsula, all with flat-lying shores, occasionally strewn with a few boulders. No cliffs of rock are anywhere to be seen. All are wooded with belts of timber, usually spruce and poplar. Of these, the largest is Spruce Island, and next to it in size is Channel Island, which is almost joined to the shore by a narrow neck of meadow land, across the north end of which is a channel fifty feet wide much obstructed by boulders of gneiss. It is at times difficult to take a canoe through this channel, for in some seasons a depth of but a few inches of water can be found in it. Low islands.

Shannon Island is also low and wooded, but a group of three small islands lying midway between this and Channel Island is of somewhat greater interest than the rest. They consist of bars of gravel, forming crests along the summit of reefs or low-lying islands of boulder-clay, and clearly illustrate the combined action of water and ice in forming the present shore features of the lake. The middle island, which is probably the most conspicuous, is a long, crescentic bar of Three islands of gravel.

water-worn limestone pebbles, very free from any mixture of clayey material. It is a mile long, 120 feet wide, and twelve feet high in the middle, where it supports a few willows and stunted elms. To the east the water is shallow for a very short distance, and then descends to a considerable depth, while to the west the shallow water extends for a comparatively long distance, leaving the bar along the eastern side of the shoal. Gneissoid boulders are scattered at the foot of the bar, and in this shallow water, especially at the north end of the island and in the immediate vicinity, a little quartz sand may also be seen in a couple of places near the water's edge.

Towards its north end the bar declines gradually to the edge of the water, and continues just beneath its surface to the point of a similar but smaller gravel island to the north.

The most southern of the three islands is divided from the middle one by a narrow strait of moderately deep water, and its northern point is composed, at the water's edge, of irregular, broken fragments of limestone with a few boulders of gneiss. The north-eastern side of the island is a gently curved bar of limestone gravel, wooded with elm and poplar, while to the south-west of this bar is a low flat, but little above the water, covered with irregular fragments of limestone and scantily overgrown with grass.

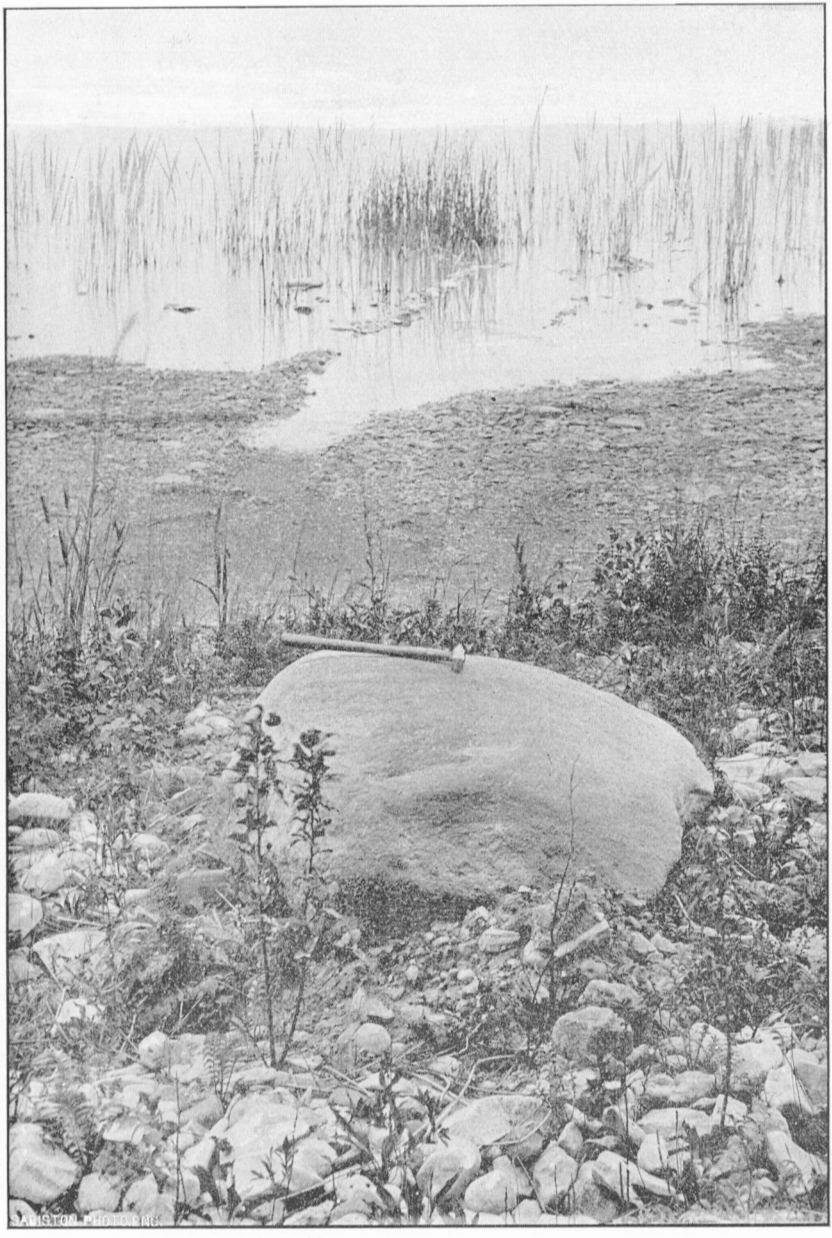
Mode of formation.

The mode of formation of the gravel bars is apparent from a consideration of the above-described characters. We have seen that the spring ice everywhere scrapes the low-lying shores of the lake, and shoves the collected debris before it into a ridge, which is often almost out of the reach of the water, the pebbles in which are therefore but slightly rounded, and are mixed with much clay and sand. In this part of the lake there have originally been islands of till or stony clay rising to about the level of the water, the southern one being still above the low water stage. The shoving of the ice in spring, out of Dawson Bay into the body of the lake, scrapes the surface of the low stony islands, and carries the collected material to their eastern side. Here the waves from the open lake beat against it, wash out the fine material, and pile the now rounded and assorted pebbles into an even ridge.

Pelican Bay.

East of Channel Island, Pelican Bay, a long shallow arm of the lake, extends southward for a distance of twenty-five miles, and its shores being low, and but little affected by waves and currents, show many beautiful examples of the influence of ice.

For sixteen miles down the west side of the bay the shore is low, with a width of from fifty to two hundred yards of bare marly flats between the water and the spruce and poplar forest. On this flat



J. B. Tyrrell, Photo., July 20, 1889.

Ice-shoved Boulder with curved Groove, showing its track from out in the Water, with the small Stones pushed in front of it.

PELICAN BAY, LAKE WINNIPEGOSIS.

are lying boulders of gneiss and fragments of Silurian and Devonian limestone. At one point there is a boulder of Devonian limestone nine feet long, eight feet wide and six feet high, with smoothed and well glaciated sides and corners, lying one hundred feet from the water. It has recently been moved at least ten feet, as a groove of this length runs out from it towards the water, while on its opposite side boulders and small stones are piled against it to half its height. Glaciated boulder.

At the end of the sixteen miles a hill of limestone rises to a height of twenty-six feet and a half behind a skirting of small poplar and birch. The surface of the limestone has been smoothly glaciated, but has been so much corroded by vegetation that I was unable to detect any striæ. Limestone hill.

Five miles south-east of the limestone hill, and at the second Narrows in the Bay, a point projects from the low shore. It is essentially composed of sandy clay scattered over with irregular angular fragments of limestone, with which are mingled a few nodules of chert and iron pyrites. In a few places on the bar is some small rounded gravel.

The bar is broken by several hollows, in which many large boulders of gneiss are lying. Some of them, especially those lying on higher ground, show clear evidence of having been shoved up by the ice. A large one, 5 ft. x 4 ft. 10 in. x 4 ft. has a groove fifty-six feet long running down from it in a direction S. 80° E., while on its opposite side is a pile of gravel and small boulders. The groove is in places eighteen inches deep, with clay and small stones piled up as a ridge on each side. Ice-grooved shore.

Also near the base of the bar is a large transported boulder of dark gray biotite granite, of the typical glacial shape, with smooth, even or slightly grooved sides and rough ends. It has a greatest length of nineteen feet three inches, a greatest width of nine feet five inches, and a height above the ground of six feet eight inches.

Two miles south of this bar, and a quarter of a mile back from the shore, among woods of small spruce, is a considerable tract of arid land covered with a crust of salt, from which the almost dry channel of a small saline brook descends to the lake. Salt spring.

This the third, or most southern division of Pelican Bay, is everywhere very shallow, and boulders are projecting out of the water at a distance of from a quarter to half a mile from the shore, which consists of mud flats, thickly scattered over with fragments of white limestone and grooved by lake ice. Back from the lake there is a large amount of good spruce.

Pelican Creek, a shallow stream, about forty feet wide, empties into the south-west angle of the bay. It is said to flow from a lake a short Pelican Creek.

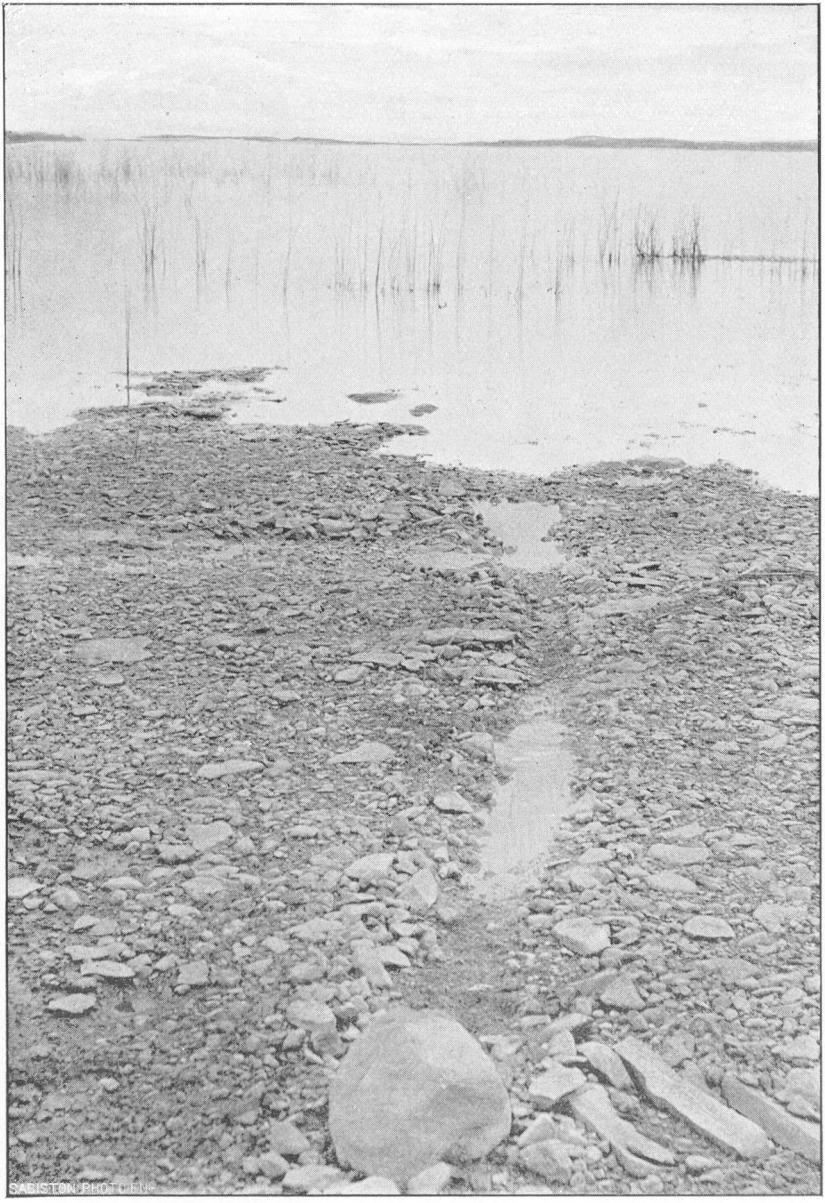
distance in the interior, known as Pelican Lake. In July, 1889, the creek was ascended in a canoe for a quarter of a mile to a stony rapid, where there was only a little water trickling among the stones. On the east side of the mouth of the creek, and a third of a mile back from the bay, is a bare hill about thirty feet high surrounded by groves of small spruce and poplar. Its face is scattered with large boulders, while on its summit, which extends as a ridge in a direction N. 75° E., are several springs of brine described on a succeeding page. This ridge is a quarter of a mile long, and slopes to the south in a narrow opening through the woods to a wide arid plain. The subsoil appears to consist of broken fragments of white limestone.

Salt springs.

Returning northward down the east side of Pelican Bay the water in the southern division is so shallow that it is practically impossible to reach the land with a large canoe, and in the second or middle division the water is also very shallow, the bottom of soft sandy clay scattered with fragments of limestone and a few nodules of iron pyrites. Many of the former have one smooth side covered with glacial striæ, and are evidently derived from the till. In this protected bay, and especially on its north side, which is bordered by a fringe of rushes, are some of the best examples of ice-grooving that have ever come under the writer's observation. Boulders are lying here and there, and most of them show signs of having been moved from three inches up to thirty-three paces. The sand and pebbles of the beach are generally piled up on their landward side, while a groove extends towards the lake. The majority of the shorter grooves on the north shore trend N. 60° to 75° W. One, ten paces long, trends N. 10° W., and in this the boulder is seen to have at first lain transversely to the direction of the groove, and to have been turned round and shoved with its greater axis along the groove. A group of six boulders have been shoved in a direction S. 70° W. Another boulder 44 x 45 x 22 inches has taken the following course, turning sharply at the changes of direction: From its starting place in the water N. 50° W. for fourteen feet six inches, then N. 10° W. thirty-seven feet, then N. 40° W. thirteen feet six inches, then N. 25° W. ten feet eight inches to the stone. Another boulder is now lying in the water at the end of a straight groove about fifty feet long, running from it in a direction N. 35° W. towards the shore, and pebbles are piled up on its lakeward side, showing that it has been shoved out from the shore when the ice was carried out by the wind. The shore throughout this distance has a constant direction S. 50° W.

Ice-shoved boulders.

The irregularity in length and direction of these grooves on a soft, straight shore shows clearly that they are caused by the irregular



J. B. Tyrrell, Photo., July 20, 1889.

ICE-SHOVED BOULDER, AND GROOVE BEHIND IT 30 FEET LONG, SHOWING ITS TRACK UP THE GENTLY SLOPING BEACH.

PELICAN BAY, LAKE WINNIPEGOSIS.

pressure of broken ice in the spring, rather than by the regular expansion of the ice during the winter with the variations of the temperature.

Ridge of boulders.

Behind this low beach is a wall of boulders that have been shoved back against the higher ground within the edge of the woods, and have reached their permanent resting place, where they can no longer be affected to any considerable extent by the waves and ice of the present lake. Within the woods is a ridge twenty feet high scattered with gneissoid boulders.

In the mouth of Pelican Bay are a number of low but beautifully wooded islands, with shores of clay and boulders running out into spits of limestone gravel.

Whiskey Jack Point.

From Whiskey Jack Point, which lies at the eastern side of the entrance to the bay, the shore turns towards the south-east, and for five miles is composed of water-worn gravel along the face of a forest of spruce and poplar. Within the forest a ridge rises to a height of twenty-five feet above the water, and its summit is strewn with large boulders of gneiss. In summer the trees close to the beach are everywhere wound with the webs of innumerable spiders, set to entrap the swarms of waterflies bred in the lake.

For another five miles, to Devil's Point, the shore is low and sloping, and composed of clay scattered over with fragments of white limestone with very few boulders, behind which is an ice-shoved ridge of irregular gravel.

Devil's Point.

Devil's Point is a relatively high, rounded promontory, extending northward towards Grand Island, from an elevated portion of the mainland. On its western side rock appears in place at the water's edge, while in other places the beach is piled to a height of sixteen feet with rounded masses of rock, over which is a grove of birch and poplar. Behind this grove is a cliff of limestone thirteen feet high, and above the cliff the land inclines gently upwards to a total height of forty-five feet. Along the western face of this slope a few large boulders of gneiss are lying, and its crest is composed of more or less rounded pebbles and cobbles of limestone.

Grand Island.

Grand Island, to the north of this point, has a general wedge-like shape, with a greatest length of five miles and a quarter and a greatest breadth of two miles. It is thickly timbered throughout, and while its northern and eastern sides slope gradually to the water, its western side rises in a cliff to a height of fifty feet, on the top of which is a gravel ridge with a total height of fifty-five feet above the lake. This evidently represents a portion of the same shore line that has already been seen at Devil's Point and on Mossy Portage, having

here formed the crest or point of an island standing out in the middle of Lake Agassiz.

Cormorant Islands.

East of Grand Island lie the Cormorant Islands, the largest of which is wooded, while the others are bare, stony bars, on which great numbers of cormorants and pelicans annually rear their young. They consist of boulders of gneiss and limestone and nodules of iron pyrites.

From Devil's Point the shore turns southward for eighty-five miles, forming the western side of the main portion of Lake Winnipegosis. For the first ten miles the beach is low and muddy, with a ridge of boulders or fragments of limestone back from the water along the edge of a tract of low-lying land covered with small burnt timber. Near a

Hill on shore.

point at the south end of this distance a ridge twenty-eight feet high, covered with burnt and partly fallen spruce and poplar, runs east and west behind the low beach, and consists on the surface of large and small rounded or partly rounded water-worn fragments of limestone with a few boulders of gneiss.

Between this hill and Fox Point is a bay surrounded by low shores wooded with fire-killed poplar and small spruce. In the mouth of the bay is a wooded island, between which and the latter point the lake has a depth of from fourteen to seventeen feet.

Pemican Island.

Six miles and a half north of Fox Point Pemican Island rises from the lake at a distance of more than two miles from shore. It has a greatest length of about three-quarters of a mile, and consists of a wooded limestone hill rising to a height of forty feet above the lake. On its northern side it is surrounded by a beach of closely-packed boulders of gneiss, while to the south and east the shore is flat, and behind it, within a belt of elm and maple, is a cliff of limestone. Towards the south-west the island is terminated by a long, naked spit of limestone gravel rising three feet above the water. The occurrence of fragments of lignite on this bar and on the adjoining beach has long been known to the Indians, and they assert that it is washed up out of the lake by every storm. It is doubtless derived from an outlier of Cretaceous sands or shales lying just beneath the surface of the water on the south side of this island.

North Manitou Island.

North Manitou Island lies four miles south-east of Fox Point, and the water throughout the distance between them has a general depth of from twenty-four to twenty-six feet, with a muddy bottom. The island has once been wooded with very large spruce, birch, poplar and elm, but most of the trees are dead and falling. The shore on its north side is a narrow belt of limestone fragments, stretching to the water from the foot of an ancient low cliff, now sloping and covered with vegetation. At the north-east point

there is a steep wall of closely piled boulders ten feet in height. The east side is a narrow beach of limestone gravel, while the west side is muddy, and slopes off into shallow water. From the south point a spit of limestone gravel extends southward for a third of a mile, and from its termination a narrow, shallow bar extends a long distance towards Birch Island.

Birch Island. Birch Island is a large land area lying in the middle of Lake Winnipegosis, and approaching to within a short distance of both its eastern and western shores, thus dividing it more or less completely into two parts. It has a greatest length of seventeen miles, a greatest breadth of five miles and a total area of seventy-four square miles. It has formerly been well timbered, but as far as can be determined from the shore, the timber has all been destroyed by fire, and none of any value remains.

At Roderick Point, on its north shore, low cliffs of limestone rise above the gravel beach. The remaining shores are generally low, the west and south sides being thickly strewn with boulders of gneiss, with long stony points occasionally running out towards the south.

"Drumlins." West of Birch Island a number of small islands lie in and obstruct the channel. They are all composed more or less entirely of boulders, and are elongated in the direction in which the Manitoban lobe of the Laurentide glacier has moved across this whole area, being of the nature of Drumlins or raised ridges of till. As a rule, a belt of elm and poplar is growing along their crests.

Camping Islands. From Birch Island to Duck Bay the west side of the lake is generally low, and often has a beach of gravel with boulder points. Off Duck Bay the Camping Islands are very similar to those already described lying west of Birch Island, and consist essentially of ridges of boulders lying parallel to the direction of glaciation. The ridges rise in places to heights of twelve feet above the lake, and they are often worn down by the waves into bars of rounded gravel. Their crests are wooded with small groves of poplar, spruce, elm and ash-leaved maple.

Duck Bay. Duck Bay is little more than a westward continuation of this group of islands. It consists of several shallow lakes connected by narrow arms, which run out towards the north and south into extensive marshes. Through one of these marshes the South Duck River flows for a considerable distance in a well-defined channel 100 feet wide before it empties into the "bay," while the North Duck River joins the most westerly portion of the open water as a brook with dry grassy banks. A short distance above its mouth, near where it emerges from the spruce forest, it is fifty feet wide and three feet deep, with a slight current.

The point south of the entrance to Duck Bay is a bar of boulders 150 yards in length piled regularly to a height of eight feet above the water. A gently rounding bay stretches southward from this point, the shore of which is chiefly composed of pebbles of limestone with a few boulders of gneiss. Near the bottom of this bay, seventy yards back from the lake, an old abandoned trading post of the Hudson's Bay Company is very prettily situated in poplar woods.

Old trading post.

From Duck Bay southward to Pine River, a distance of about eleven miles, the beach is composed of sand or gravel, behind which is a wall of boulders, and the salient points are also entirely surrounded by boulders. On the ridge thus formed a row of poplar and ash is growing, behind which a low meadow extends for a short distance to a forest.

Pine River.

Pine River, for a mile and a half up from its mouth, is about one hundred feet wide and from three to five feet deep, with dark, brackish water, without perceptible current. The banks are low and mostly grassy, and back of them are forests of poplar and spruce. At the head of this navigable stretch is a rapid down which the river flows through an accumulation of large boulders of gneiss, and a shortdistance below this rapid the Hudson's Bay Company have a trading store on the west bank, which was built in the autumn of 1887, when the store at Duck Bay was abandoned. Below this store, but on the east bank, the Roman Catholics have a church and mission school. On the west bank of the river half a mile above its mouth, is a bare, salty plain, in the middle of which are several springs of brine. The springs are surrounded by broken masses of limestone and boulders of gneiss, while the ground generally is a soft, springy mud.

Sagemace Bay.

From Pine River, Sagemace Bay stretches southward for twenty-five miles, and is separated from the main body of the lake by the point of land known as Red Deer Peninsula. Its shores and islands are everywhere low, and without any signs of the underlying limestone. The beach on its eastern side is composed chiefly of boulders from four to eighteen inches in diameter; with a few limestone pebbles, except in two or three of the most sheltered bays, where short, sandy beaches are found. In some places the larger boulders, which are mostly of gneiss, are piled in an evenly sloping wall, but in the majority of places the smaller boulders of gneiss and limestone are scattered on a slight incline down to the lake, while the larger ones lie near the roots of the trees at the level of the highest stages of the water. Off the shore the water is generally moderately deep and free from weeds. The southern and western sides of the bay are shallow, and, except at the points, are fringed with narrow bands of rushes. The beach is a ridge of small

gravel, with boulders along its crest, and is covered with grass, deciduous plants and small berry bushes. Poplar, oak and willow form small groves all along the shore.

The islands are all very similar in character. The interiors are wooded, the larger ones with spruce as well as poplar. The shores are composed of sand and boulders, and are occasionally fringed with rushes in the more sheltered places.

Red Deer Point.

Red Deer Point is surrounded by a wall of boulders of gneiss and limestone, and the low island to the north of it is simply a boulder reef.

From this point southward to the mouth of Mossy River, a distance of twenty-nine miles, the shore is very irregular, being broken by narrow bays and long gravel or boulder points. Low cliffs of limestone occasionally overhang the lake in the first half of the distance, but most of the salient points throughout are composed of boulders. The bays have beaches of more or less rounded gravel, in front of which a sloping boulder pavement sometimes stretches to the water.

Monkman's salt springs.

At a point six miles north of Mossy River the straight beach is composed of small boulders and pebbles of gneiss and limestone. A hundred feet back from the water the shore rises in a low ridge of rounded gravel wooded with a few small willows. Behind this ridge a grassy prairie stretches westward for a quarter of a mile, to several springs of brine, rising in the distance about eight feet. To the north it is bounded by a grove of poplar and small oak, while to the south the poplar is mixed with spruce. On an arid, salty plain to the west are the ruins of several old houses where Monkman and others used to live when they supplied the Red River colony with salt, and the remains of iron pans in which the brine was boiled down. These salt springs will be treated of more fully on a subsequent page.

South shore of lake.

From the mouth of Mossy River eastward to Meadow Portage, a distance of thirteen miles, the south shore of the lake is everywhere low, and surrounded by a naked wall of boulders; while in the rounded bays between the points the beach is occasionally a closely-packed boulder pavement sloping up at an angle of about 15° to a wave-formed gravel ridge, or in other places boulders are more thinly and irregularly scattered in front of this ridge. On the ridge itself there is usually a narrow belt of maple, elm, ash and oak, while behind it a low-lying marsh stretches back to the poplar forest.

LAKE DAUPHIN.

Position and extent.

Lake Dauphin lies in the midst of an alluvial plain about nine miles south of Lake Winnipegosis, into which it is discharged by the Mossy

River. It has a greatest length of twenty-six miles, a greatest breadth of eleven miles, a shore line of sixty-four miles, and an area of one hundred and ninety-six square miles. Its greatest ascertained depth is twelve feet and its approximative elevation, deduced from barometric readings and the estimated fall of Mossy River, is eight hundred and sixty feet above the sea.

History. Its name is associated with the earliest explorations in the North-west, since Fort Dauphin, one of the trading establishments of the French before the cession of Canada to Great Britain, appears to have been situated on its shore, and probably near its north-western extremity. This fort was founded in the autumn of 1741 by Pierre, one of the sons of Sieur de la Verendrye, who travelled northward from Fort la Reine (Portage la Prairie) across Prairie Portage into Lake Manitoba, and thence probably by the old canoe route to Lake Dauphin*.

Ruins of old forts. At the present time ruins of old trading posts of the Hudson's Bay Company can be seen on the west side of the lake, eight miles south of the mouth of Valley River, and at the edge of the forest at the south-east angle of the lake.

Low shores. The shores of the lake are everywhere low, and show no exposures of the underlying Palæozoic rocks. The projecting points, except those formed by the tributary streams, are composed entirely of boulders, which on the south side run out as comparatively long, narrow arms into the water, while on the east side they are merely gently-rounded prominences. Between the points the west and south shores are very low, and are surrounded by a sand and gravel beach, extending back into a marsh. The east shore often presents to the lake a regularly built embankment of boulders or cobble-stones, behind which there is occasionally a low cliff of light gray till with boulders. Elm, ash, oak and maple are growing on top of the beach, and in the background is often an open forest of poplar.

Five small streams empty into the south and west sides of the lake, most of which rise on the summit or eastern face of the Riding Mountain and flow across the rich alluvial plain between the mountain and lake.

---

*P. Margry. Mémoires et Documents, &c. Vol. 6, pp. 591, 594 and 617. Bougainville states that "80 lieues from La Reine (the fort) is situated on the River Minanghenachequeké or de l'eau trouble" evidently Mossy River, as the name given me by the Indians for this stream was Minàkweniskegow, which is clearly the same word. P. Margry. Vol. 4.

Peter Pond, who appears to have been the first Englishman to occupy this fort after it was abandoned by the French, gives the location of the post occupied by him in 1775 at the north-west angle of the lake. P. Pond's Map of 1785. Can. Arch., 1889, p. 53.

For other references to this post see "Henry's Travels," p. 260. "Harmon's Journal," p. 52. Alex. Mackenzie's History of the Fur Trade. Alex. Henry Ms. in Parliamentary Library.

Turtle River is the most southern of these five streams. It is stated to rise in small brooks on the eastern face of the mountain and in some extensive marshes on the plain to the east. At the crossing of the cart trail to Lake Manitoba, the creek, in October, 1889, was twenty feet wide in a winding channel twelve feet deep. The bottom was stony, and the banks were wooded with poplar, elm and willow. Here a thriving Métis settlement has been established within the last few years. From this point to the lake the adjoining country is generally a level, grassy plain, and at its mouth the river is fifty feet wide and from two to four feet deep, emptying into the lake over a shallow sand bar. Turtle River.

The trail mentioned above runs for about seven miles through undulating country dotted with poplar groves, at first ascending a gradual slope scattered with boulders of gneiss, &c. It then enters the poplar forest, through which it is cut eastward to Ebb and Flow Lake. The surface continues generally undulating, and appears to be underlaid directly by light gray till. In range 13 the trail reaches a small ridge of rounded gravel five feet high and 250 feet wide, along which the old trail followed by Prof. H. Y. Hind in 1858 is stated to run for several miles, and which here joins the trail now used. The ridge comes from the north-west, and a quarter of a mile to the south-east it ends in a rounded point, beyond which is a level, grassy plain. The elevation of this ridge, as determined by several aneroid readings, is 933 feet above the sea. From this ridge, on which we had camped for the night, the trail runs for about 150 yards on an ill-defined ridge trending north-east, and then turns eastward on an open, narrow, well-rounded ridge of small gravel, on the south side of which is a meadow, while to the north is a lower country wooded with spruce and tamarack. The face of this ridge or old beach is thickly scattered with boulders; it soon turns to the north and may continue for a long distance, but the trail leaves it and descends into the woods. Near the eastern side of range 13 the trail crosses another well-defined ridge, consisting of sand. and small rounded pebbles of limestone. It runs N. 50° W. and S. 50° E., is four feet high and 150 feet wide, and has an approximate elevation of 910 feet above the sea. Manitoba House trail. Old trail. Gravel ridge.

From this ridge the trail runs north-eastward for two miles and then turns south-east and runs for a mile or more along the face of a light slope thinly wooded with small oaks. This is also an old shore line, and has an approximate elevation of 875 feet above the sea, being probably the same as the 60-foot beach around Lake Winnipegosis.

Ochre and Vermilion rivers rise on the summit of Riding Mountain and flow down its eastern face in deep valleys that will be more fully described in the strictly geological part of the report. The first named Ochre and Vermilion rivers.

stream flows through woods to within a short distance of its mouth, while the Vermilion winds across the partly-wooded plains in a channel overhung by a belt of elm and maple.

Wilson River. Wilson River was not followed to its source, but it appears to rise on the north-eastern face of the mountain, where the escarpment is a longer and more gentle slope than usual, and thence it flows eastward across the level of Lake Dauphin plain to empty into the west side of the lake two miles north of the mouth of Vermilion River.

Valley River. The last and largest of the five streams is Valley River, which is stated to rise in Singoosh Lake in the interior of Duck Mountain, and thence flows southward through Angling Lakes into the bell-shaped valley that separates the Riding from the Duck Mountain. Near where it enters the valley it is joined by Short Creek flowing from the west in a deep, narrow valley, which connects at its western

Indian village end with the valley of Shell River. Here there is a small Indian village, where a band of Ojibways spend the winter. East of this village the river flows for some distance through a rolling morainic country, some of the hills being rounded and scattered with boulders, and others elongated in the direction of the valley, and composed of stratified sand and gravel. Further east the surface is much more even, and is underlaid by a fine white silt, resting on the glacial till. The woods are chiefly poplar and willow scrub.

Sandy plain. The country maintains much the same character to about the middle of range 22, where a trail branches off to the south. Here a sandy plain commences and extends to the eastern side of the same range, a few oaks being scattered over it here and there. At the above-mentioned trail the river flows in a valley eighty feet deep and half a mile wide. Land slides characterize its northern slopes which are covered with vegetation, while the south side rises in open gravel

Gravel ridge. terraces fifteen and thirty feet above the river. Near the eastern side of the above range two low gravel ridges are crossed at elevations of 1,280 and 1,260 feet above the sea, respectively, and near the western side of range 21 a strongly-marked gravel ridge is crossed at an elevation of 1,220 feet. The river here flows in a beautiful valley sixty-five feet deep, and near the bottom of the north bank is a spring of clear, cold water, smelling and tasting strongly of sulphuretted hydrogen.

About the middle of the same range the river cuts through a heavy gravel ridge on which a cart trail starts northward to Pine Creek Indian reserve, and still further east in the same range are two other ridges, the lowest of which has an elevation of 1,075 feet above the sea. Near this latter ridge is an old ford, and here the river is seventy-five

feet wide, flowing in an irregular valley a quarter of a mile wide and from thirty-five to fifty feet deep, with wide gravel flats on each side of the stream. A mile below this the banks are low, and covered with grass or timber.

Near its mouth the river flows through an open grassy plain in a channel about forty yards wide and from three to six feet deep, and empties into the lake over a bar of sand at the end of a long alluvial point.

MOSSY RIVER.

Lake Dauphin is discharged northward into Lake Winnipegosis by Mossy River, a beautiful winding stream twenty-two miles and a half long, from 150 to 200 feet wide, with an average depth of from two to four feet, and an estimated fall in its whole length of thirty-two feet.

Point of discharge.

It empties into the latter lake through low meadow land, which, in June, 1889, was two feet above the water, but is evidently often flooded. This meadow is about a quarter of a mile wide, and behind it on either side is a forest of aspen. An old trading post of the Hudson's Bay Company is situated on the east bank of the stream, three-quarters of a mile above its mouth, on a narrow strip of grassy land between the forest and the river. A mile above its mouth, in a direct line, the old Government location of the Canadian Pacific Railway crosses the stream, and near it are three exposures of Devonian limestone, the upper one forming a low cliff on the west bank. Above this cliff no rock in place is seen on the river.

Crossing of old C.P.R.

Boulders.

Two miles and a half above the Canadian Pacific Railway location there are some small islands in the middle of the stream, and between them the channels are filled with boulders, causing rapids with a fall of two to three feet. Throughout the distance to here the river is from 100 to 150 feet wide, with an average depth of four feet and a current of a mile an hour. It has no valley, except the channel in which it flows, and which it fills from side to side. Few bars of sand or gravel obstruct its bed, but boulders of gneiss and irregular fragments of white limestone are scattered along its banks. In places the boulders stretch across the river and form ugly rapids. As the water is generally muddy, these pebbles and boulders are coated with mud.

The bank is from ten to eighteen feet in height, fringed with grass and sedge close to the edge of the water, above which is a row of small willows, and on the level land on either side is a forest of white poplar, in which there are a few trees of ash and oak. On the west side much of the forest has been burned, and there are a few open

or thinly wooded spots by the river, while on the east side the bush is mostly green, with trees from six to eight inches in diameter.

Banks of till.

For the next two miles in a direct line the river is crooked, and is obstructed in four places by accumulations of boulders of gneiss and limestone which have fallen from the banks of loose light gray till. The banks are from eight to ten feet in height, the eastern one wooded as before, while on the west the river cuts into a long strip of open prairie, along which is an old cart trail to the Lake Winnipegosis salt springs. This bank is cut by several runnels, in one of which water was standing distinctly impregnated with salt. This level plain is underlaid by stratified alluvial sand or silt.

For most of the rest of the way to Fork River the stream flows by the side of this alluvial plain in a moderately straight course almost unobstructed by boulders or sand bars. It has a very easy current of from half to three-quarters of a mile an hour, is 150 feet wide and from three to four feet deep. The banks are from twelve to eighteen feet high, and composed chiefly of a loose light gray unstratified clay, often holding bands of well striated pebbles.

Fork River.

Fork River empties into the west side of Mossy River at a total distance of fourteen miles and a half from Lake Winnipegosis following the windings of the stream. At its mouth it is thirteen yards wide, and flows with a depth of an inch or two over a shallow bar of gravel. The water is dark brown. For half a mile above this the brook is about two feet deep, without current, and is choked with Algæ, Charæ and water lillies. At this distance the channel is blocked by large boulders of gneiss, between which the water flows in tiny streams. This channel winds from side to side of a well-defined valley twenty feet deep, with rather extensive *intervales* wooded with poplar. North of this brook is a grove of poplar, oak, ash and maple, near which is a favourite Indian camping ground. For about seventeen miles westward across the almost level country this stream was not followed, but it was again crossed, and traced for several miles, in the vicinity of the main gravel ridge on which the trail runs northward to Pine Creek.

Fishing River.

From Fork River to Fishing River, a distance of five miles along the winding channel, Mossy River is often obstructed by boulders of gneiss, and the banks are almost everywhere clothed with vegetation, most of which is poplar from three to eight inches in diameter.

Fishing River is a small sluggish brook flowing into Mossy River from the west. At its mouth it is forty feet wide, and without perceptible current. Ascending it for three-quarters of a mile, its width diminishes to twenty feet, and its depth to fifteen inches. Its bed is sandy, and its banks are fifteen feet high, and are wooded with poplar and oak.

Three miles from Fishing River, Mossy River flows from the north-west end of Lake Dauphin opposite some small boulder islands. Throughout this distance its banks are from eight to twelve feet high, sloping and wooded, and in many places a swift current flows over a bed of sand, clay and boulders. Head of river.

SWAN LAKE AND SHOAL RIVER.

Swan Lake lies seven miles south of Dawson Bay, into which it discharges through Shoal River. It is situated in a somewhat more undulating district than Lake Dauphin, the surrounding country being, as a rule, generally immediately underlaid by glacial till. It has a greatest length of twenty miles, a greatest breadth of eight miles, a shore line of seventy miles, and an area of 121 square miles. It contains nine small wooded islands, with a total shore line of fourteen miles and an area of one and a half square miles. The mean depth of the water is only five feet, and the greatest depth found in 1887 six feet. The bottom is soft and muddy. Its altitude, estimated from the fall of Shoal River, is twenty-seven feet above Lake Winnipegosis, or 855 feet above the sea. The writer was informed by Antoine Chenaye, a native half-breed, that about twenty years previous to 1889 the lake was at its highest stage, about six feet above its present level and that Shoal River then overflowed its banks. Some years previous to that date the lake was at its lowest level, when during the prevalence of a north wind Shoal River was dry at its head, and some of the men living in the vicinity used to race horses on the dry bed of a small lake near the mouth of Swan River. Position and extent. Altitude.

The east shore is generally a gravel beach, fringed with rushes at the bottoms of the bays, while the numerous points are surrounded by a sloping wall of boulders four to six feet in height. The boulders are chiefly of dark gray or reddish gneiss, while some are of limestone. The land rises very gently from the lake, and is wooded with poplar, with a forest of spruce in the distance. East shore.

At its south end the lake is very shallow, with a bottom of soft mud, so that it is difficult to get a canoe to the dry land. Back of this muddy beach is a ridge of rounded gravel six feet in height, wooded with elm, behind which the country descends slightly, and is wooded with balsam-poplar, spruce and balsam-fir. A spring of brine is bubbling up at one place on this low beach, in which the water gave a reading of 16° on the percentage salometer. Close to this spring a bridle trail to Pine Creek enters the woods, and runs for a mile and a quarter across low land much obstructed by windfalls, and then ascends a hill with a South shore. Kettle Hill.

total height, as determined by the aneroid, of 274 feet above the lake. On its face are six distinct terraces, the brows of which are 75, 113, 151, 170, 198 and 236 feet above the lake, the highest one rising in a long slope to the summit. The highest slope up to 236 feet is very steep and appears to consist of sand and pebbles, while a great number of boulders of gneiss and limestone are scattered on the brow of this terrace.

Sand.

The summit is composed almost entirely of reddish sand, underlaid by rounded pebbles, with boulders of gneiss, limestone and white Dakota sandstone scattered here and there. The surface, which is slightly irregular, is thinly wooded with small Banksian pines and a few oaks. Towards the north-east the terraces are wider and more distinct than on the line of the trail. They are generally sandy and sparsely wooded, and on one of the higher terraces, at an elevation of about 200 feet above the lake, are many bare, rounded or hemispherical masses of white Dakota sandstone, from eight to twelve feet in height, with their planes of stratification horizontal, and apparently lying where they were eroded out of the soft sandstone of the base of the Cretaceous. They show no signs of glacial action, and have clearly been formed in post-glacial times, when the waves of Lake Agassiz cut this terrace in the face of the pre-existing slope.

Dakota sandstone.

Drumlins.

The west shore is broken by long alluvial points, at the end of the most prominent of which Swan River empties into the lake. The islands off this point, near the centre of the lake, are ridges of boulders lying approximately in the direction of the glacial striation, wooded with groves of elm and maple, while the islands in the north end of the lake are composed of cream-coloured Devonian limestone polished and grooved by glacial action. These glacial grooves have a very persistent bearing S. 50° W., and the direction of the motion of the glacier is clearly shown by the fact that the hummocks are evenly rounded towards the north-east, and ragged and broken towards the south-west.

Glacial grooves.

Shoal River House.

Near the north-east angle of the lake, Shoal River House, a trading post of the Hudson's Bay Company, is beautifully situated on a small open plain close to the shore, with a gently sloping beach of gravel, extending to the edge of the water. In the open clearing the land rises gently to a total height of twenty feet above the lake, beyond which is a forest of spruce and poplar. The trail from the post to the mouth of the river is cut through this forest, and at a distance of a mile and a half ascends to a height of sixty feet above the lake on a ridge of sand and gravel wooded with Banksian pine.

Shoal River.

Shoal River flows out of the north-east angle of the lake over a low ridge of till, is nearly ten miles long, and has an average width of from

D. B. Dowling, Photo., Sept. 3, 1889.

ROUNDED BOSSES OF DAKOTA SANDSTONE.

ON A TERRACE 1053 FT. A.T. ON THE NORTH SIDE OF KETTLE HILL, MANITOBA. LAT. N. 52° 21′ 30″, LONG. W. 100° 37′.

150 to 200 feet. The channel is generally not more than from six to ten feet in depth; the banks are sloping, and wooded with poplar and spruce, except on some open saline tracts, while the bed is often strewn with boulders, which are collected in places and form disagreeable rapids.

RED DEER LAKE AND RIVER.

Position and extent.

Red Deer Lake is a more or less rectangular sheet of water lying in the midst of a level alluvial plain north of Porcupine Mountain and west of Dawson Bay. It is thirteen miles long and nine miles and a half wide, has a shore line of fifty-one miles, and an area of one hundred square miles. It has a mean depth of five feet with a bottom of soft mud. Its altitude, estimated from the fall of the river, is forty-seven feet above Lake Winnipegosis, or 875 feet above the sea.

Shores.

The south shore was examined by the writer in 1889, while the others were surveyed by Mr. Dowling in the previous year. All are low, and except at one point on the south side no rock is to be seen. This latter side is fairly straight, and the beach in the bays is composed of sand and pebbles, while on the points it consists entirely of rounded boulders of gneiss and limestone, closely laid in an even slope, which rises at an angle of 10° to 12° from the water to edge of the spruce and poplar forest.

Red Deer River.

The Red Deer River empties into the west side of the lake at the end of a long alluvial point, and again flows from its south-east corner eastward towards Lake Winnipegosis. From its head, where the water is very shallow, to the mouth of Rice Creek, the river is wide, with a swift current, and boulders of gneiss form bars out into the stream.

Rice Creek.

Rice Creek, called by the Indians Manomina Sipi, was ascended in a canoe for a mile and a half to a light rapid where the water flows over loose slabs of white limestone. It is a small creek from twenty to twenty-five feet wide, generally with a soft bottom, and occasionally almost blocked with grass. The country on both sides is low, level, and often saline, and the banks are overhung with willows. From the little rapid an open wet meadow extends southward for a couple of miles to a forest of spruce. The creek appears to flow down the face of the mountain in a narrow gorge, on the sides of which are some bare white cliffs, which appear very conspicuous from the islands and shores of Dawson Bay.

Long Rapid.

From the mouth of Rice Creek to the head of the Long Rapid, where a band of limestone crosses the stream, the river fills the channel from bank to bank, and with the exception of one slight rapid, flows

with an even current and is moderately deep. The banks are low, and wooded with poplar and a few spruce. The limestone shows strong glacial grooves striking S. 75° W., or directly across the river. In the rapid, which is about a mile in length, the river is shallow, and filled with large granite boulders, while several wooded islands break up the channel. On the south bank, opposite these islands, is a watercourse coming from a wide saline area scattered with pebbles and boulders, and dotted with groves of poplar. Several springs of brine are rising in this flat, but all were so shallow and muddy that it was impracticable to test them with the salometer. A small stream of brine was flowing about five gallons a minute in the bottom of the watercourse.

Upper Salt Spring.

At the bottom of the rapid the river bends sharply towards the north-east, and is moderately deep for a mile and a half to a hill which rises on the north bank to a height of twenty feet, on the south side of which are some brine springs at which the Indians occasionally boil down the water to obtain a small quantity of salt. The hill is composed of limestone, and its north-east side, which is bare in places, shows indistinct glacial striæ trending S. 65° W., and on the south-east side is a little patch about three feet square of a light, reddish till holding rounded pebbles and cobbles of gneiss and limestone. The face of the hill, down which the brine is trickling, is covered with fragments of limestone, among which were many beautifully preserved fossils. A mile below this hill, which has been called the "Upper Salt Spring," a small salty creek, carrying about four gallons of water a minute, flows in from an open area towards the south.

Glacial striæ.

From this creek downwards to the lowest Salt Spring the river is one continuous rapid, flowing in a winding course through boulders, having a bare gravel beach on each side.

A short distance below the briny creek, and still on the south side, is a slightly elevated mound, from the centre of which is issuing a spring of brine flowing about ten gallons a minute. It has a temperature of 42° F., and gave a reading of 22° on the salometer.

At the bend below is a cliff of limestone, the summit of which is polished and scored with grooves running S. 80° W. Above the limestone is a hard, light gray clay, containing striated pebbles and boulders. Just below this cliff is a small salty brook flowing five gallons a minute, and in which the salometer gave a reading of 22°.

Higher banks.

From this point the banks ascend to a height of twenty feet, and consist in many places of cliffs of limestone overlaid by till filled with pebbles and boulders, most of which are granite or local rock, while some are Niagara limestone, containing *Pentamerus decussatus*. The lowest cliff of limestone on the river is also overlaid by till, and the

surface of the rock below the till is beautifully polished and striated in a direction S. 80° W.

The Lower Salt Springs occupy an open area of about 100 yards square on the north side of the river and twelve feet above it. The area is strewn with eroded boulders of gneiss and limestone, and small springs of brine bubble up every here and there, in one of which the brine seemed to be very concentrated, giving a reading on the salometer of 75 per cent. Lower Salt Springs.

Below these springs the banks are low and alluvial, and there is but little current in the river.

CEDAR LAKE AND SASKATCHEWAN RIVER.

Cedar Lake is an irregular body of water lying in the extreme northern part of the area included in the map, and is separated from Lake Winnipegosis by a narrow belt of high land from four to five miles in width, which cuts across what would otherwise appear to be a single natural basin. Its greatest length is thirty miles, its greatest width is fourteen miles, it has a shore line, within the map, of 108 miles, and an area of 330 square miles. Its depth is from thirty to forty feet, and its elevation above the sea 828 feet, both these measurements being the same as those for Lake Winnipegosis. Position. Extent.

At its western end the lake receives the waters of the Saskatchewan River in the middle of a little archipelago of small rocky islands. On the outermost and largest of these islands the early French traders are stated to have had a fort. This fort or trading post, which was called Fort Bourbon, was founded by one of the sons of Sieur de la Verendrye in 1741. He reached the site by travelling northward from Fort la Reine (Portage la Prairie) across lakes Manitoba and Winnipegosis. The island is thickly wooded with spruce. At its north end is a low cliff of limestone with a gravel spit projecting beyond it, behind which is a pleasant harbour for small boats. At its south end is a rounded hook of gravel inclosing a shallow bay. Old Fort Bourbon.

From the mouth of the Saskatchewan southward the shore of the lake is low, with a more or less sandy beach, behind which is a level spruce and tamarack swamp. With the sand and debris on the beach are scattered many particles of fossil resin that have been washed down by the Saskatchewan River from the Cretaceous shales and sandstones higher up the stream. The south shore is without prominent cliffs, and consists of stretches of even sandy beach between salient points piled high with large boulders of gneiss. Fossil resin.

Rabbit Point.

Rabbit Point is a low, sandy promontory on the north shore, invested with a mournful interest, as here lie the remains of Benjamin Frobisher, one of the early partners of the North-west Company. In the troublous times just before the union of the North-west and Hudson's Bay Companies he was taken prisoner by the latter and carried to York Factory, from which place he escaped in the autumn of 1820. He ascended the Nelson and Saskatchewan rivers on his way to a trading post on Moose Lake, but at Rabbit Point, worn out by hunger and fatigue, and while his Indians were absent at Moose Lake in search of relief, he expired beside his lonely bivouac fire.

Rocky Islands

North-east of Rabbit Point an arm of the lake extends for twelve miles past low wooded shores and small rocky islands, where gray cliffs of limestone peep out here and there from under the covering of dark green spruce. At the end of this arm of the lake a deep, narrow channel, known as "The Narrows," runs between a small island and the south shore. Here the Saskatchewan River may be said to commence again, but its characters are entirely different from those of the sluggish stream which flows into the west side of the lake. Instead of filling, it is rapidly deepening its channel, tumbling and sliding down rocky limestone ledges in wild rapids, between which are quiet stretches. One of these expands in Cross Lake into a comparatively large body of water.

Grand Rapid

The Grand Rapid (the last of these rapids and the most interesting feature on the Saskatchewan River) has a total fall in five miles of seventy-one feet, the most of which is concentrated into two miles in the middle of the distance. In these two miles the river has cut a deep, narrow gorge in the horizontal limestone, part of which gorge is post-glacial and part pre-glacial in age.

Tramway.

To overcome the difficulty of transporting goods and boats past this rapid by hand, the Hudson's Bay Company engaged Walter Moberly to build a tramway three miles and a half in length past the rapids. This was done in 1877, and on the eleventh of September of that year Lady Dufferin, who, with Lord Dufferin, the Governor-General of Canada at that time, was travelling in the west, drove the last spike in this remote railway.

Descent of the rapid by John Fleming.

The following excellent description of the descent of the Grand Rapids below the east end of the old portage is given by Mr. John Fleming :—

"In running the rapid we followed as closely as possible the instructions given to us by our old guide on the plains (John Spence) who had often piloted the old N. W. Co.'s *north* canoes down its entire length. In attempting, according to his directions, to cross

from the north to the south side of the rapid in order to get into what was reported to be the best channel for a small canoe, such was the fierceness of the current and the turbulence of the great surges and breakers in the middle that we were nearly engulfed; and although every nerve was strained, we were swept down with impetuous velocity, and did not get near the other side till we were about three-quarters of a mile below our starting point. We were then impelled with astonishing swiftness along the south side of the torrent, often in dangerous proximity to the rugged wall of rocks bounding the channel, and now and then whizzing past—almost grazing—sharp rocky points jutting out into the river, against which the thundering waters seethed and foamed in their fury. During the descent the voyageurs exerted themselves to the utmost of their strength, and evinced an admirable degree of coolness and dexterity.

"The Grand Rapid is acknowledged by those who have witnessed it, and who have had opportunities of traversing the great river systems of the continent, to be unsurpassed in magnificence and extent, as well as in volume of water."*

PHYSICAL GEOGRAPHY AND GEOLOGY

COUNTRY WEST OF THE LAKES.

General character.

This region is entirely underlaid by the soft and easily-eroded Cretaceous shales and sandstones, which are lying in an undisturbed and almost horizontal attitude. The streams are small, and in many cases are not now actively eroding their channels, and old escarpments soon crumble down to easy slopes and become overgrown with vegetation, so that good natural exposures are infrequent. Very often the lines bounding the different formations have therefore necessarily been drawn on hypsometrical evidence. It has consequently been found inadvisable at present to separate the description of the geography from that of the older geology of this district.

For the sake of greater accuracy, the river valleys and trails followed will be described in succession, beginning with those in the south-eastern portion of the district.

Ochre River.

The Ochre River rises on the summit of the Riding Mountain and flows in a general direction N. 25° E. for twenty-five miles to its mouth at the southern extremity of Dauphin Lake. In the upper part of its course it flows in a wide and gradually deepening depression, in the

*Report of the Assin. and Sask. Expl. Expedition by H. Y. Hind, Toronto, 1859, p. 78.

bottom of which it has cut its own distinctive valley. Where it crosses the line between ranges seventeen and eighteen, the valley is seventy feet deep, the banks are composed of light gray unstratified boulder-clay, and the bed of the stream consists of rounded pebbles of limestone, &c., with a few rounded fragments of rather hard light gray clay shale. Beyond, the hills rise both to the east and to the west to a height of about 700 feet. In most cases these hills are thickly wooded with spruce and poplar, but there are a few steep, naked banks, apparently of the light gray clay shale, that everywhere constitutes the topmost Cretaceous beds on this mountain. It was to the top of the hill west of this valley that Prof. H. Y. Hind climbed in his trip from Dauphin Lake to Riding Mountains in October, 1858.

High hills.

Following the river downwards from the crossing of the above line, which is at an elevation of 1,250 feet above the sea, the bed of the stream soon becomes very much obstructed by large boulders of gneiss and limestone, many of the latter of which are striated. In the bank, croppings of dark gray soft clay shale begin to make their appearance from under the overlying till, and soon become conspicuous in all the scarped banks at the convex bends of the stream. A mile south of the Correction Line a bore-hole was sunk to a depth of 150 feet. The rock is a soft, unctuous dark clay shale, showing in many places an efflorescence of sulphate of iron, and often containing between its layers thin sheets of small crystal aggregates of selenite. A hard band of limestone runs along close to the edge of the water. Mr. A. McDonald, who sank the above mentioned bore-hole, informed me that with the exception of a 2-inch seam of coal, which was passed through at a depth of forty-four feet, the whole 150 feet was sunk in dark gray clay shale similar to that seen at the surface.

Pierre shales.

Bore hole.

For two miles and a half below this point, or for one mile and a half below the seventh Correction Line, similar shale is seen in the banks of the river. Close to the crossing of the Correction Line a ridge crosses the river, which in ascending section shows twenty-five feet of dark gray clay shale overlaid by fifteen feet of rounded pebbles and boulders bedded in a sandy matrix. The ridge is 450 feet wide, slightly rounded on top, and rises sharply for forty feet from low land of about the same height on both sides. The course of the ridge is N. 88° E. It is thickly overgrown with poplar mixed with some oak, maple (*A. spicatum*) and elm, while birch, ash-leaved maple and spruce are growing on the adjoining low lands. Beneath this heavier timber there is a thick growth of Amelanchier and Pembina bushes. There are other ridges both above and below this one, on one of the former of which is an Indian trail leading to the south, but this one is the most clearly defined of any that cross this river.

High gravel ridge.

Just above this ridge a number of fossils were collected from the dark shale and an included band of limestone, consisting of *foraminifera*, oysters, Inocerami and fragments of plates of fishes. Fossils.

For a mile and a half below this ridge similar soft dark clay shale crops out at intervals, including in one place a bed of hard sandstone holding numerous remains of small oysters.

The whole of the Cretaceous beds seen on this river appear to be lying almost or quite horizontal, the total thickness seen from the first outcrop below the line between ranges 17 and 18 down to the last outcrop seen on the river being about 175 feet. Cretaceous beds.

Before reaching the above-mentioned lowest outcrop of dark shales, the hills on either side have fallen away, and the river has left the Riding Mountain and now flows across the lacustrine plain at its foot towards Dauphin Lake. Its channel becomes ten to forty feet deep, forty feet wide and very crooked, the wide gravel flats and bars seen higher up the stream having here almost entirely disappeared. The banks show neither the underlying shale, nor till, but are composed entirely of stratified clay often mixed with a considerable quantity of sand. Winding channel

The channel is usually skirted with a dense belt of trees, such as cottonwood, balsam-poplar, elm, &c., behind which are many beautiful meadows sprinkled over and separated by groves of aspen and willow.

Edwards's Creek rises in the Riding Mountain a short distance south of the 7th Correction Line, and flowing parallel with the last-named stream, joins the Vermilion River a few miles above its mouth. Edwards's Creek.

At the crossing of the Correction Line the valley is only forty feet deep, and the bed is at an elevation of 1,820 feet above tide. The valley, however, rapidly deepens, soon becoming a narrow gorge 160 feet deep with very precipitous scarped banks of horizontal light gray shale, often appearing red from iron stains. Deep gorge.

Three-quarters of a mile below the Correction Line and just below the entrance of a small stream of slightly greater size from the east, there is a steep bank on the east side showing an exposure 160 feet in height. The upper thirty feet consists of sandy boulder clay or till containing small pebbles, most of which are of limestone, but some are of granite. Below this is 130 feet of slaty light gray clay shale, much jointed and generally showing iron stains on the jointage faces. A quarter of a mile down the stream, but at thirty-five feet lower level, and at an elevation of 1,720 feet, this light lead-grey slaty shale is seen to be underlaid perfectly evenly and conformably by fifteen feet of dark grey Millwood shale. The difference between the two shales is quite clearly marked, especially as the lower shale weathers out into irregular High cliff of Odanah shale.

rhombic particles, while the upper weathers into thin flakes. For a mile and a half below this the banks of the valley consist largely of irregular slides of the overlying slaty shale, but in several places near the river a soft dark gray clay shale was seen, crumbling into clay, precisely like the Pierre shales of the Bow River and Upper Saskatchewan. Near the lower end of the above distance this shale includes a band of lenticular nodules of clay ironstone. This is at an elevation of 1,500 feet above the sea.

Boulders. For the next three miles down the river, or to the mouth of a small spring brook coming from the east, no exposures of the Cretaceous rocks were seen. The channel is at first very much blocked by Archæan boulders, and fragments of ironstone as large as cobble-stones are quite numerous, but soon the boulders disappear and the bed of the stream Odanah shale. is composed of pebbles of Odanah shale, with some of quartzite and gneiss and a few of ironstone. The banks, too, are at first composed largely of pebbles of light gray slaty shale, but this soon changes to stratified sand overlying unstratified till, and the stratified sand again to stratified clay.

Gravel ridge. Half a mile above the mouth of the spring brook a gravel ridge twenty-five feet high crosses the course of the stream, composed, to the bottom, of stratified sand and gravel. The gravel consists almost entirely of smooth lenticular pebbles of lead-grey clay shale, mixed with a few small pieces of ironstone, and pebbles of quartz and gneiss as large as marbles.

Niobrara shale. At the mouth of the spring brook, at an elevation of 1,271 feet above tide, a dark gray clay shale, mottled with small particles of calcareous material, makes its appearance, and the valley becomes rapidly deeper and the bed of the stream is filled with large gneissoid boulders.

Three-quarters of a mile below the mouth of the creek a bed of rather hard, gray, argillaceous limestone, containing Inocerami, crops out four feet above the bed of the creek, overlaid by fifteen feet of dark gray mottled clay shale, and this is again overlaid by a bed of unstratified till holding large gneissoid boulders. Three-quarters of a mile further down, where the river crosses the southern line of township 24, the valley is fifty feet deep, the lower thirty-five feet of the bank consisting of dark gray mottled clay shale, the top of which consists of a bed one to two feet in thickness of white or light yellow chalky limestone, containing numerous fragments of Inocerami and scales of fishes similar to those Foraminifera. found on Ochre River, as well as numbers of foraminifera belonging to the genera *Textularia*, *Rotalia*, *&c.* This is the same band as the one mentioned in the last exposure, but it has become less argillaceous and much softer and more chalky, When struck, it emits a slight odour of petroleum.

It is directly overlaid by eight feet of rounded gravel, mostly of limestone and shale, but mixed with pebbles of quartzite and gneiss. This gravel is moderately fine throughout, but much the finest near the surface. Ascending the bank, this escarpment is seen to be the section of a gravel ridge extending across the country parallel to the face of the mountain and rising in easily rounded slopes ten feet above the country on either side. On going a little further north a steep slope is encountered, descending abruptly for fifty feet, and the above ridge runs parallel with this slope and about 300 yards back from its brow.

From the foot of this slope the country descends gently to Lake Dauphin, being either open meadow land, scattered poplar coppice, or swamp.

Vermilion River rises near the summit of Riding Mountain in several small streams which flow together either in, or near, the foot of the mountain. The branch followed rises a short distance north of Lake Audet and flows northward for ten miles till it is joined by a similar stream from the west, and throughout this distance the waggon trail to the Lake Dauphin settlement follows its eastern side, at first through groves of poplar separated by prairie openings, and then through thick though not very heavy timber, consisting of aspen and balsam poplar, with some spruce, tamarack and small birch. Five miles south of the fifth Correction Line a small stream joins the Vermilion River from the east, flowing in a narrow gorge-like valley. At the point where the trail crosses this valley it is ninety feet deep, and the elevation of the bed of the stream is 1,750 feet above tide. Just above the crossing there are several small crumbling exposures of light lead-gray fissile Odanah shale, similar to the upper beds on Edwards's Creek; and two miles farther down the main stream, similar shale again crops out. At the trail crossing, a short distance above the forks, the stream is twelve feet wide, and when crossed in July, 1887, was six inches deep, with banks consisting of pebbles of gneiss and limestone.

Vermilion River.

Odanah shale.

Two miles and a half below the forks, on the south side of the river, there is a cut bank ninety feet high, consisting at the top of twenty feet of dark gray friable clay shale holding bands of nodules of white or light gray limestone very much veined with calcite, and weathering down into a white powder, while below it, is seventy feet of dark slate-gray clay shale, emitting, when struck, a strongly bituminous odour. At the bottom, these beds contain numerous acicular crystals of selenite. A mile below this point the trail crosses the river at an altitude of 1,310 feet; 300 yards above the crossing is a high cut bank of horizontal slate-gray clay shale, mostly very friable and holding many small crystals of selenite. In the bank were some thin bands of ironstone and large

High cut banks.

Trail crossing.

Fossils.

nodules coated with a layer of calcite, which has the appearance of being the partly decomposed shell of Inoceramus. A fragment of a Baculite was also found. About a mile south of the crossing, a high hill rises 325 feet above the level of the river at this point, or to a height of 1,635 feet above the sea. On the top of it may be seen small irregular outcrops of soft crumbling light gray shale, with bands of nodular clay ironstone a short distance below the summit. Fifty feet below the summit a considerable thickness of this shale is exposed lying quite horizontally.

At the crossing several low outcrops of shale are exposed close above the edge of the water. It is here very tenacious, has a greasy feel, cuts like cheese, and emits a strong bituminous odour.

Boring on Vermilion River.

A well was bored near this point by the Manitoba Oil Company to a depth of 743 feet, in the hope of obtaining petroleum. The following is the report of this well as published by the writer in the Trans. Roy. Soc. Can., Vol. ix., Sec. iv., pp. 102–104.

"*Boring on Vermilion River.*

Position.

This boring was sunk by the Manitoba Oil Company on the west bank of the Vermilion River, a short distance below the crossing of the Strathclair and Lake Dauphin trail, in Township 23, Range 20, west of the Principal Meridian.

Date.

In the spring of 1887 a percussion drill was hauled north from Strathclair station, on the Manitoba and North-western Railway, and the well was drilled to a depth of 292 feet, when an accident happened to the machinery which delayed the work for a time.

In the following year the drill was moved a short distance down the valley, work was resumed, and a final depth of 743 feet was reached.

From a comparison of the sections, the second well is found to have been begun nine feet lower, geologically, than the first, and therefore the levels of all the specimens obtained from it have been corrected by the uniform subtraction of nine feet, in order to give them their proper position in the total section.

For the log of this well, with illustrative specimens, I am indebted to the kindness of W. R. Baker, Esq., Superintendent of the Manitoba and North-western Railway, who was one of those most deeply interested in the success of the well.

The record as given below is compiled from the log kept by the driller and the results of my examination of the specimens.

HEIGHT OF SURFACE AT BORING ABOVE SEA, 1,300 FEET.

Synopsis of record.

Number.	Description of Material passed through.	Thickness of layer in feet.	Depth of bottom of layer from surface.	Height above sea.	Remarks.
1	Soft, dark gray clay shale.	95	95	1,205	Pierre (Millwood series).
2	Fragmental limestone	4	99	1,201	Niobrara.
3	Gray calcareous shale	124	223	1,077	Niobrara.
4	Dark gray fissile shale....	178	401	899	Benton.
5	Coarse sandstone, with pyrites....	19	420	880	Dakota.
6	Compact white limestone.	120	540	760	Devonian.
7	Blue-gray clay shale..... .. .	10	550	750	Devonian.
8	White gypsum.....	15	565	735	Devonian.
9	Red shale.....	110	675	625	Devonian.
10	Shale and limestone	68	743	557	Devonian.
11	Red shale..	At bottom.			Devonian.

Pierre shales.

No. 1.—Specimens from 30, 48 and 91 feet show this to be a soft, dark gray, non-calcareous clay shale belonging to the Millwood series of the Pierre shales, similar to that seen in the naked and almost vertical cliffs washed by the river a few hundred yards above the trail crossing.

Niobrara shales and limestones.

No. 2.—This is a hard band that was spoken of as "sandstone" by the driller. It consists almost entirely of fragments of the prisms of the shells of a large *Inoceramus*, mixed with fragments of *Ostrea congesta?* This evidently represents the band of sandstone-like limestone that outcrops on the Assiniboine River below the mouth of Cypress Creek, and is also seen at several places along the eastern face of the Riding Mountain. It lies at the top of the Niobrara formation.

No. 3.—Specimens collected from 146 and 164 feet show this to be a mottled, blue-grey, calcareous clay shale or marl. Under the microscope it is found to be mixed with prisms of the shells of *Inoceramus*, fragments of the shells of *Ostrea congesta?*, minute portions of fish skeletons and quite a large number of foraminifera. These comprise such forms as *Globigerina cretacea* and several species of *Textularia*, and with them are associated many *Coccoliths* and *Rhabdoliths*. These evidently represent the characteristic shales and marls of the Niobrara formation.

Benton shales.

No. 4.—Specimens obtained from 213–247 feet consist of a dark blue-gray, fine-grained, unctuous, non-calcareous clay shale, breaking down into thin flakes. These represent the typical Benton shales.

Dakota sandstone.

No. 5.—A specimen from 411 feet consists of grains, varying greatly in size, of clear, white quartz. Some of these grains are quite angular

in shape, and many are stained on the outside with iron. With the sand grains are mixed small cubical crystals of pyrite. In a paper published in "The American Journal of Science" for September, 1890, the writer gave the Dakota formation in this well a thickness of 55 feet, but he has since found reason to believe that a specimen of sandstone labelled 369 feet is not to be depended on, and the record has therefore been altered as above to agree with the log kept by the driller, thus reducing the thickness of the Dakota to 19 feet.

Devonian limestone.

No. 6.—A specimen from 509 feet is a moderately hard, fine and evenly-grained, light gray limestone, through which are scattered small subangular grains of colourless quartz and grains of pyrite. A specimen marked 510–540 feet consists of similar limestone, with fragments of light and dark gray clay shale.

Shale.

No. 7.—A specimen from the lower part of the band consists of a mixture of light blue-gray clay shale, particles of limestone, some few crystals of colourless quartz, and particles of opaque white gypsum from the top of the band below.

Gypsum.

No. 8.—A specimen marked 550–565 feet is made up largely of fragments of opaque white gypsum, mixed with a few fragments of colourless quartz, and small nodular masses of pyrite.

Shale.

No. 9.—A specimen marked 565–645 feet consists of a soft, light brownish-red, fine-grained shale, mixed with fragments of light gray shale and particles of limestone. In the clayey mass are also many minute and very perfect crystals, as well as irregular particles of clear transparent quartz.

Shale and limestone.

No. 10.—A specimen from 718 feet consists of a light pink, hard, compact, fine-grained limestone that effervesces strongly in HCl., leaving a similarly coloured fine clayey precipitate. With the limestone are many fragments of a fine-grained, white sandstone, and a very few white, opaque particles of gypsum. A specimen from 740 feet is a mixture of fragments of cream-coloured limestone and reddish shale. It effervesces strongly in HCl., leaving a residue of dark gray and buff-coloured shale, fine grains of quartz and small particles of pyrite.

Absence of fossils.

No fossils have been obtained from the Palæozoic rocks drilled through in this well, and in the absence of direct stratigraphical correlation their exact age cannot at present be determined. However, their geographical position clearly shows that they are of post-Silurian age, and the absence of dolomites excludes them from the middle or Winnipegosan formation of the Devonian. It is also altogether unlikely that fossils would have been so uniformly absent from the drillings if some of the lower highly fossiliferous beds of the Manitoban, or Upper Devonian formation had been passed through. Many of the

limestone fragments from near the bottom of the bore correspond closely with the limestone outcropping near the mouth of Mossy River, at Point Wilkins, etc., belonging to the higher portions of the Manitoban formation exposed in natural sections, and the known south-westerly dip of a few feet to the mile would account for the difference in elevation of the beds.

Upper Devonian.

It is therefore probable that the Palæozoic beds passed through in the Vermilion River boring represent an upward continuation of the Point Wilkins limestones, and therefore in the main, overlie the highest Devonian beds seen on the shores of Swan Lake or Lake Winnipegosis."

Vermilion River below the trail.

Following the valley of the river for three miles below the trail crossing, the banks are high, and generally consist of soft dark gray Cretaceous shale, though in places unstratified till composes the greater part, or even the whole, of the cliff. At one of the latter places the scarped bank consisted of forty feet of light yellowish-gray till, in the top of which was imbedded a layer of large transported boulders, overlaid by twelve feet of yellowish-gray stratified sandy clay without boulders. At the end of the three miles, and at an elevation eighty feet lower than the river at the crossing, the bank is composed of similar dark gray soft shale, while at the edge of the water a bed four feet in thickness of hard sandy limestone crops out, holding remains of oysters and Inocerami. As the river is followed down still further this limestone band gradually ascends in the banks, till at the end of a mile it is seventy-five feet up the bank, and is underlaid by mottled gray shale through which are scattered fragments of Inocerami and remains of fishes. In Four Mile Creek, which is a small stream flowing in from the east half a mile below the last mentioned exposure, this hard band is seen ninety feet above the level of the river at its mouth. Fifty feet below this band of hard limestone there is a band of rather hard light grey shale, and as the river is descended this band becomes better defined, till at the outer, steep slope of the mountain it is a band of rather hard white limestone crossing the face of the escarpment at a height of ninety feet above the river. This band of white limestone contains many Foraminifera of the genus *Textularia* with great numbers of *Coccoliths*. For one-third of a mile below the edge of the escarpment similar mottled shale crops out, but the banks have now become low and often swampy. At this point Mr. Arch. McDonald sank a bore-hole 120 feet, and found similar shale to the bottom, and the same man informed me that similar shale crops out in low exposures for a mile further down the creek, beyond which nothing is seen but drift and alluvium. Three miles further down, where the river was again seen, the banks consist for several miles entirely of bedded clay. The

Limestone.

Bore hole.

river flows in a narrow winding channel, has a muddy bed, often scattered with pebbles, and belts of timber skirt its sides, beyond which the country is generally open, grassy meadow land.

Wilson River. Wilson River rises on the north-east side of the Riding Mountains and flowing eastward, falls into Dauphin Lake a short distance north of the mouth of Vermilion River. Where first seen in township 25, range 22, the banks are twenty feet high, with steep grassy slopes to the edge of the water. The elevation at this point is 1,300 feet above the sea. Following the stream eastward the valley gradually deepens till the banks are about 100 feet high, and then it again becomes shallow and like the other rivers in the district flows in a winding channel through almost level partly wooded country to its mouth.

Banks of till. At the point where the river was first seen and for three miles and a half below it, the banks consist of light gray sandy unstratified clay containing numbers of irregular pebbles and boulders, but about the centre of the distance a low ridge of rounded gravel, with an elevation of 1,288 feet above the sea, crosses the valley, running in a N. N. W. and S. S. E. direction. This ridge was the highest ancient lake beach observed on this river, and west of it the country gradually rises in the low gently rounded swells and undulations typical of the western plains.

Niobrara shale. At the lower end of the portion of the valley above mentioned, and at an approximate elevation of 1,190 feet above the sea, a light gray mottled calcareous shale of Niobrara age outcrops on the side of the bank ten feet above the river, and ten feet above it is a band of cream-coloured marl containing fragments of such fossils as *Ostrea*, sp., *Inoceramus problematicus*, an obscure fragment of an Ammonite, and great numbers of foraminifera belonging to the genera *Globigerina* and *Textularia*. The beds have a light dip S. 60° W.

Descending the river, for the next three miles the banks vary considerably in character, but everywhere the bottom is found to be composed of clay shale, sometimes very much darker than that first seen, and often containing interstratified beds of soft white unctuous clay. The beds are throughout horizontal and often contain fragments of oysters, Inocerami and scales of fishes. The exposures of shale are in some places fifty feet high and are generally overlaid by a light yellowish-gray compact till, often, especially towards the bottom, containing a great number of large boulders of gneiss and limestone

Gravel ridge. At the point which has now been reached, a strongly marked ridge of rounded gravel having an elevation of 1,150 feet, crosses the country in a general direction parallel to the one already passed higher up the river. This ridge is devoid of timber and thinly grassed on top

and on it the Indians have one of their main trails into the country to the north. After cutting through it the river takes a course a little south of east and flows in a thickly wooded valley, with high banks that often show good exposures of horizontal mottled gray calcareous clay shale. Two miles east of this ridge is a cut-bank showing a very good section of fifty feet of this shale, in which, fifteen feet from the bottom, is a bed of what appears on first sight to be a light brown lamellar sandstone, but which, on closer examination, is found to be composed of minute dark brown fragments of teeth and bones of fishes, cemented together by a calcareous cement. This shale is highly phosphatic. A specimen of it was analysed by Mr. Hoffmann of this Department, and he reports that it contains 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. The extent of this phosphate bed could not be determined at the time, but if it should prove to be large, it will furnish a very valuable source of supply of phosphate of lime to renovate the wheat lands of Manitoba and the adjoining Territories. In many of its characters it approaches closely to the coprolite beds which are so extensively worked for phosphate of lime both in France and England.

Phosphatic shale.

For a mile below this outcrop of phosphatic shale, small naked scarps of dark gray shale occasionally overlook the river, and then the valley becomes more diffuse, and appears to assume the characters of the Vermilion and Ochre river valleys in the lower parts of their courses, with banks composed entirely of stratified alluvial sand and clay.

Valley River is stated to rise in Singoosh or Weasel Lake in the north-eastern portion of the Duck Mountains. It flows first south-westward and then southward over a drift covered region, till it emerges in the wide valley north of the Riding Mountain. It is here a beautiful clear stream thirty feet wide and two feet deep, flowing over a bed of rounded limestone pebbles. The valley which it has entered is more or less open and grassy throughout, though, of course, dotted with groves of poplar and willow, and there is here a pleasant looking little Indian village, consisting of several well-built log houses, with good, though diminutive, stables, around which a small amount of land has been tilled, and a considerable quantity of hay is annually cut. The large number of new graves on the tops of the surrounding knolls testified to the fearfully high mortality rate prevailing among these people, who are gradually diminishing in numbers, not because a sufficient number are not born into the world, but because all the ordinary laws of hygiene are so entirely neglected that only a few of the very hardiest ever reach maturity.

Valley River.

Indian village.

From the Indian village the river flows eastward for ten miles. For the first mile the valley is generally open, with a gently rolling surface.

Morainic ridge.

For the next two miles the cart trail on the north side of the river winds over and among morainic hills, which appear to extend across the valley and along the face of the escarpment on either side. The hills are in the shape of rounded knolls, which may be joined together in irregular ridges, often one hundred feet high, among which are numerous little rounded freshwater ponds, without apparent outlet. The sides of these hills are covered with large gneissoid boulders and small pebbles of quartz, gneiss and limestone of very irregular shapes. Some of the latter are striated, though all are very much covered with calcareous tufa. But one geological section was seen in these hills, and it consisted of twenty feet of light brown slightly sandy calcareous clay, containing a few pebbles and small boulders. One of the latter was a lenticular nodule of ironstone, evidently derived from the Cretaceous rocks. The clay was quite unstratified and a large number of the pebbles were of limestone, almost all of which showed glacial striæ.

Near the eastern side of this hummocky ridge, a small stream flows from the north, and its bed is covered with large irregular boulders of gneiss. The altitude of the mouth of this stream, where it flows into Valley River, is about 1,362 feet.

For a mile and three-quarters below the mouth of this creek the bottom and sides of the valley are much more even, but a great many large gneissoid boulders are scattered over the flats on each side of the stream.

Kames.

Below this boulder-strewn portion of the valley, the banks diverge to a certain extent and a kame-like ridge, or series of ridges, begins and continues eastward for four miles down the middle of the valley. These ridges have a generally oval contour, with sides rising in rather steep slopes from the bottom of the valley. Their tops vary from slightly undulating, to quite rough and hummocky, and are generally more or less thickly strewn with gneissoid erratics. The most westerly of these kames is three-quarters of a mile in length and 250 paces wide on top. On its south side, where the river impinges against it, there is a naked bank showing an exposure forty feet in height, though on account of slides it was impossible to measure the different beds of which it was composed. At the top the exposure consists of rounded and water-worn pebbles and boulders of limestone, gneiss, &c. The pebbles are separated out and arranged in horizontal layers. The lower part of the bank consists of sand without pebbles.

Below these kames the river turns and flows for ten miles in a general north-easterly direction. The valley which had become very much

diffused, again becomes well defined and rather narrow. The banks are sloping and either grassy or covered with small aspens, and the soil of the valley and the surrounding country is occasionally sandy, but is usually a fine clay formed from the weathering of a fine light gray or white silt that overlies the boulder clay. Sloping banks.

Very few exposures of the underlying beds were seen, and these consist almost entirely of light gray unstratified till, containing numerous striated pebbles and boulders of limestone, &c. In some places the irregular surface of the till is overlaid by from two to three feet of fine grained yellow or gray silt with a well defined stratification, which follows closely the surface irregularities of the till.

At the end of this stretch the banks of the valley are thirty feet high, and the river is flowing over a bed of pebbles many of which are distinctly striated. Here the river takes a great sweep to the south, while the trail turns to the east and, after crossing a level plain for five miles, comes to its north bank again where another trail crosses it and running south-eastward to the Riding Mountain joins the Vermilion River trail near the forks of the latter stream. The valley of Valley River is here half a mile wide, eighty feet deep, and the stream flows over a bed of rounded water-worn pebbles and boulders. The north side is very uneven and probably much slidden, but on the south side there is a bottom land consisting of stratified sand and gravel fifteen feet above the water, fifteen feet above which is a well-defined terrace of similar deposits, beyond which the bank rises to the general level, at an elevation of 1,270 feet above the sea. Vermilion River trail. Valley terraces.

From this point the river flows in a general north-easterly direction for ten miles. For the first four miles the valley is very rough and uneven and the trail keeps some distance back from it on a slightly undulating, gravelly or sandy plain, thinly covered with a sparse growth of short grass, on which are standing here and there a few stunted oaks, while to the north are seen numerous groves of small aspen. This sandy plain is an ancient delta deposit formed by the stream that here flowed into the western side of Lake Agassiz, when this large post-glacial lake stood at one of its highest stages. A quarter of a mile before the trail again touches the bank of the river a low ridge of rounded gravel is crossed, the most westerly ridge seen on this river, having an elevation above the sea of 1,290 feet. The trail reaches the bank of the river on another of these ridges of rounded gravel, its even grassy surface having been a favourite camping ground for the Indians hunting through the district. The top of this ridge, which is seventy feet above the river, is seen to be composed of stratified sand and gravel, but most of the lower portion of the face of the bank Ancient delta. Gravel ridge.

is covered with slides, so that very little of the underlying rock is seen. What is exposed, however, is a mottled gray Niobrara shale with bands of almost white chalk marl, holding fragments of *Inoceramus problematicus* and many foraminifera of the genera *Globigerina*, *Textularia*, &c. Near the foot of the bank is a spring of clear cold water tasting and smelling very strongly of sulphuretted hydrogen.

A mile and a quarter below this ridge, a small stream joins Valley River from the north, and at its mouth is an excellent exposure of six feet of horizontal, gray, mottled clay shale holding a broad form of *Inoceramus problematicus*. Below the mouth of this creek the banks again become largely composed of boulder-clay, and the underlying shale was not seen for a distance of three miles and a half, when a dark gray clay shale was seen in an exposure extending sixteen feet above the river. The boulder-clay or till which overlies this shale and forms the banks for most of the remaining distance, is, as usual, a light gray unstratified sandy clay containing numerous pebbles and boulders, most of the limestone ones of which show distinct glacial striæ. Two very distinct gravel ridges cross the river in this distance. One of them, two miles and a quarter below the mouth of the small creek, was very carefully examined. It is the same ridge that was noted as being the largest ridge on the Wilson River, and on it the Indians have their main pitching track towards the north along the eastern face of the Duck Mountains. The ridge is here being rapidly cut away by the stream, and the following descending section is distinctly shown :—

Section of post-tertiary deposits.

	ft.	in.
Sandy and pebbly loam	2	3
Well stratified gravel in a matrix of light yellow quartz sand. The pebbles are mostly limestone, though some are of granite, and are rounded or slightly lenticular in shape. The gravel is beautifully interstratified with beds of sand, and is arranged in finer and coarser layers, the pebbles increasing in size, from above, downwards	8	0
Gravel, similar in character, but not so well rounded, a few of the limestone pebbles showing glacial striæ.	1	6
Fine yellowish quartz sand very irregularly interstratified with coarse sand, gravel and plastic clay	1	9
Very coarse sand or fine gravel		7
Plastic yellow clay	1	6
Unstratified light gray sandy clay or till holding polished and striated pebbles and boulders of gneiss, limestone, &c	35	0

The line between the last two is very indistinct. In this section just at the top of the bed of fine rounded gravel a number of sharp-angled and apparently chipped fragments of quartzite were found. Two of them were roughly in the shape of arrow heads, and one was a very thin flake. The others were very irregular. Associated with them was a broken fragment of one of the toe bones of a moose or elk. These irregular fragments were all lying with their longer axes horizontal, and were overlaid by a sandy loam, which had apparently been deposited as a coarse sand, and which has since been affected by weathering and by the growth of vegetation over it to about the depth at which these "chipped flint" are lying. This slightly loamy sand is plainly though not very clearly stratified and includes towards the bottom, and above the "chipped flints" many thin water-worn lenticular pebbles of shaly or thin bedded limestone. Chipped pieces of quartzite.

A mile north-east of this ridge, another ridge runs away to the north-west, and for a mile below it the banks of the river show dark gray unctuous clay shale to a height of from fifteen to twenty-five feet. At the end of this mile the banks become low and sloping for a mile at least, and a man who was with me stated that he had been down the river for four miles further and the banks continued of the same character throughout. Wherever seen the unctuous Cretaceous shale contained some fragments of the shells of Inocerami.

Where the banks fall away another gravel ridge crosses the country, and is said to continue towards the north-west, though it was impossible to follow it rapidly through the thick woods. Low country.

The ridge west of it, with an elevation of 1,084 feet, was, however, followed for a long distance. Its surface is underlaid by fine gravel, and is generally even and lightly covered with short grass, forming a grassy plain from 100 to 200 paces wide. Pitching ridge.

On either side is a fringe of stunted oaks beyond which the ground is very swampy and is thickly wooded with poplar and spruce. The ridge is quite level, resembling a beautiful gravel road running between long rows of trees. For five miles it runs N. 20° W., maintaining the same open, avenue-like character. At the end of this distance it is cut across by Drifting River, a small stream flowing south-eastward to join the Valley River. Its valley is here forty feet deep and a quarter of a mile wide, and is very thickly wooded with maple and willow. Beyond this break of a quarter of a mile the ridge is again encountered, but for a mile and a half it is very irregular, being in some places almost cut away by Drifting River, which here flows southward along its western side. Beyond the point where the creek first strikes the ridge it is again beautifully rounded with a width of 150 feet and rises about ten feet Drifting River.

above the level of the surrounding country. Three-quarters of a mile from the creek the cart-trail to Pine Creek joins this ridge, coming from the one to the west of it, and the ridge then continues for thirteen miles almost due north to Fork River, being in this distance broken through by two small streams flowing eastward, the beds of which are covered with pebbles and gneissoid boulders, but neither of them show any indications of shale or rocks of local origin. Throughout the southern part of the distance the ridge was lightly wooded with poplar, after which it is thickly wooded with heavy poplar, and long marshes or shallow lakes extend along its western side. Around these there is some good white spruce, most of which have lately been burnt. At the end of this distance, Fork River, a small stream ten feet wide and two feet deep, cuts across the ridge from the west. On the west side of the ridge and south of the river a beautiful wide grassy meadow stretches for several miles to the south, on the north end of which, close to the stream, is an old Indian shanty.

Pine Creek trail.

Fork River.

For the next eight miles the summit of the ridge was not followed, but for the most part, if not for the whole distance, it could be clearly seen from the cart trail to the west. In north latitude 51° 38′ 15″ the cart trail comes again to the ridge and after following it northward enters a grove of large spruce, in which it crosses South Pine Creek, here twenty-five feet wide. Beyond this stream the ridge is found to present a beautiful open, though narrow stretch, a mile in length with the river flowing southward along its western side and a spruce forest to the east, until a small Indian village is reached. Here a band of Indians from Pine Creek Reserve pass the winter in small but substantial log houses. They obtain an abundant livelihood by hunting and trapping in the immediate vicinity. Moose, bear, otter beaver, marten, fisher, fox and skunk are the principal game.

Indian village

From this village a cart trail thirty miles in length strikes off to the Hudson's Bay Company's post and Indian Reserve, near the mouth of Pine Creek. This trail is described on a succeeding page.

From the Indian village on South Pine Creek the ridge continues in a direction N. 25° W., being generally low but moderately well defined. It is wooded with small aspen, among which are scattered a few stunted oaks. To the west, a meadow, a quarter of a mile wide, follows the ridge for several miles, while to the east is a thick growth of small spruce. Five miles north of the village the ridge is cut across by Little Pine Creek (*Minégo Sipi Wanichan-sin*, The Child of Pine Creek), a small stream twelve feet wide flowing over a bed of pebbles and boulders. It is said to flow into North Pine River. Two miles and a quarter further north another small tributary of North Pine Creek,

Ridge becomes wooded

about six feet wide, crosses the ridge. Between these two creeks the ridge is twice broken through, first by a narrow gully that possibly at one time was the channel of Little Pine Creek, and secondly by a wide shallow depression.

North of this small tributary the low gravel or sand ridge was followed for three miles and then for one mile was lost in a heavy spruce and poplar forest south of North Pine Creek. North of North Pine Creek it was further followed as a low but still distinct ridge for three miles, until an accumulation of heavy timber and windfall made it necessary to leave it, and to strike westward across a tamarack swamp to an almost vertical escarpment sixty feet in height, along the foot of which is a line of rounded cobbles, apparently on the level of the next higher Lake Agassiz beach. The total distance through which this gravel ridge has been practically continuously traced northward from Wilson River is fifty miles. Time would not permit of levelling it instrumentally, but a careful series of barometric readings seem to show that it is about a hundred feet higher at the northern than it is at the southern end, having a rise northward of about two feet to the mile. This agrees closely with the observations already made on these beaches in Southern Manitoba and the adjoining States.

Ridge obscured.

A typical example of the country west of Lake Winnipegosis may be seen along the cart trail from the ridge just north of South Duck River to the Hudson's Bay Company's trading post, near the mouth of Pine Creek. East of the Indian village the trail runs eastward for four miles and a half, through country wooded with small spruce and poplar, across tamarack swamps, and little sandy plains sparsely wooded with Banksian pine, to a rounded ridge of sand, twelve feet in height, through which South Pine Creek flows in a comparatively shallow channel. This sand ridge has an elevation, as determined by the barometer, of 1,047 feet. The trail follows it in a N.N.W. direction for a mile, and then leaves it and turns north-eastward for two miles across a willowy or grassy plain, often underlaid by sand, to another ridge about thirty feet below the last, composed of sand and small gravel. It also has an elevation of about twelve feet above the surrounding country, an average width of 150 feet, and is lightly wooded with small poplar and large Banksian pine.

Pine Creek trail.

South Pine Creek.

The trail continues northward on this ridge for a mile, and then turns north-eastward, and, after crossing a level tract of country, ascends the point of a sandy ridge with about the same elevation as the one just left. This ridge is also followed by the trail for a couple of miles, in which distance it is interrupted in places, and generally has an extensive sandy plain stretching away to the north-west of it. In

places it is lightly wooded with Banksian pine, poplar, and a few small oaks.

Ford.

Two miles and a half from the north-eastern end of the ridge the trail crosses Pine Creek at a good ford, over rounded boulders and cobbles of gneiss and dolomite. From the crossing, north-eastward to the trading post, the trail is never at any great distance to the south-east of the river. For the first three miles it crosses an almost level plain, generally overgrown with willows, with here and there burnt stumps of spruce and poplar, and on which are tracts more or less thickly scattered with boulders. On this plain the old location of the Canadian Pacific Railway is crossed, and near it a well rounded gravel ridge, 200 feet wide and six feet above the surrounding country. The elevation of this ridge, as given by the Canadian Pacific Railway survey, is 960 feet above the sea. Thence the road passes over grassy plains and through poplar woods, in which a few boulders may occasionally be seen. A few low and intermittent sandy ridges, the heights of which were not determined, mark old shore lines of Lake Agassiz.

Old location C.P.R.

Upper pitching ridge.

Returning to Valley River a high, well-defined gravel ridge has already been recorded a mile to the west of the one followed, and about fifty feet above it. On this ridge the cart trail to Pine Creek, and the ancient hunting trail of the Indians to the eastern face of Duck Mountain, starts northward from Valley River. The ridge is also well defined southward to Wilson River, and is probably continuous with those most strongly marked near the face of the escarpment on Vermilion and Ochre rivers.

For four miles northward from Valley River it is gently and evenly rounded, rises twelve feet above the level of the surrounding country, and finally spreads into a gravel plain a quarter of a mile wide. South-

Small lake.

west of this plain is a small lake of beautifully clear water, to the east of which, extending across the gravel ridge, is a fine grove of oak. Very few boulders were seen on the ridge, but some were found near the border of the lake, chiefly of grey and reddish gneiss, but one was of dark green trap, and a few were of Palæozoic limestone.

After passing through the grove of oak the ridge is again seen stretching towards the north as a long line of grassy prairie through the centre of a forest of spruce and poplar. A mile and a half north of the lake Drifting Creek strikes the western side of the ridge and from there follows it for two miles, till at length it cuts through it in a valley twenty feet deep, but quite narrow. This stream is flowing over a bed of boulders and pebbles derived from the superficial deposits, and shows no signs of the underlying Cretaceous rocks.

Drifting Creek.

On the north side of Drifting Creek the ridge becomes wooded with poplar and the cart trail leaves it, and strikes eastward over a flat

marshy tract covered with dead poplar and willow until the ridge already described is reached, up which it turns as far as Fork Creek, when it again turns westward and after crossing Fork Creek reaches a ridge which is at the same elevation above the one we have last followed as the main ridge at Valley River, of which it is doubtless a continuation.

Fork Creek is a small stream ten feet wide and two feet deep at this point. It rises on the eastern face of the Duck Mountain, and flows eastward to join the Mossy River in the north-east corner of township 29, range 20 W. For much of its course it flows through a more or less low swampy country, and its water is consequently of a decidedly brownish colour. At the trail crossing, just below the upper of these two ridges, its bed is composed largely of limestone pebbles as well as boulders and pebbles of gneiss, but there are also many fragments of a rather hard grey clay shale. The upper course of the stream is entirely through drift deposits, but close to the last-mentioned gravel ridge horizontal dark grey clay shale, representing the summit of the Benton or the base of the Niobrara shales, is seen in several small exposures close to the edge of the water. Fork Creek. Cretaceous shale.

From the camping place on the Pitching Ridge, just north of this creek, and at an elevation of 1,180 feet above the sea, a pack trail turns off to the west. Where this trail crosses the creek a low sandy ridge, ten feet higher than the last, runs N.N.W., and a mile further along the trail, or two miles from the Pitching Ridge, a well-defined ridge of rounded water-worn gravel, with an elevation of 1,235 feet above the sea, rises six to eight feet above the level of the surrounding country. Its general bearing is N. 25° W. Two miles further along the trail, another ridge from 300 to 400 feet wide, ten feet high, and 1,287 feet above sea level runs off parallel to the last, and consists, like the others, of rounded gravel. Half a mile beyond this is another low ridge of rounded gravel, and three-quarters of a mile beyond it again is yet another similar ridge, with an elevation of 1,365 feet above the sea, well defined where there is low land behind it, but in other places it is less distinct where it is backed by low cliffs, that have formed the shore when the waters of Lake Agassiz stood at the height of this ridge. This is the highest level that the water appears to have reached. Higher ridge.

West of this highest ridge the country becomes more undulating, and the soil is a dark, sandy clay, covered with numerous pebbles and boulders, which are all more or less distinctly angular, and show no sign of having been rounded by water action. They are simply weathered out of the underlying boulder-clay which everywhere forms the surface. Undulating country.

Upper pitching ridge.

North of Fork Creek the Pitching Ridge is evenly rounded, and about twelve feet above the level of the surrounding country, consisting, on the top at least, of fine, rounded, water-worn gravel, with pebbles chiefly of limestone. A prairie area here has evidently been a favourite camping ground for the Indians. From here the ridge follows a general direction of N. 20° W. For three miles and a half it is open or lightly wooded with poplar, and carts were taken along it without much difficulty, but at the end of this distance it is cut across by a small tributary of Fork River, twelve feet wide and a foot deep, flowing in a rather shallow valley 700 feet wide, and thickly wooded with large spruce.

After crossing this creek the cart trail again turns to the north and leaving the ridge continues through a forest of large poplar and spruce to a long open meadow lying west of the lower ridge already described. This meadow in 1889 was moderately dry and covered with long grass, while a lake a mile and a quarter long extended through it, but in years of high water it is doubtless an impassable marsh. The trail follows the meadow in a N.N.W. direction for three miles, with a forest of small spruce and tamarack to the west, and then rises a few feet to the top of the lower ridge.

Travelling northward in 1887 the carts were left on the higher ridge south of the tributary of Fork River, and the course of the ridge was followed on horseback and with packhorses.

Ridge more sandy.

North of the creek the ridge becomes thickly wooded with heavy poplar and spruce, but still it is well defined though now often more sandy than was usual further south. To the west it is bordered by a grassy marsh, while towards the east lies an extensive spruce-covered swamp. The ridge here, and as far north as we followed it, maintains the direction N. 20° W.

South Pine River.

For five miles it continues to maintain much the character of that just described, when it is cut across by South Pine River, a stream of clear brownish-coloured water thirty feet wide and two feet deep with sandy banks covered with a deep coating of moss or sedge. Its bed is a coarse rounded limestone gravel, and there is no sign on it of any of the underlying Cretaceous shales or sandstones.

North of South Pine River the ridge for a mile is an open grassy prairie, beyond which it begins to be more and more thickly wooded, till six miles north of the above river the pack trail leaves it and turns on to the lower ridge. For the next three miles it was not followed, though it was often seen to the west of the trail, but it was again reached on the banks of North Pine River. It was followed north-north-westward for a mile and a half, when it became so covered

with a heavy windfall of burnt spruce and poplar that further travel along it was impossible. Its summit here has an approximate altitude of 1,250 feet above the sea.

When the trail leaves the lower ridge a short distance further north, it ascends the face of a steep escarpment sixty feet in height, which would appear to have been cut by the waves of Lake Agassiz when its waters formed the beach that we have last been following. The top of the hill is pretty thickly scattered with boulders, and the hill itself is probably a glacial accumulation of the character of a moraine or drumlin. Steep escarpment.

Throughout all the distance that this ridge was followed north of Fork Creek, it maintained much the same character, being from 150 to 250 feet wide, and six to eight feet above the level of the surrounding country, rising on both sides with an easily rounded slope, and almost level on the top. The top generally consists of sand or fine gravel, which becomes coarser at a depth of a few feet, as can be seen in places where trees have been blown down, and their out-torn roots have left deep holes in the otherwise level surface.

All these ridges are doubtless connected with some of those to be described further north, but the country is so densely wooded that it was impossible to follow them continuously.

From the trail on the Pitching Ridge another trail branches to the west up North Pine River, on which several high gravel ridges are crossed, and from which many good exposures of the underlying Cretaceous shales may be seen. As far as the writer's observation went, the lowest exposure of these shales on the river is on its north bank where it cuts through the Pitching Ridge last described. The following descending section is here shown:— North Pine River. Benton shale.

	ft.	in.
Horizontally stratified gravel, with pebbles of gneiss and limestone up to three inches in diameter.....	6	0
Light gray unstratified till, with irregular pebbles and a few boulders. The lower portion almost entirely local.....	10	0
Dark gray thin-bedded clay shale.....	4	0
Soft white clay, with sweetish taste.....	0	6
Dark gray thin-bedded clay shale, with many small crystals of selenite, to water.....	6	0

The clay and shale appear to represent beds about the summit of the Benton formation.

The trail runs along the top of the south bank of the valley, on gradually rising ground, through poplar woods. The valley gradually becomes deeper, and a quarter of a mile or more in width.

Niobrara shale.

About a mile up the valley from the Pitching Ridge the bank shows the following section :—

	ft.	in.
Light brown sand	5	0
Soft light gray mottled shale in thin beds, weathering into small flakes, and forming a steeply sloping cliff	15	0
Hard white clay	0	1
Light gray mottled chalk marl	5	0
Hard white clay	0	2
Soft light gray mottled chalk marl or marlite in beds ranging in thickness from three inches down to a thin shale, and weathering into a vertical cliff. It contains many shells of a large *Inoceramus*, *Ostrea congesta ?*, fragments of fish bones, and many foraminifera, among which *Globigerina Cretacea* is particularly abundant	5	0

These shales and chalk marls are typical of the Niobrara formation.

Half a mile further up the river, and just east of the trail crossing, a similar excellent exposure of foraminiferous Niobrara shale may also be seen.

Trail crossing

At the crossing the valley is seventy feet deep, with wide stretches of level bottom land, through which the river winds in a channel filled with boulders. West of it the trail continues along the north side of the valley for nearly five miles. For the first mile and a half it passes over a sandy tract, generally wooded with Banksian pine, on which three gravel ridges are crossed at respective elevations, as determined by aneroids, of 1,383, 1,402, and 1,439 feet above the sea. Opposite these the valley is 100 feet deep, and the banks are composed of till from which a large number of boulders are falling, while the bed of the river is filled with large boulders.

Delta plain

West of the highest of the three ridges just mentioned, the trail passes for a mile and a quarter across a wide plain, thickly wooded with small Banksian pine, and chiefly underlaid with brown sand and water-worn pebbles, some of which are as much as eight inches in diameter, though for the last quarter of a mile the soil is finer and more silty, and over the silt a few boulders are scattered. This sandy plain would appear to have been an old delta deposit formed by the prototype of North Pine Creek, when Lake Agassiz was at one of its highest stages. There is a rise of forty or fifty feet from its eastern to its western side. The river, opposite this latter point, flows in a valley fifty feet deep, ten feet of this being its immediate channel. Twenty feet above the river is a terrace stretching from bank to bank of the valley, underlaid by alluvial gravel consisting of pebbles and boulders up to a foot in diameter, of gneiss and Devonian limestone.

For the next two miles and a quarter the country is rolling or hilly, many of the hills being literally covered and probably largely composed of boulders, chiefly of gneiss. The whole tract is clearly morainic. Here the trail reaches the river which is twenty-five feet wide, and approximately 1,627 feet above the sea. Just above this point, and on the north side of the river is a bank, fourteen feet high, showing from top to bottom light slate-gray horizontally stratified clay shale, breaking down readily into small angular fragments. The beds clearly belong to the Pierre formation, and doubtless to its lower portion. Though no large and typical fossils were observed, the shale, under the microscope, was found to contain many radiolaria apparently similar to those found on Bell River, but generally so corroded that Dr. Rüst, who described those from the latter place, was unable to identify the species. Moraine. Pierre shales.

This exposure of Pierre shale is close to the foot of the main escarpment of Duck Mountain, where North Pine Creek emerges from it in the bottom of a wide sloping valley from 300 to 400 feet deep. Wherever any other scarped banks were seen on its sides, they appeared to consist of light gray till.

On the south side of the valley a long esker rises to a height of 150 feet above the bottom land, and a scarped bank on its southern side shows the following section :— Esker.

	ft.	in.
Light yellowish gray unstratified clayey till, containing many irregular striated pebbles of limestone and gneiss	6	0
Cut off obliquely by, and lying unconformably under the above is a light yellowish-gray, horizontally stratified, fine sand or silt, free from pebbles	3	6
Coarse red sand and small pebbles	0	4
Fine sand, slightly coarse at bottom	1	9
Stratified gravel, with pebbles up to four inches in diameter imbedded in a matrix of coarse sand. A number of the pebbles are of a light gray till, different, however, from that above	5	0
Horizontally stratified fine light brown sand	3	6
Very light gray slightly coarse sand	1	0
Covered	50	0
Dark gray, horizontally stratified, tenacious clay or clay shale	1	0

The summit of the mountain to the south, as well as its face, is strewn with boulders of Archæan gneiss, &c., and Devonian limestone.

Following the Indian hunting trail northward from North Pine River, a branch of South Duck River is crossed in north latitude 51° 52′. It is twenty feet wide and flows over a bed of gravel in a narrow South Duck River.

South Duck River.

valley through the ridge. The banks are composed at the bottom of twelve feet of light gray mottled Niobrara shale holding *Ostrea congesta*, above which are thirty-four feet of badly exposed interbedded layers of till and stratified sand and gravel.

A short distance north of this stream the trail reaches a well rounded gravel ridge, with an elevation of about 1,360 feet above the sea; and five miles north of the last mentioned stream it crosses the main branch of South Duck River which here flows in a valley seventy feet deep, with a channel thirty-five feet wide. From the top of the ridge a beautiful view can be had of the wooded face of the Duck Mountain, where a dark line of heavy spruce forms a rich background to the lighter green of the intermediate poplar forest, while the distant sky line rises and falls in easy undulations.

The almost vertical bank of the valley beneath shows the following section of Lake Agassiz deposits and Niobrara shales :—

	ft.	in.
Stratified light brown sand underlaid by gravel.....	22	0
Dark gray horizontal fissile mottled clay shale holding fragments of *Ostrea congesta?*, *Inoceramus* sp. ; and a few small species of foraminifera.....	14	0
Light gray mottled clay shale, the beds becoming thicker below.....	31	0

A mile further north, in a low exposure of similar shale on the banks of the same river, *Belemnitella Manitobensis* and *Loricula Canadensis* were also found.

Trail to Duck Mountain.

Between these two streams, at a small grove of oaks, a bridle trail turns off the ridge towards the west. For a mile and a quarter it runs through poplar forest, passing a beautiful grove of large elms, and then for three-quarters of a mile follows a gravel ridge with an elevation of about 1,400 feet above the sea. From this ridge it makes straight up the easy slope of the side of the mountain, through woods of poplar and spruce, and over hills often thickly strewn with boulders, to some small brooks flowing into North Pine River. Here the country becomes thickly wooded with small pine and tamarack, and the trail strikes across stony morainic hills to the head of Favell River.

Returning to the east side of the mountain, the main trail follows the ridge for two miles and a half north of the crossing of South Duck River, and then turns north-eastward and runs through a tamarack swamp, intersected by drier belts covered with poplar, and over land composed largely of sand and boulders, to the north point of an old sand spit or beach fifty feet in height. This beach stretches away to the south, and is generally composed of rounded gravel, though its surface

Sand spit.

is also thickly strewn with boulders. Its summit has an approximate elevation of 1,290 feet above the sea.

Along its eastern side, and fifty feet below it, runs another well defined ridge of rounded gravel, which continues northward to North Duck River, just north of which it is crossed by the old location of the Canadian Pacific Railway, at an elevation of 371 feet above Lake Winnipegosis, or 1,199 feet above the sea. Another similar ridge is also crossed by the old location survey, a short distance further east, at an elevation of 1,149 feet above the sea. North Duck River.

The North Duck River where crossed, close to the foot of the ridge, is thirty-six feet wide, and on the 10th of October, 1887, was six inches deep, with a bed of sand and pebbles. The banks were all of stratified gravel, and nothing was seen of the underlying Cretaceous beds.

Beyond North Duck River the ridge continues northward for about three miles, in which distance it is often scattered with many boulders of gneiss. At the end of this distance it turns to the west around the north-eastern angle of Duck Mountain, and runs up the valley of Swan River, but it was not definitely followed further.

SWAN RIVER AND TRIBUTARIES.

Swan River rises on the western side of the Porcupine Mountain and flows in a general south-easterly direction to the crossing of the Second Initial Meridian. A brief account of this portion of the stream is given by Prof. Macoun in the Rep. of Dept. of Interior, 1881, pt. I., pp. 81–85.

A short distance below the crossing of the Second Initial Meridian Snake Creek flows into Swan River from the south, in a deep wide glacial valley, which is a continuation northward of that followed by the Assiniboine below Fort Pelly. Snake Creek rises in a marsh north-west of Fort Pelly and close to the elbow of the Assiniboine River, and I am informed that in high water, when this river overflows its banks its waters run into Snake Creek and Swan River. Snake Creek.

On the east side of Snake Creek valley, just above its mouth, is an extensive triangle-shaped prairie, sloping from the higher land to the south-east to within about ninety feet of the level of Swan River. This prairie is irregularly undulating, in some places being almost level, in other places low rounded hummocks alternate with shallow depressions, but everywhere it is thickly covered with boulders of reddish and greenish gneiss from two to three feet in diameter. The valley of Prairie.

Snake Creek to the west of this prairie is about 1,500 feet wide and seventy-five feet deep, while towards the west its banks rise into a prominent spruce-covered ridge. Close to its mouth the valley is blocked by high rounded boulder-strewn morainic hills, through which the creek has again cut a narrow channel.

Police barracks.

On the northern side of the above prairie the Mounted Police had a large barrack which was burnt by a prairie fire in 1884. The place where the fort stood is now strewn over with charred wood, pieces of rusty iron, &c.

Half a mile south of the old fort, the telegraph line on the old location of the Canadian Pacific Railway crossed this prairie from east to west, and here the town of Livingstone was intended to have been laid out. The level of the bottom of Snake Creek valley, as laid down on the profile of the old location of the Canadian Pacific Railway, is 567 feet above Lake Winnipegosis, or 1,397 feet above the sea.

Swan River bore.

On the alluvial flats close to the banks of Swan River and a few paces east of the mouth of Snake Creek, Dr. Selwyn in 1874 and 1875 had a bore-hole sunk to the depth of 501 feet to ascertain quickly and certainly whether coal was to be found in any considerable quantities within working distance of the surface. The height of the surface here as compared with the nearest points on the old location was found to be about 1,360 feet above the sea.

"The specimens of the strata taken out are nearly all of dark blue, gray or black shale, and hold *Inoceramus*. At 259 feet a calcareous band, about nine feet thick, was passed through. This and the lowest twenty feet of shale, rather slaty, show organic remains, small spines and fish scales."*

The shale here passed through is probably the same as that seen lower down on Swan River, and belongs to the Niobrara formation of the Cretaceous.

Swan River.

Following the river downwards from the mouth of Snake Creek, Mr. Dowling saw some small exposures of dark gray clay shale, mixed with some thin bands of white unctuous clay; and on the bars in the river, at the crossing of the trail from Fort Pelly to Swan Lake, a large number of fragments of dark gray clay shale, mixed with clay ironstone, near which were found pieces of sandstone, holding *Ostrea congesta ?*. A short distance below the crossing, dark gray friable rather soft clay shale is sliding out of the bottom of the bank, mixed with some dark brown clay ironstone.

*Alfred R. C. Selwyn. Rep. of Prog, Geol. Survey, 1875-76, p. 292.

An alluvial flat occupies the bottom of the valley, which is here half a mile wide and 150 feet deep. Through the alluvial deposit the river has cut a winding channel that but seldom impinges on the sides of the valley, which are doubtless chiefly composed of Cretaceous rocks. Valley.

The sides of the valley are everywhere sloping and covered with small aspen. In many places the bottom is open and grassy, but the river channel is always fringed with willow and ash-leaved maple.

For eight miles from a point two miles below the crossing place, the river was not examined, but, where seen, three miles above the mouth of Bear's Head River, the valley was but thirty-five feet deep, and the immediate banks were low and thickly wooded. The river was 150 feet wide, with a bed of large boulders, over and through which the water was flowing.

Half a mile below Bear's Head River, the banks of Swan River are sixty feet high, and show at the bottom fifteen feet of horizontally bedded dark gray clay shale of the Niobrara formation, including harder calcareous bands, holding Inocerami, oysters and bones and scales of fishes. Nodules of iron pyrites are also falling from the face of the bank. Niobrara shale.

This shale is overlaid by three feet of light gray unstratified till, holding many polished and striated pebbles, on which is resting eight feet of coarse red stratified sand and gravel. Copious springs of water, highly charged with calcareous material, flow from this bed, and form a heavy tufaceous deposit on the face of the cliff. The sand is overlaid by several feet of light gray laminated clay. Till and sand.

Half a mile further down the river, where the bed of the stream has an elevation of about 1,240 feet above the sea, the bank is thirty-five feet high and its bottom is composed of dark gray clay shale, holding bands of soft limestone, in which were found fragments of *Inocerami*, *Ostrea congesta*, *Serpula semicoalita* and *Belemnitella Manitobensis*. This is overlaid by a coarse reddish stratified sand, which, within a short distance, is either quite loose, loosely cemented together by calcareous material into a soft friable sandstone, or bound together by calcareous or ferruginous cement into a hard sandstone, or conglomerate. It is quite evident that this is the same deposit as the sand overlying the till at the last named exposure. This sand is overlaid to the surface by twelve feet of more or less distinctly laminated light gray clay. Niobrara limestone.

North-west of this part of the river, and at a distance of about four miles from it, Thunder Hill rises as a high isolated prominence from the middle of the plain. Its height, as given on the plans of the old Thunder Hill.

Thunder Hill. location of the C. P. R., is 1,167 feet above Lake Winnipegosis, or 1,997 feet above the sea. The height as determined by two aneroids during 1887, was 1,848 feet, and allowing that there was some point a little higher than that reached, the highest point would not exceed 1,900 feet, which may therefore be taken as the true height of the hill. The following section was measured by Mr. Dowling, who collected specimens of the different beds. The rock was usually seen in small isolated exposures.

At the summit, at an altitude of 1,848 feet, were twelve feet of drift deposits, holding numerous small irregular pebbles. This would appear to be till.

Immediately below it lies a soft dark gray unctuous Cretaceous clay shale, holding a thin band of soft white clay, to a thickness of eleven feet at least, often stained with a yellow incrustation. At a height of 1,770 feet is an exposure of about thirty feet of a rather hard soapy shale.

Niobrara shale. At a height of 1,750 feet is the top of an exposure showing ten feet of light yellow clay shale, below which is fifty-five feet of a light gray chalky shale, descending about the middle into a chalk marl at 1,715 feet, and at the bottom showing a band of a hard gray limestone holding several fossils, viz., *Ostrea congesta*, *Inoceramus* sp. with very thick shell, *Inoceramus*, possibly a large form of *problematicus*, and *Cladocyclus occidentalis*. The chalk marl also contains several genera of foraminifera, viz., *Textularia*, *Discorbina* and *Globigerina*, with Coccoliths and Rhaboliths. Below this the face of the hill is covered with slides and the country slopes away to the level of the plain.

Extension of the terrane. The band of limestone or chalk marl, which is here seen at an elevation of 1,700 feet, is very similar to the Niobrara limestone on the Valley, Wilson and Vermilion rivers, ninety miles S. 35° E. from this exposure, where it has an approximate elevation of 1,200 feet. 105 miles further in the same direction, in section 36, township 8, range 11, and at an elevation of about 900 feet above the sea, a band of hard gray limestone, ten feet thick, outcrops on the banks of the Assiniboine. It is very similar to the lowest calcareous band on Thunder Hill, and contains precisely similar fossils. In all three localities the marl is overlaid by a dark gray clay shale, which in both of the southern exposures, at least, would appear to belong to the Pierre formation.

Thickness of the terrane. The greater height at which the chalk marl and limestone occur in Thunder Hill may be due to the light south-westerly dip of the strata, or it would appear more probably to be due

to a thickening of the underlying Cretaceous sandstones and shales, as all the information at hand goes to show that the underlying Palæozoic limestones are practically horizontal on their extreme western outcrop, from Mossy River to the east end of Red Deer Lake. If these limestones extend horizontally under the shales of the Duck and Riding Mountains, the Cretaceous beds lying below the layer of chalk marl would show a thickening of 500 feet on going north-westward from Vermilion River to Thunder Hill. If an even dip towards the south-west is assumed from the line of outcrop of the limestones, the evidence of thickening would be still stronger in favour of a thickening of the Niobrara-Benton formation towards the north-west, for while the outcrop on the side of Thunder Hill is forty-two miles from the approximate line of outcrop of the underlying Palæozoic limestones, the outcrop on Vermilion River is only about twenty-eight miles from the same line, so that any dip of the surface of the limestone in this direction should show a still greater increase in the thickness of these beds towards the north-west. That the surface of the underlying limestone does not rise towards the south-west from its line of outcrop, is shown by the bore-hole that was sunk near the mouth of Snake Creek, the bottom of which is about the same level as the surface of Swan Lake.

River banks of stratified sand.

Returning now to Swan River the next point examined, below the exposures near the mouth of Bear's Head Creek, was about five miles east of Thunder Hill, where the river makes a sweeping bend towards the north. The banks are here about thirty feet high, and consist of fine, regularly stratified sand. Four miles further down the river, one of the gravel ridges, of which mention has already been made, crosses the valley, its surface being open and grassy. It is locally known as the "Square Plain," and consists, like the other similar ridges, of rounded water-worn limestone gravel. No complete section of it was seen, the upper twenty feet was covered with slides, but the lowest fifteen feet, down to the river, consists of unstratified glacial till, holding many finely striated pebbles. The underlying Cretaceous beds are entirely concealed.

Till.

For twelve miles north-east of the "Square Plain" the river was hastily examined, but its banks appeared to consist entirely of superficial deposits.

The underlying Cretaceous rocks now reappear, but their character is different from that of the shales near Bear's Head River. The dark gray unctuous clay is present on the top, below it the clay is lighter in colour and more compact, and is interbedded with layers of sandstone.

Near Tamarack Creek.

Two miles below Tamarack Creek the following section is exposed on the north bank of the stream :—

	ft.	in.
Light coloured stratified sand	4	0
Very irregularly stratified soft plastic clay	6	0
Bed of same containing numerous large pebbles	1	6
Light yellow horizontally stratified fine-grained slightly clayey sand, containing a few striated pebbles	15	0
Band of dark Cretaceous clay with small irregular concretions of pyrite	0	2
Horizontally stratified fine white very soft sandstone, streaked with bands of red and black	2	3
Similar sandstone containing large red lenticular nodules of hard sandstone	0	9
Soft white sandstone with dark bands	6	6
Covered	3	0

Stratified dark blue clay at the bottom of which is a band of hard sandstone containing a great number of well-preserved specimens of an *Ostrea* like a large and clustered variety of *O. congesta*, with *Modiola tenuisculpta*.

Dakota sandstone.

A short distance further down the river, under fifteen feet of alluvial deposits, is shown seventeen feet of white soft false-bedded sandstone containing thin layers of dark coloured very plastic clay. Below this clay are two feet of lamellar hard brown sandstone, which is again underlaid by six feet of lead coloured soft unctuous clay in which, near the top, is a thin very irregular bed of impure lignite, much of which has been replaced by pyrite. This lignite is sometimes associated with nodules of ironstone which contain fragmentary remains of plants.

The sandstone and light gray clay extend for a mile or more down the river, the face of the hard band of brown sandstone being in one place quite rounded off and covered with longitudinal glacial scratches, but it is impossible to make out their exact direction as the blocks that formed the point of the band have all been more or less displaced.

Last Cretaceous outcrop

A short distance further down the stream, where an ancient lake terrace crosses the country and the river flows out to the lower plain from a valley seventy feet deep, and extends away to the north-east in a shallow winding channel, the underlying Cretaceous rocks are seen for the last time in descending the river.

The section here is as follows :—

	ft.	in.
Plastic stratified superficial clay	8	0
Unstratified clay with a few pebbles lying unconformably on, and filling the irregularities in the underlying rocks (till)	8	0
Fine white soft stratified Cretaceous sandstone	2	4

	ft.	in.
Dark gray sandy shale	2	2
Soft white and light yellow sandstone with intermingled beds of dark gray clay shale	5	6
White sand and dark gray clay shale thinly interbedded	3	0
Soft plastic dark gray clay shale	4	6
Thin band of small fragments of lignite	0	½
Hard lead gray clay shale weathering into rounded butte-like shapes	12	0

Lignite.

Partially imbedded in this shale was lying a considerable mass of lignite showing all the details of its woody structure. It consisted of the partially carbonised trunk of a large tree which had fallen and become imbedded in the shale. All the lignite seen on Swan River was of this character, nowhere having become compacted into regular seams. A specimen now in the Geological and Natural History Museum in Ottawa, collected by Mr. J. W. Spencer in 1874 on Swan River, is also of precisely the same character and has evidently been broken from a carbonised tree-trunk buried in the shale.

Age of sandstones.

The above sandstones and light gray shales differ considerably from the soft unctuous shales, limestones and marls that have been already recognized as belonging to the Niobrara-Benton subdivision of Meek and Hayden's typical Nebrasca section, and which have been together designated the Colorado group by Dr. C. A. White. They also undoubtedly underlie these shales and limestones. They therefore correspond, both in position, and to a certain extent in character, to the typical Dakota sandstones of Meek and Hayden. Very few fossils have been found in them, but those that are known, favour this view of their age, and the absence of all the species found to occur in the overlying beds, is suggestive of a difference in age.

The approximate elevation of these beds where last seen is 150 feet above Swan Lake, where the Devonian limestone occurs in many places.

Rolling River.

Let us now examine the banks of Rolling River, which flows into the Swan River four miles below the last-mentioned exposure of Dakota sandstone, and which, with its tributary the Favell River, drains a considerable area in the northern part of the Duck Mountain. The upper portion of the east branch of Favell River was not examined, but the west branch, and Rolling River in their upper portions, before they leave the mountain, show nothing but drift deposits, and in descending them it is not until these streams cut a deep gully through a high ridge lying some distance from the foot of the main escarpment of the mountain, and known to the Crees as Minitonas, or Isolated Hill, that the Cretaceous rocks are first seen.

Minitonas. The Rolling River, where it reaches this hill, at a point two miles above the old location of the C. P. R., is 1,300 feet above the sea. The banks are 100 feet high and composed of slate grey mottled calcereous clay shale, holding remains of *Inoceramus problematicus*, *Ostrea congesta*, *Enchodus Shumardi* and *Cladocyclus occidentalis*. Forty feet at the bottom is soft and quite shaly, while the rock above becomes harder, more compact and much more calcareous. It breaks with an irregular fracture, is much jointed, and stands out as a bold vertical cliff overhanging the sloping bank of softer underlying shale.

Niobrara-Benton shale For a mile northward from where this first exposure of shale is seen, both sides of the winding stream show alternate outcrops of dark bluish-gray friable clay shale similar to the lower portion of the first-mentioned outcrop, and from which, in several places, issue springs of clear cold water smelling very strongly of sulphuretted hydrogen and leaving a white coating of sulphur on stones or other objects over which they flow. The river is here bounded to the east by a bank 120 feet high. The lowest fifty feet consist of the dark gray clay shale just mentioned, above which twenty feet of the bank is hidden, being covered by land slides. The upper fifty feet consist of fine-grained stratified sand very similar in character to that seen on the banks of Swan River, a short distance below the mouth of Bear's Head River.

At this high bank the river turns sharply in a direction N. 65° W., to about half a mile beyond the crossing of the old location of the Canadian Pacific Railway, a distance in all of two miles and three-

Benton shale. quarters. For a mile and a half, dark gray clay shale, similar to that already mentioned, crops out in low exposures close to the edge of the water, beyond which the banks for a long distance are composed entirely of boulder-clay and alluvial deposits. The lowest outcrop of Cretaceous rocks seen was at an approximate elevation of 1,200 feet.

Favell River. On the west branch of Favell River where it flows round the eastern point of Minitonas, the bed of the stream is at an elevation of 1,330 feet. It is flanked on the west by a bank sixty feet high of grey mottled calcareous Niobrara shale, containing fragments of fish remains, and of a long thin-shelled *Inoceramus*, probably *Inoceramus problematicus*. These beds are, undoubtedly, a continuation of the upper harder beds seen on Rolling River. Close at hand are several springs strongly impregnated with sulphuretted hydrogen.

The shale is here overlaid by ten feet of unstratified glacial till with striated boulders.

Rolling River. Returning now to Rolling River at a point S. 25° E. from the mouth of Tamarack Creek, where the bed of the stream has an eleva-

tion of 1,050 feet, a band of Dakota sandstone crops out from the bottom of a high bank, and crossing the stream, makes a succession of little cascades. This band consists of hard brown thick-bedded quartzose sandstone, massive or lamellar and often made up of small concretions about the size of peas, which are finely shown on many of the weathered surfaces. The surfaces of the slabs are often beautifully ripple marked, and on the edges show false-bedding in layers of about four inches in thickness. They contain *Lingula subspatulata*, *Modiola tenuisculpta*, *Lamna Manitobensis*, and pieces of carbonised or pyritised wood. The band of hard sandstone is overlaid by a bed of soft white sandstone or incoherent sand. The whole outcrop is a continuation of that seen opposite to it on the Swan River, and, lying below the shales of Niobrara-Benton age, clearly represents some of the beds of the Dakota group. Dakota sandstone.

Below this outcrop the river was followed for a little more than a mile, and Cretaceous strata were not again seen, the banks being almost entirely covered with slides, but the same series doubtless occurs here, as has already been described on the Swan River.

In following the section of the rocks, as shown in the banks of Swan River and its tributaries, some of the more prominent surface features of the surrounding country have necessarily been omitted for the time, and it will now be necessary to mention some of the most important of these. Surface features.

As was stated in the beginning of the report, Swan River flows in the bottom of a wide preglacial valley averaging about 1,200 feet in depth, cut through the Cretaceous plateau of the Duck and Porcupine mountains. The exact age of the valley is uncertain, but it is not improbable that it was largely formed during the period when the South Saskatchewan gravels were deposited in the west, and it would therefore be of Pliocene age. During the glacial period the valley was ascended by a lobe of the great glacier of the Winnipeg basin, and after the retirement of this glacier, most of the lower portion of the valley was occupied by a wide bay of Lake Agassiz, and is now generally covered with lacustrine or alluvial sands or clays. Preglacial valley.

An old cart trail, that has been used by the Hudson's Bay Company for the greater part of the present century, runs down the valley from Fort Pelly to the marsh at its mouth, keeping for most of the distance on the north side of the river. From the ford, ten miles north-east of Fort Pelly, the trail ascends the north side of the immediate valley of Swan River, and enters the "Five Mile Woods," a grove of spruce and poplar in which the soil is generally a dark clay, composed almost entirely of the subjacent Creta- Cart trail. Five Mile Woods.

ceous shale. East of this is a sandy plain, extending for about three miles and a half, and scored with old buffalo trails. In its eastern portion, the soil is a coarse sand, but towards the west it contains a large amount of gravel and its surface is strewn with boulders of red-

Delta plain.

dish and greenish gneiss. This is clearly an old delta plain, and the conditions now existing are very similar to those found on the highest gravel plains on North Pine River, with which this corresponds more or less closely in altitude.

For the next mile and a half the trail winds through small poplar, growing on the gentle slope of the face of the old delta deposit, and then it crosses a gently undulating sandy plain for about six miles, beyond which is a belt of poplar in which the land falls about 100 feet. This poplar covered belt is locally known as the "Coast Ridge," and seems to represent the eroded face of another lacustral or delta deposit.

From the "Coast Ridge" to the "Square Plain" is a more or less open, and often sandy tract which extends up the south side of the river to beyond Bear's Head Creek. It was formed when the waters of Lake Agassiz washed the foot of the "Coast Ridge."

Square Plain.

Square Plain is a wide ridge of rounded water-worn gravel, rising about twenty-five feet above the swampy land to the east of it. In some places it is a quarter of a mile wide, and is composed of five distinct ridges separated by light hollows, representing slightly different stages of Lake Agassiz. North of Swan River it flattens out rapidly, and was not followed for more than three miles, while south of the river it sweeps round in a gentle curve to the east, for at least five miles, which was as far as it was followed in this direction. It is about 1,160 feet above the sea, as compared with the height of the bed of Rolling River at the crossing of the old Canadian Pacific Railway location, which is given by the railway survey as 1,180 feet. It is probably part of the same old shore line as the 1,151 feet ridge near the north-east angle of the Duck Mountain.

Low country.

For five miles north-east of the Square Plain the trail runs over level country consisting of belts of small poplar and low meadow land. At the above distance there is a light slope, on which an irregular ridge of barren sand dunes marks another shore line of the ancient lake.

For the rest of the distance to Oak Creek on the southern trail, extensive meadows are separated by little belts of poplar, while the northern trail runs through a forest of thick poplar for five miles, on a well rounded ridge of coarse gravel wooded with poplar and oak. This ridge appeared to be at about the same elevation as the Square Plain ridge, but the two were not definitely connected by survey.

Our camp was pitched for several days near the mouth of Oak Creek, on the grassy bottom land by Swan River. The valley is sixty feet deep, and its sloping grassy banks descend in two beautiful terraces to the water. From here the writer made a trip with horses round and over the north-eastern point of Duck Mountain, his course being marked in a dotted line on the map. Oak Creek.

Two miles below Oak Creek a distinct gravel ridge crosses the country, and for nine miles further in the same direction the "Great Meadows" extend. They are wide stretches of rich flat land, covered with a thick growth of long grass, separated by narrow irregular belts covered with willow, and small, sometimes large, poplar. A forest of heavy poplar is then entered, and the trail is cut through it for six miles to the ford over Swan River, on the north-west side of which the Hudson's Bay Company used to have a store-house. Great Meadows.

For the next six miles, the trail is on the south side of the river in heavy poplar, till a ford is reached, where the river has a sandy bed. The banks are here fifteen feet high, and consist of white or light yellow stratified alluvial sand, the north bank being steeply cut. About twenty-five paces back from this abrupt bank, and just to the east of the trail, is the site of an old trading post of the Hudson's Bay Company, which was moved in the early part of the century to its present position near the head of Shoal River. The country is very level, and the site is marked by six hollows or depressions, some of which were doubtless cellars, and two heaps of stones where chimneys formerly stood. Old Fort, H.B.C.

In a poplar grove between two and three miles further down the river, at the point indicated on the map, the old trading post of the North-west Company was said to have been situated, but the spot was not visited. This post, and in fact much of the Swan River valley, is described by Daniel Harmon in his Journal, as it was at the beginning of the present century, and it is also mentioned or described by David Thompson, Alexander McKenzie and others. Old Fort, N.-W. C.

Below this old trading post the river is skirted by groves of poplar, elm, ash and ash-leaved maple, while flat low lying meadows extend towards the lake.

Returning to the streams that flow from Duck Mountain northward into Swan River, Bear's Head Creek, where crossed on a level plain three miles and a half from its mouth, was thirty feet wide, and ran over a bed of pebbles. It was not followed further, and its course is mapped from the survey of the western boundary of Manitoba. Bear's Head Creek.

Rolling River was examined from a point a short distance west of the 101st meridian, where it is about 2,250 feet above the sea. Rolling River.

It is here a small stream in a valley fifteen feet deep, with a spruce swamp on both sides. Its bed is covered with boulders, and its channel is much obstructed by beaver-dams.

Pleistocene deposits.

A short distance lower down it flows in a deep valley, the sides of which show some excellent sections of Pleistocene deposits.

One of these sections on the north bank is as follows:—

	ft.	in.
Stratified gravel	10 ?	0
Unstratified till with striated pebbles	22	0
Stratified sandy clay, becoming almost a pure laminated clay at bottom, where it contains many plants and fresh-water shells such as *Taxus baccata, Elodea Canadensis, Vallisneria ?, Navicula lata, Encyonema prostratum, Denticula lauta, Licmophora ?, Cocconeis; Lymnæa catascopium ?, Valvata tricarinata* and a keelless variety, *Amnicola porata ?, Planorbis parvus ?, P. bicarinatus, Pisidium abditum* and *Sphærium striatinum*	6	0
Stratified gray sandy clay	20	0
Slightly sandy stratified clay, coloured dark brown with bituminous matter, and containing a few small bivalves	1	10
Plastic clay	5	0
Coarse stratified sand	12	0
Covered to water	12	0
	88	10

Heart Hill.

A quarter of a mile further down the river, near what is called "Heart Hill," a scarped bank 150 feet high shows a very similar section. The upper forty feet consist of unstratified till holding many pebbles and boulders of gneiss, quartzite, mica-schist, ironstone, &c., with scratched and polished pebbles and boulders of limestone. This is underlaid by seventy feet of stratified clay, sand and gravel, below which forty feet of the bank is covered with slides. The bed of the river is here about 1,800 feet above the sea, and, falling from the overlying till are many fragments of Niobrara shale, which have been shoved up by the glacier out of Swan River valley to the north.

Terrace.

For three-quarters of a mile below this interesting exposure, the valley has a well marked terrace forty feet above the bottom land, and then a moraine nearly half a mile wide crosses the valley. It consists of rounded hills covered with boulders separated by small inclosed basins. This moraine appears to have blocked the river for a time and permitted the formation of the terrace just mentioned, but the stream now flows in an irregular channel through it. The moraine was not followed beyond the valley, and its extent was therefore not determined, but it would appear to have been formed

Moraine.

near the close of the glacial period, by a small glacier flowing northward or westward from a névé on the summit of the Duck Mountain, after the great glacier of the Winnipeg basin had receded, and sufficient time had elapsed to allow for the excavation of the main valley of Rolling River.

Below the moraine the wide and often open valley continues westward for about three miles till it is joined by Round Lake Creek, also flowing in an old wide valley, one branch of which is said to be continuous with the upper valley of Shell River.

Here Rolling River turns northward and follows the bottom of a deep, thickly wooded valley to the northern face of Duck Mountain. At the mouth of this valley is an extensive gravel plain through which the river now winds in a channel from thirty to forty feet in depth. This plain is between 1,400 and 1,500 feet above the sea, or about the same height as the highest sand and gravel plain seen on Swan River, and the two were probably formed at the same period. The gravel underlying this one is often very coarse, and was washed out of the till when the deep valley of Rolling River was being rapidly excavated. Deep valley. Delta plain.

Below this plain the river has been for the most part already described in connection with the sections of the Cretaceous rocks. At its lowest crossing, a short distance above the mouth of Favell River, it flows through a level country in a valley a quarter of a mile wide and sixty feet deep. At the bottom of the bank are exposures of Dakota sandstone, while above it are beds of stratified lacustral sand and clay.

Favell River also rises on the summit of Duck Mountain. Its east branch was not followed, but the source of the west branch is not far from the source of Rolling River, among rugged morainic hills covered with boulders and supporting only a scanty growth of small Banksian pine. It then enters a more even country wooded with spruce and poplar, and turning northward flows through a deep narrow valley to the northern face of the mountain. No sign of the underlying Cretaceous rocks were thus far seen, but where the bed of the river is about 1,800 feet above the sea a steep cliff shows at the top 100 feet of light gray unstratified till with striated pebbles and boulders, below which sixty feet are covered with slides. Favell River.

From the foot of the mountain the river flows in a shallow channel across a heavily wooded plain for three miles, till it reaches the south side of Minitonas Hill, where it turns to the north-east and cuts through the hill, exposing some good sections of Niobrara shales.

Near its mouth, where the stream is about eight feet wide, it cuts through a well-marked gravel ridge with an altitude of about 1,030 feet

above the sea. This ridge was also followed across the east branch and for some distance into the country to the east.

East of Favell River the country was traversed on the dotted lines laid down on the map to the north-east point of Duck Mountain, and was found to be very level throughout, consisting, close to the mountain, of spruce and tamarack swamps, and further north of meadows and poplar forest.

PORCUPINE MOUNTAIN.

Position. The Swan River valley is bounded to the north by the dark heavily wooded slopes of Porcupine Mountain, the streams from which, uniting to form Woody River, flow independently into the west side of Swan Lake. The most of this country was not personally examined but is mapped from sketches and triangulations made in the valley below, and from information received from native Indians or half-breeds. However, the trail from the mouth of Birch River to Kematch River was explored, and the valley of this stream was followed for a short distance.

Birch River. Birch River flows into the west side of Swan Lake at the end of a long alluvial point, where it is thirty-five feet wide and five feet deep without current. Its banks are wooded with elm and oak, but a low meadow-land stretches away on both sides.

Bridle trail. Starting at a point seven miles above the mouth of Birch River, the bridle trail strikes first westward and then southward across a level country without boulders, at first partly open, and afterwards wooded with large poplar. Ponds of saline (alkaline) water were occasionally found in some of the more open places, probably marking the line of outcrop of the Dakota sandstone at the base of the Cretaceous series. The trail crosses several small streams and then reaches an open ridge ten to twelve feet high and 500 wide running north and south. The ridge is a well rounded beach of Lake Agassiz with an approximate elevation of 1,125 feet above the sea, and is composed entirely of reddish quartz sand.

Kematch River. Kematch River cuts a valley fifty feet deep through this ridge. The bed of the river is thirty feet wide, but towards the end of August the stream was only twelve feet wide and six inches deep. The bars are scattered with pebbles and cobbles of limestone, gneiss, ironstone and light gray Niobrara shale. At the foot of the bank is a low outcrop of hard bluish brown-weathering sandstone, doubtless belonging to the Dakota formation, overlaid by ten feet of dark slate-gray clay shale, breaking into minute flakes, and weathering to a soft mud.

These shales are very typical of the Benton formation and here represent its base.

Escarpment. From the ridge, the course of the river was followed on foot for two miles to the face of the escarpment of Porcupine Mountain, where it flows out of a deep valley, from half to three-quarters of a mile in width. A number of low exposures of Benton shale may be seen during this distance, but the banks are generally composed of pebbles and small boulders, resting on a light gray till. The stream is overhung by gigantic balsam-poplars.

At the foot of the mountain the side of the valley is very steep and 140 feet high, but so overgrown with vegetation that the underlying rock could not be seen.

Coast cliffs. When returning to the bridle trail at the ridge, a course was taken south of the river. It first led down a steep slope sixty feet high on the face of the escarpment, then across a plain half a mile wide, and down another slope fifty feet high, at the foot of which was a flowing spring of clear water, tasting quite strongly of sulphuretted hydrogen. These escarpments represent ancient coast cliffs on the shore of Lake Agassiz, when the waters washed against their bases. The approximate elevations of these two shore lines would be about 1,270 and 1,200 feet above the sea respectively. Between the escarpment and the trail, much of the country is thickly wooded with large spruce, and another sand ridge is crossed with an elevation of 1,150 feet, on which is a grove of small oak trees. All this country is a famous hunting ground, and was everywhere beaten with fresh tracks of moose.

Further northward the face of the escarpment becomes higher and more abrupt, and the gorge from which Bell River flows can be clearly seen from Swan Lake as a deep notch in the brow of the dark green mountain.

Mr. Dowling travelled on a footpath from the mouth of Birch River to the summit of the mountain beside this gap and gives the following description of the country passed over :—

Trail to Bell River. "The trail leading from Swan Lake starts just west of the mouth of Birch River and follows a small creek coming from near the foot of the mountain. At the lake, a fringe of poplar about a mile wide is growing on the eastward slope, but this is succeeded by level land somewhat swampy, on which some spruce is occasionally seen. The rise for some distance, however, is very slight, and at seven miles from the lake the altitude is 1,000 feet above the sea, or 145 feet above Swan Lake. From there, however, after passing an apparently level mossy swamp, the rise is more abrupt, and beyond a patch of burnt

Bell River.

country on the surface of which are seen many large boulders of gneiss and limestone, the trail leads over several very distinct gravel ridges, forming an ascending series varying in elevation from 1,207 to 1,300 feet above the sea. These occupy a belt extending along the foot of the mountain, which, where crossed, is open, bearing only a few trees, principally jack pine (*Pinus Banksiana*). The trail deflects to the north, and leaving the gravel plain gains a somewhat level terrace, the steep face of which is strewn with boulders and the surface clothed with scrub poplar. The elevation of this terrace is about 1,400 feet above the sea, and in character it is very similar to the upper delta plain of the Swan River valley. Through it, the Bell River has cut a valley more than fifty feet deep, which seems to expose nothing but drift material.

The first exposure in this valley is above this delta plain, at an elevation of 1,450 feet above the sea. It is on the north side of the river, where a somewhat slidden hillside shows, to a height of thirty feet, a scarped face of dark gray clay shale. Thirty-five feet higher up

Pierre shales.

the bank and on the south side of the river, is an outcrop of light gray hard siliceous clay shale, associated with a few dark nodules of ironstone. These shales were found by Dr. Rüst to contain the following species of Radiolaria:—

Caryosphæra æquidistans. Cenellipsis hexagonalis. Prunulum calococcus. Cyrtocalpis crassitestata. Dictyocephalus microstoma. Dictyocephalus macrostoma. Theocampe sphærocephala. Tricolocapsa salva. Tricolocapsa thoracica. Tricolocapsa Dowlingi. Tricolocapsa Selwyni. Dictyomitra Canadensis. Dictyomitra polypora. Dictyomitra multicostata. Stichocapsa Tyrrelli. Stichocapsa Dawsoni.

Pleistocene deposits.

"Above this, no rock in place was seen, and on the upper part of the valley the immediate banks show a few escarpments of light clay containing sand, pebbles and small pieces of light gray shale. The whole is partly stratified. Above the valley on the edge of the escarpment of the mountain, dark clay mixed with shale is overlaid by sandy clay, probably a mantle of drift material covering the mountain. The valley viewed from the edge of the mountain is seen to be rough, small hills appear scattered in all directions. The surface is dotted with boulders, and the bed of the stream is a mass of boulders of all sizes."

The remainder of the eastern and the northern slopes of Porcupine Mountain were mapped from sketches and triangulations made on Swan Lake, Dawson Bay, Rice River, and Red Deer Lake and river, and the hydrography of the interior of its summit is dotted in from sketches obtained from John Beardy, Kematch, and Peter Moore, three Indians living on Shoal River. They also informed me that the summit is generally rough and uneven, probably morainic, and is wooded

with small spruce and Banksian pine, like many of the higher portions of Duck Mountain.

RED DEER RIVER.

North of Porcupine Mountain, lying between it and Pasquia Mountain, is another great valley similar to, but even more extensive than Swan River valley. It is almost entirely drained by Red Deer River, though Overflowing River occupies much the same position in this valley, that Woody River occupies in the Swan River valley. Wide valley.

At the mouth of Red Deer River, where it flows into Red Deer Lake, a small band of Indians make their headquarters. From these Indians horses were obtained, and a trail was explored from the south-west corner of the lake to the Smoking Tent, and thence westward to the mouth of the Etoimami River, whence another old trail was followed down the north bank of the river to its mouth. A brief description of this route will convey the best idea of the general character of the valley. Indian camp.

The trail leaves the lake just west of an old winter trading post of the Hudson's Bay Company, and runs for nine miles over almost level country through a forest of large poplar and spruce, with open grassy glades, to Swampy Creek, a tributary of Armitt River. This creek is ten feet wide, with a channel two feet deep, in which only a few inches of clear water was flowing in September, 1889. The banks are of sand and fine gravel. The creek flows from what appears to be a deep gap in the northern face of the mountain. Porcupine Mountain trail.

A mile and a half south-west of this creek the trail crosses a well-marked gravel ridge which rises ten feet above the surrounding land and has an elevation of 1,100 feet above the sea. For the next two miles and a quarter the course is through belts of spruce and poplar and open meadows to Armitt River, which is here a beautiful clear stream flowing in a channel five feet deep, in the bottom of a valley fifty feet deep, over a bed of rounded pebbles of gneiss, limestone and Niobrara shale. Armitt River.

200 yards below the crossing, on the west side of the river, is a scarped bank fifty feet high, showing at the top six feet of clay with striated pebbles, probably till. The rest of the bank is a series of slides, but on the face of one of the slides, close to the edge of the water, is twelve feet of dark gray fissile Benton shale, and a few yards further down the stream are many large masses of white Dakota sandstone, holding carbonized impressions of plants, &c. The height of the bed of the river at this point is 1,090 feet above the sea. Benton shale.

Sandy plain. From here the trail ascends the west bank of the valley and strikes southward through open pine woods, on a sandy plain with a mean elevation of 1,180 feet above the sea, to a well rounded ridge, with an elevation of 1,230 feet above the sea, on which it turns to the west.

Between the trail crossing and the ridge, a distance of about one mile and three-quarters, the bottom of the valley was also followed, and some good exposures of the Cretaceous beds were measured.

Niobrara shale. A mile and a quarter above the crossing a steep cliff rises on the east bank of the river, showing at the top eight feet of light gray till with limestone pebbles, underlaid by thirty-two feet of dark gray soft fissile Cretaceous clay shale, in which there is a narrow band of soft white clay.

A third of a mile further up the river, and a short distance below the main gravel ridge followed by the trail, is a high bank of dark shale. In this bank, ten feet above the water, is a thin nodular band of light gray mottled calcareous Niobrara shale, containing many foraminifera, with prisms of *Inoceramus* and fragments of fish skeletons.

At the ridge, the river is beginning to be much obstructed with boulders, and the banks southward to the mountain seem to be generally low, while the surrounding country is chiefly timbered with poplar, and is probably crossed by other low ridges.

Gravel ridge. The ridge followed is composed of sand and fine gravel, is generally raised from six to ten feet above the surrounding wooded or marshy country, and is wooded with a thin growth of small aspen. The trail runs along its summit for ten miles, in which distance it is cut across by several brooks, which do not expose sections of any particular interest. At Bushy Creek the trail forks, one branch turning northward towards Red Deer River, while the other branch, which was the one followed, turns southward across a level country to another wooded ridge twenty feet higher than the last, and then westward along this ridge for more than a mile to Smoking Tent Creek, which flows in a valley 300 feet wide and twenty-five feet deep. Its bed is twenty-five feet wide, and covered with rounded gravel. Half a mile west of the ford and close to where the creek first strikes the ridge, is a small open prairie locally known to the Indians as the

Smoking Tent "Smoking Tent," where they are accustomed to camp from time to time. The point is close to the extreme western limit of the area covered by the accompanying map, and from it a direct trail is stated to run to Fort Pelly.

West of this place, the trail, back to the upper Red Deer River, continues on the ridge for two-thirds of a mile and then turns to the lower ridge, which it follows for between seven and eight miles,

to the west end of a long meadow which skirts its upper side. The trail then turns southward for more than a mile to a small open prairie, on another ridge which is clearly the continuation of the Smoking Tent beach. This ridge is generally composed of fine gravel, is about 125 paces wide, and is raised ten feet above the surrounding country. It was followed for between six and seven miles, as it curves gently towards the north, till about a mile past a point where it is joined by a good pack trail from Fort Pelly, it becomes indefinite and merges into a wide sandy plain dotted with sand dunes lightly wooded with Banksian pine. Here we turned north-eastward, and crossing the sandy plain for a mile and a third, reached the Red Deer River in a valley thirty feet in depth. Extensive delta plain.

The channel is 250 feet wide, but the water at the time was not half that width, and was flowing over and through a bed of large boulders of gneiss and limestone. The banks at the bottom are composed of light gray unstratified till, holding pebbles and many large boulders similar to those in the river, while above is a reddish stratified sand. The sandy plain was clearly formed by a river which flowed into Lake Agassiz when its waters stood at the height of the Smoking Tent beach, but its exact correspondence in age to other delta plains on the west side of Lake Agassiz has not yet been determined.

Two miles further upstream Fir River (O-kik-kan-tago Sibi) joins the Red Deer River from the north, draining the southern face of the Pasquia Mountain. It is thirty feet wide, with water from bank to bank, and its bed, like that of the main river, is covered with boulders. Its mouth is fifteen miles west of the accompanying map, in north latitude 52° 50′ and approximate west longitude 102° 24″. Fir River.

Just below it the bank of the river is forty-five feet in height, and consists at the top of twelve feet of light red horizontally stratified sand, underlaid by a few feet of gravel. The rest of the bank is covered with debris but springs are flowing from its foot, and it is therefore probable that it is in great part composed of stratified deposits.

A short distance further down stream is the mouth of the North Etoimami or Shallow River (Ka-pa-kwa Sibi), which was ascended by Professor Macoun in his trip from Red Deer to Swan River in 1881. At its mouth it is about 100 feet wide, with a bed of large boulders, over which little or no water was flowing in September, 1889. A cliff of light gray till twelve feet in height overhangs its western bank, and on a magnetic bearing N. 55° E. from this cliff, on the bottom land on the north side of Red Deer River, are the chimneys and cellars of two old houses that were formerly occupied as a trading post by the North-west or Hudson's Bay Company. North Etoimami River.

Trail north of Red Deer River.

From the mouth of Fir River a bridle trail, often very obscure, was followed down the north side of Red Deer River to within seven miles of its mouth.

The first mile is across a sandy plain wooded with Banksian pine, and the next six miles are over level or gently sloping country wooded with poplar or studded with small dead spruce. At the end of this distance, near the mouth of Spring Creek, the river is moderately deep, with an easy current, and the banks are composed of stratified sand or till. A large boulder of white Dakota sandstone is here lying in the bed of the stream. Its surface is pitted with holes caused by the decay of nodules of pyrites and in them the Indians put small offerings of bullets, shot, &c. The boulder is twenty-five feet long, sixteen feet wide, and rises three feet above the surface of the water. Its angles are well rounded off, and its upper surface is clearly marked by a number of elongated dints, often running into irregularly disrupted gouges, parallel to the river, and evidently made by the spring ice or stones, &c., borne along by it. But these markings are quite distinct from a series of long continuous nearly parallel gouges or scratches, which cover the whole upper surface of the boulder, running parallel to its greatest length, and which have been quite clearly formed under the influence of glacier ice.

Boulder of Dakota sandstone.

The river at this point is about 1,100 feet above the sea, and the boulder has been carried up the valley, by a westward flowing lobe of the great glacier of the Winnipeg basin, from the beds of the Dakota sandstone which outcrop twenty miles further to the north-east, and at from 100 to 200 feet lower level.

From Spring Creek to opposite the mouth of Smoking Tent Creek, close to the western edge of the map, the trail keeps near the river, often on its alluvial flats, and the banks were found to consist entirely of superficial stratified sand, &c., or glacial till.

Ash-leaved maple.

Opposite Smoking Tent Creek is a fine grove of large ash-leaved maple, close to which is a sandy plain by the river, where the Indians camp when they come in the spring to make maple sugar. Leaf Lake (Was-ki-té-poo Sakàhigan) on Overflowing River, was stated by an Indian who accompanied me, to lie immediately to the northward, and sufficiently close that in favourable weather in winter, a gun fired on the lake could be heard here.

For nine miles below the sugar bush the river continues to flow in a north-easterly direction, between banks overhung with elm and maple, while a poplar forest stretches away on either side. The banks generally consist of till with boulders, often overlaid by stratified alluvial clay.

Banks of till.

The river then bends to the east, and at the bottom of the bank light green Dakota sandstone appears for the first time. The section here exposed is as follows :— Dakota sandstone.

	ft.	in.
Unstratified till in the form of light gray hard sandy clay, with many striated pebbles and small boulders of gneiss and limestone, with a few of iron pyrites	17	0
Covered	22	0
Soft green clayey sand	1	0
Horizontal green Dakota sandstone	1	6
	41	6

This sandstone is very similar to that seen at the crossing of Armitt River, but here it was found to contain some pyritised wood, with teeth and bones of fishes, and a small species of *Lingula*.

Below this sandstone the river turns to the south, and a deep abandoned valley continues to the east, which is entered again by the river two miles further down. The valley is here seventy feet deep, and the banks consist chiefly of light gray till. For a mile and a half further eastward the trail runs across a sandy plain dotted with sand dunes, and at the end of the distance the bank of the river shows at the bottom five feet of soft brown or red Dakota sandstone, in places clearly false-bedded. It includes some thin bands of black clay, as well as many pebbles? of a clayey sand holding remains of plants. This is overlaid by fourteen feet of soft white evenly-bedded sandstone, and this again by light gray till with striated boulders. Abandoned valley.

For the next three miles the valley is deep, and the white Dakota sandstone outcrops here and there along its sides.

To within half a mile of the lowest outcrop of this sandstone, Mr. Dowling made a micrometer and compass survey of the river from the lake upwards in 1888, but there further ascent of the river with canoes became impracticable at the then stage of the water.

From this point the trail descends through woods of small poplar into a grove of beautiful tall spruce, and then through poplar, elm and maple to the river at its most northerly point, where its bank rises in an abrupt cliff of till thirty feet high. Our course then passed through woods of elm, poplar, maple and willows to the next bend of the river, where there is a patch of ground that had clearly been tilled long ago, and is now overgrown with golden rod, beyond which the trail follows the bank of the river on a beautiful grassy plain to the site of the Old Fort of the North-west Company. Thick woods.

This fort had a pleasing situation on a level alluvial plain, in front of which the river, with a width of 250 feet, flows in a channel fifteen feet Old Fort, N.-W. C.

Old Fort, N.-W. Co.

in depth. Just on top of the steep bank, and almost ready to be carried away by the first flood, is a heap of earth and stones, representing a chimney of one of the old houses, while all the others seem to have been already carried away. Several small depressions in the vicinity may, however, represent old cellars or holes in which potatoes were stored.

Standing with his face towards the river the writer looked across to a lovely forest of elm and maple, just tinted with brilliant autumn colours, while to the right were groves of maple and willow, and to the left was a forest of poplar pinnacled with spires of dark green spruce.

At the beginning of the present century this place was an important trading establishment of the North-west Company, being mentioned by Sir Alexander Mackenzie as one of the three chief trading posts of the Lake Manitoba district. From it a cart trail is locally reported to have led up the north side of the river to the western plains, but no trace of such a trail can now be seen.

A mile and a half below this old fort the trail crosses the river, where a fine grove of large ash-leaved maples is growing near the southern bank. A mile further down stream the remains of an old fort of the Hudson Bay Company are to be seen within a heavy poplar forest.

Old Fort, H. B. Co.

For the rest of the distance to its mouth, the banks of the river are low, and stretch back to extensive meadows covered with rank grass.

DUCK MOUNTAIN.

Position and extent.

Duck Mountain is an elevated table land or extended ridge rising in some places to 1,900 feet above Lake Winnipeg or 2,600 feet above the sea. It is bounded on the north by a wide sloping valley, down the centre of which Swan River flows into Swan Lake, and thence by Shoal River into Lake Winnipegosis. To the north of this valley the Porcupine Mountain rises apparently to a height equal to that of Duck Mountain, while in the middle of the valley, Thunder or Bird Hill rises 500 feet above the plain at its base, having been left as an outlier by the denuding agencies that carved out the valley from the once continuous plateau. Towards the east the mountain is bounded by the Manitoba escarpment sloping down into a wide depression, the bottom of which is occupied by Lakes Winnipeg, Winnipegosis, Manitoba and a number of small surrounding lakes. Towards the west the mountain slopes off much more gradually to the valley of the Assini-

boine River, the head of which at Fort Pelly is 650 feet above the level of Lake Winnipeg. Towards the south it merges into the Riding Mountain, being separated from it merely by the valley of Short Creek, which towards the east opens out into the wide funnel-shaped valley drained by Valley River.

Drainage.

The eastern face of the mountain is drained by several small streams that flow into Lakes Winnipegosis and Dauphin, most of which, however, rise below the summit of the escarpment. A belt along the north side of the mountain is drained by streams that flow northward into Swan River. The greater portion of the area of the surface, however, is unwatered by the Valley and Shell rivers, which flow parallel to each other southward for a considerable distance and then diverge, one to flow eastward into Dauphin Lake, and the other, after flowing westward for six miles, to again turn southward to join the Assiniboine River. West of Shell River several small streams drain the country south-westward into the Assiniboine River. Very few of the streams show signs of the underlying Cretaceous rocks, the country being generally thickly covered with drift deposits, but it is quite probable that in some cases the valleys of the streams are cut down to a much greater depth than the thickness of this superficial covering of drift.

Rough hills.

East of Shell River the Duck Mountain is generally very rough and uneven, consisting of ridges, and apparently irregular areas, of drift hills thickly covered with gneissoid boulders, often bearing a scanty growth of Banksian pine, between which are extensive areas of comparatively level marshy land densely overgrown with spruce and tamarack. The southern portion of this district is drained southward into Valley River, part of the central portion westward into Shell River, while the northern portion is drained either northward into the Rolling and Favell rivers or eastward into the Duck and Pine rivers.

Head of Valley River.

The source of Valley River was not visited, but Indians who were hunting in the vicinity reported that it rose in Singoosh or Weasel Lake and flowed south-westward to Angling Lakes. Another small branch of this stream was, however, found to rise in a wide swampy level country covered with spruce and tamarack, and probably underlaid by alluvial or lake deposits. The small creek, flowing from this swampy area towards the south-west, soon cuts through a ridge of irregularly rounded hills running in a north-westerly and south-easterly direction. These hills are thickly overstrewn with boulders and separated by basin-shaped depressions, and have all the appearance of being an old moraine. After flowing through this morainic ridge, the creek enters a wide valley. The bottom is swampy and covered with willow or spruce. The south side is a continuation of the high ridge that extends east-

ward to Manitowachi, while the north side rises in beautiful gravel terraces to what appears to be an alluvial or flood-plain of considerable extent. Continuing towards the south-west for two miles, and then turning north-westward for about three miles, this small creek joins the main stream of Valley River.

South of the river is a rough morainic tract rather thickly timbered with spruce, birch and poplar. West of this morainic area a more or less level district stretches for several miles, in the bottom of which lie several small lakes known to the Indians as the Angling Lakes. Near these are a number of well built log houses in which Côté and his band of Saulteux live during the winter season, while hunting and trapping in the neighbouring forests.

Angling Lakes.

Indian cart-trail.

Following the cart-trail westward from these lakes an area of rich meadow land is passed over, consisting of wide swails separated by long low ridges. The surface consists of sand and rounded water-worn gravel, the latter chiefly composing the low ridges on one of which the Indian houses are built.

About two miles west of the village the trail crosses a ridge of rounded knob-like morainic hills scattered over with gneissoid boulders. Beyond this again is a lightly rolling country generally thickly timbered with large aspen and dotted here and there with small marshes. In the middle of this district the trail crosses the north end of a wide valley, the bottom and sides of which are covered with sand and gravel, no boulders being seen on the surface. The south side is open and grassy and rises in regular terraces, the surface of which in many places, however, are not at all level, but show low knobs and basin-shaped depressions, very much like the usual morainic contours, but it seems not impossible that the depressions may be caused by the unequal carrying away of the finer particles from among the gravel by underground drainage, and the consequent irregular sagging of the surface.

Wide valley.

Valleys of the Champlain or Terrace Epoch.

Shell River valley.

The most noticeable of these valleys is that of Shell River, its extreme northern portion being occupied by Rolling River. This valley runs in an almost due north and south direction through the centre of Duck Mountain. At the northern end it opens on the abrupt escarpment of the mountain into the wide valley of the Swan River and its tributaries, and at its southern end joins the valley of the Assiniboine. Its length measured in a straight line from one end to the other is sixty-seven miles, but counting its windings its total

Extent.

length is ninety-five miles. It has an average width from brim to brim of three-quarters of a mile or a little more, and its depth ranges from 100 feet at the mouth of the east branch to 365 feet at the trail crossing at Asessippi.

Slope.

As is shown by the present course of Shell River, the valley has a general slope towards the south. The height of the river flats at the mouth of the east branch is 2,050 feet above tide, and of the flats at Asessippi 1,450 feet above tide, giving a fall of 600 feet in seventy-five miles, or an average fall of eight feet to the mile. This fall is pretty evenly distributed throughout the whole of the above distance, though towards the mouth it is a little steeper than elsewhere. The north end of the valley for three miles is occupied by Rolling River, but, unlike that further south, is here thickly wooded with spruce and poplar, and it is much more difficult to see its salient features. About thirteen miles of the course of the valley was not followed, but looking up the north branch of Shell River it was seen to continue onward for several miles till a light bend cut off the view, and the bottom was filled from bank to bank by a deep marsh, in which the stream appeared to take its rise. Looking from Rolling River, it appears as a deep valley, down which flows a small tributary. A half-breed who was with me, and who was acquainted with the country, stated that this valley is a continuation of that of Shell River, and in it there is a marshy watershed.

Stream flowing northward

Beginning in latitude 51° 43′, a short distance above the confluence of the east branch, the valley is a mile wide and largely occupied by a beautiful even prairie lying on the east side of the river, and sloping very lightly towards the west. This prairie is underlaid by small rounded water-worn gravel, and represents a flood-plain of the ancient stream. Proceeding southward to the mouth of the east branch, which flows in a narrow lateral valley, the main valley is a mile wide, with an alluvial flat on the east side which is underlaid by a sandy loam, and partly covered with willows, while on the west side of the river a low sparsely wooded terrace half a mile in width extends along the foot of the bank. The Indians allege that at this point, huge bones were found at the bottom of a land-slide and were brought to the officer in charge at Fort Pelly, by whom they were forwarded to England. Hon. W. J. Christie, of Brockville, Ont., who was in charge of Fort Pelly at the time, informs me that the bones were shoulder blades, and that in 1853, some years after the first bones were brought in, he visited the place, "and examined the spot carefully where the blade was taken out of the river at low water. A land-slip had occurred from the bank and carried the bones into the river. I found from cross-questioning my

Shell River flowing southward.

Bones of Mastodon.

Bones of Mastodon.

guide, that the Indians had collected the bones, and burnt them on the bank, from superstition, and buried what would not burn. I examined the spot where they had buried the bones, but what remained crumbled to pieces when touched."

These bones, consisting of a pair of mutilated scapulæ of a fossil elephant, were submitted to Sir John Richardson for examination. He first described them as belonging to a new species which he named *Elephas Rupertianus*, but afterwards identified them as belonging probably to *Mastodon giganteus*. His descriptions are not generally known, and will be of interest here.

Description by Sir John Richardson.

"The scapulæ are right and left, and, being of the same size, were most likely members of the same individual. The broad ends of the blade in both are wanting, and most of the spinal ridge. On comparing what remains with scapulæ from Eschscholtz Bay, and with the homologous bone of the *Elephas primigenius* in the British Museum, I find that these fragments differ in possessing a well-marked depression between the humeral end of the ridge and the anconal edge of the bone. This depression is 4½ inches long, and has an abrupt edge, upwards of an inch deep, next the spinal ridge, but gradually passes into the flat bone in other directions.

The length of the glenoid cavity is	9·1 inches.
Its breadth	5·5
The space between the depression and the acromial edge of the bone where narrowest is	4·0
Length of the largest fragment	17·5

"The probability is that the Swan River (Swan River district) bones belonged to the *Mastodon giganteus*, and that the range of that species must be extended northward in Rupert's Land to the fifty-second parallel of latitude."*

For four miles below the mouth of the east branch the valley appears to be less definite, and being more or less wooded its characteristics are more difficult to make out in a running examination.

Valley deepens.

Turning south-south-eastward from the point where a pack-trail from Coté's Reserve crosses the river, the valley is moderately straight for seven miles, and its banks quickly increase to 200 feet in height. On the west side of the valley a terrace rises to the height of 100 feet, but its eastern face, instead of being abrupt, is sloping and grassy or dotted with a few scattered Banksian pines, the top of the terrace is covered

*The Zoology (of the) Voyage of H.M.S. Herald; Vertebrals, including Fossil Mammals, by Sir John Richardson, pp. 101-102 and 141-142, 4to, London, 1854.
Also Proc. Bost. Soc. Nat. Hist., Vol. 5, (1854) p. 82.
And Am. Jour. Sci., Vol. 19 (1855) pp. 131-2.

with spruce and poplar, the most of which has, however, been lately destroyed by fire.

Turning now towards the south-west for seven miles the valley shows a beautiful series of terraces reaching up on either side to near the tops of the banks, those on the north side being grassy and open, while those on the south side are covered with poplar. Close to the river the bottom of the valley is often wooded with spruce and tamarack. These terraces consist of water-worn gravel, the brows of the higher ones being scattered with boulders of gneiss. The lowest one is generally wide, and smooth, and reaches to near the bank of the stream. Terraces.

At the end of the above distance, the river sweeps round to the left and for ten miles flows in a south-easterly direction, at right angles to the course that it has just been following. A high gravel terrace runs round the outer side of the bend for a considerable distance, and before it is entirely cut away, it reappears as a beautiful wide open bench on the opposite side of the river. Throughout the whole of the distance that the river keeps this south-easterly course the banks are very regular, being composed entirely of high terraces, the upper one of which extends back a considerable distance to the higher land behind. Near the southern end of this straight stretch slight exposures of clay are seen in the banks on opposite sides of the valley, that on the east side, which was more closely examined, showing six feet of unstratified light gray sandy clay holding striated pebbles, overlaid by three feet of stratified water-worn gravel. Also in a gully at the bend of the stream a slide has very imperfectly exposed about thirty feet of light gray and yellowish clay and sand, the upper part being a fine slate gray clay, while below it is a yellowish slightly clayey sand. The face of the bank is covered with slidden pebbles, some almost round and others very irregular, of limestone much striated, quartzite occasionally striated, gneiss and ironstone. Till and gravel

Now turning at right angles the valley continues for seven miles in a south-westerly direction. It is wide and open, bending in long sweeping curves. The inner sides of the curves rise in many grass-covered gravel terraces to 120 feet above the river. The banks are moderately well defined, scored by small lateral gulleys, but are nowhere cut into rounded hills separated by deep basin-shaped depressions, as they are below the next bend. The brows and often the tops of the higher terraces are generally strewn with gneissoid boulders.

At the end of the course towards the south-west, the river again bends round to the left, and for eleven miles flows in a general direction S. 30° E. The character of the valley now suddenly changes. It is sometimes as much as two miles wide, and its banks are very irregular Uneven banks.

and from 200 to 300 feet high. At first, gravel flats and low terraces continue down the centre of the valley, and the sides are rough, or with a skirt of rough rounded hills under the brow of the main bank. In some places wide terraces stretch out towards the river, and deep "kettle-holes" are found in the otherwise level bench, beyond which again may be a ridge of rounded hills thickly covered with gneissoid boulders. Near the crossing of the north line of Township 26, the sides of the valley are fringed with these rounded hills. On the east side, the river cuts into one of them, and though the exposure is very largely hidden by slides, yet at the height of sixty feet above the water there can be seen eight feet of light yellowish-gray unstratified slightly sandy clay, holding pebbles of gneiss and limestone, the latter of which are all plainly striated. Springs of water are running from the bottom of the bank, and as the above described boulder-clay is seldom sufficiently porous to allow water to flow through it, it is probable that the Cretaceous shales may here be found under the boulder-clay and above the level of the bottom of the valley.

Moraine.

For a mile and a half further down the valley the river flows through a wide gravel plain, and then the rounded drift hills, thickly strewn with boulders, close in from both sides and choke the valley, the river cutting a comparatively narrow channel through them. Below this barrier the drift hills are confined to the east side of the river, and from their base a wide alluvial plain stretches across the valley, above which, on the west side, gravel terraces very soon begin to rise. The hilly country extends for a considerable distance back from the river towards the east. The river cuts into the side of one of the hills, and shows it to be composed of unstratified till, against which on both sides stratified river gravels are lying horizontally. This hilly ridge which has thus been seen to run very obliquely across the deep valley of Shell River would seem to be an old moraine left by the continental glacier in one of the later glacial periods, or by a lobe of it which occupied the valley of the Assiniboine.

From the south end of this course of the river, a narrow valley with its bottom occupied by small lakes or marshes, continues southward but drains northward into Shell River.

Short Creek.

Another deep narrow valley also turns off to the east, in which Short Creek begins to flow eastward to Valley River. It is at first clearly defined, with steep banks 150 feet high and about three-eighths of a mile apart on the top. The bottom is a marshy flat. Deep narrow gullies join it from both sides, out of one of which the creek takes its rise. A short distance west of this gully the sides of the valley have been washed down causing a dam which forms the watershed between

the waters flowing to the east and to the west. The lower part of the valley of Short Creek is wider and much more sloping, with banks cut into rounded knolls, and generally covered with gneissoid boulders. The difference between the two parts of the valley is very abrupt and striking, showing the eastern portion to be a much older drainage channel than the steep narrow portion further west. The newer part of the valley has probably been excavated by the waters of the upper Shell River, which found their way along the east side of the morainic ridge just described, and thence flowed eastward down Short Creek into the west side of Lake Agassiz.

Lower portion of river.

Turning westward from the point where these valleys join, Shell River flows almost due west for five miles, then south seventeen miles, and then north-west four miles to its mouth. The valley throughout this distance maintains very much the same character as before, except that it is generally wider and becomes much deeper towards its mouth. High terraces rise on either side, the upper one of which on the north side extends back one to two miles before the main bank is reached. At the bend towards the south the valley is two miles wide and on the inner side of the curve, gravel terraces rise to a height of 140 feet above the river. The brows of these terraces are, as before, often thickly strewn with large gneissoid boulders. About section 15, township 24, the valley is again more than a mile and a half wide and the east bank rises in five well-defined terraces, which are respectively about 30, 75, 125, 170 and 180 feet above the river. Above the top of these, the bank again rises 120 feet to the level of the surrounding country. In section 34, township 25, the highest gravel bench on the south-east side of the valley is 100 feet above the river and is thickly strewn with boulders. It differs from the terraces in most parts of the valley, however, in not having a level surface. Its middle line is the highest, and from this line it declines from ten to fifteen feet towards each side, in the one direction to the brow of the terrace, from which it descends sharply to the bench below, and in the opposite direction to abut sharply against the side of the valley, which rises high above it. This latter depression probably indicates an ancient channel of the river when the bottom of the valley was at the height of this terrace.

Five terraces.

Asessippi.

At Asessippi, where the river finally bends towards the north-west to join the Assiniboine, several well-defined terraces occupy the north side of the valley, the highest of which is 185 feet above the level of the river at the mill-dams. The top of the bank of the valley on this side is 250 feet high, north of which, for several miles is a small area between the Shell and Assiniboine Rivers, covered

with alluvial sandy deposits, indicating the existence of a former lake at the junction of these two streams.

The south bank of the valley at Asessippi is more than 100 feet higher than the north bank, is very steep and largely covered with land-slides. As far as can be seen, it consists of unstratified glacial till, but it is not improbable that the bottom of the bank, if uncovered, would be found to be composed of Cretaceous shales.

A description has thus been given, in greater or less detail, of the principal one of these old glacial valleys cutting through the Duck Mountain. Between the Shell River and the Assiniboine, however, there is a plexus of similar valleys which was crossed in several places. It is now drained by the Little Boggy and Big Boggy creeks and a small brook flowing into Shell River.

Big Boggy Creek.

Big Boggy Creek, at the crossing of the Fort Pelly trail, is a small stream twelve feet wide and one foot deep, with a bed of rounded pebbles. Its valley is 180 feet deep. The north side is rough and uneven, its character being in all probability determined both by former terraces and old land-slides. On the south side a sandy flood-plain forms the top of the bank and lies only a few feet below the surrounding more irregular country. The next point where this valley was seen was in section 29, township 28, on the cart-trail from Côté's Reserve to Angling Lakes. The creek is here four feet wide and two feet deep, and flows through a very swampy bottom. The banks of the valley are 145 feet high and very abrupt. On the eastern side of the valley is a beautiful grassy flood-plain or terrace, underlaid by water-worn gravel, which stretches a long distance towards the south, and half a mile back from the brink of the valley. To the west the country is scattered over with boulders and is underlaid by a light coloured fine silt including pebbles. The boulders are especially numerous on the tops of the pointed knolls that lie along the face and summit of the escarpment which faces towards the west and overlooks the apparently level plain of the Assiniboine below. From the point where the Angling Lakes trail leaves the river, the valley continues in a northerly direction, and our guide stated that it united with that of Little Boggy Creek.

Little Boggy Creek.

At the crossing of the Port Pelly trail, Little Boggy Creek is a small stream fifteen feet wide and one foot and a half deep. It is thus seen to be much larger than the Big Boggy, the first adjectives referring rather to the amount of swamp on the banks of these little streams than to the size of the streams themselves. Two and a half miles east of the trail crossing, Little Boggy Creek flows from a wide valley about 200 feet deep at its mouth. Seven miles further

in a north-north-easterly direction, at the crossing of the western boundary of Manitoba, it is stated by J. P. O'Hanly to be 260 feet deep, and my half-breed guide also stated that it then turned south-eastward and joined a similar deep valley that carries a small stream into Shell River in Lat. 51° 31′. From the western mouth of the valley the Little Boggy now sweeps round towards the north, but the ancient stream would appear to have turned southward into a deep swampy valley, through which it found its way to the Assiniboine.

ASSINIBOINE RIVER.

Source. The Assiniboine River rises near the head waters of Red Deer River, and flowing south-eastward, crosses the Second Initial Meridian close to Fort Pelly.

From here it was descended in a canoe by the writer in June, 1890, but as its valley has already been described by S. J. Dawson, Prof. J. Macoun, Dr. R. Bell, and others, it will not be necessary to mention anything but its geology, and a few points in reference to its history as a trade route.

Descent in 1890. Our boat, a small Osgoode canvas canoe, was put in the river in June, 1890, opposite Fort Pelly, and the river was descended to Portage la Prairie, thirty days being occupied on the trip.

Fort Pelly. Fort Pelly is situated on rising sandy ground on the east side of the river, and is a large well-built fort protected by a high fence or wall of sawn planks. Over the heavy gate in front is a stout bastion, from the top of which a magnificent view can be had of the surrounding country. This fort was built by the Honourable W. J. Christie, Chief Factor of the Hudson's Bay Company, in 1856-57, while previous to that date the fort had stood on lower land 500 yards distant in a direction N. 65° W., where there is a low sandy ridge rising six feet above the general level of the bottom of the valley. The site of the old fort is now marked by ten pits in three rows, and a few small boulders.

Pierre shales. Three miles in a direct line below Fort Pelly the west bank of the river is twenty-five feet high, and is thickly strewn with nodules of iron-stone and boulders of limestone and gneiss. The upper part of the bank is a dark gray till, below which is two feet of Lower Pierre (Millwood) shales, consisting of a brownish-gray soft clay shale, weathering into a soft light gray clay. This shale contains a number of light gray nodules of ferruginous limestone, but no traces of fossils could be found.

Boulder of Dakota sandstone. At a fish-weir, a quarter of a mile further down the stream, a large spherical or hemispherical nodule of Dakota sandstone, like those out-

Boulder of Dakota sandstone.

cropping on Kettle Hill south of Swan Lake, is lying at the foot of the bank, having evidently fallen out of the till. The nearest point at which the Dakota sandstone outcrops is in the banks of Swan River not far from the mouth of Tamarack Creek, forty-two miles distant in a direction N. 50° E. and at an elevation of 1,025 feet above the sea. This formation is believed not to outcrop at a higher elevation than 1,125 feet above the sea anywhere on the whole face of the Manitoba escarpment. The place where the boulder is now lying has an approximate elevation of 1,475 feet or 450 feet above the nearest bed of parent rock, or 350 feet above any outcrop of the rock, for there is every reason to suppose that there are no exposures of the Dakota formation to the west of Fort Pelly until the disturbed strata in the vicinity of the Rocky Mountains are reached.

Its journey.

The boulder has therefore been carried up the Swan River valley in a south-westerly direction, for at least forty-two miles, by the Swan River lobe of the Winnipeg glacier, rising in the distance travelled at least 350 feet.

Alluvial banks.

From this point to the mouth of White Sand River the banks are generally stratified alluvial sand or clay, with here and there a slight exposure of Lower Pierre shales holding ironstone nodules. The river begins with a width of about fifty feet and a swift current, with sandy points stretching into the stream on the concave sides of the bends, and the channel much obstructed by snags and boulders, but it gradually increases to a width of 120 feet, becomes more sluggish, and the inner sides of the bends are rounded and covered with long-leaved willow.

White Sand River.

White Sand Creek is a stream thirty feet wide and three feet deep, with a perceptible current to its mouth.

From White Sand to Little Boggy Creek the river is generally deep with a sluggish current, and with a few slight rapids at the bends. The banks of the channel are ten to fifteen feet high, of alluvial clay, while the sloping banks of the valley are thinly scattered with boulders.

Little Boggy Creek, about fifteen feet wide, flows through a wide alluvial meadow to its mouth. Above this meadow it flows through a moderately level plain, with a mean elevation of 1,540 feet, rising

High terrace.

gently to the foot of a terrace along the base of Duck Mountain. North of Little Boggy Creek this latter terrace is a mile and a half wide, extends for a long distance to the north, and has a mean elevation of 1,700 feet above the sea. To the eastward, Duck Mountain rises as a long undulating slope, the nearest parts of which are only lightly wooded.

Crow's Stand.

From the upper terrace an elongated hill or ridge, known as the "Crow's Stand," rises abruptly to a height of 120 feet. This hill is

lenticular in shape and trends N. 25° W. and S. 25° E. Its north-west end and both sides are very steep, and its top is rounded, but may be said to be fifty feet wide. Its highest point is close to its north-west end, whence it slopes very gradually S. 25° E. for half a mile and then dips more rapidly to the general level. There are no cuts or breaks in the surface of this hill to show its true character, but its summit is sandy, and scattered with large boulders of gneiss and dolomite, while its sides are gravelly and its whole surface is too barren to grow any timber. It has therefore every appearance of being a drumlin or ridge of sand, gravel and boulders formed beneath the ice when this whole valley, stretching westward from the foot of the Duck Mountain, was filled with a glacier. Drumlin.

The terraces were then formed on the shore of the lake, elsewhere called Lake Assiniboine, that occupied this basin when the glacier withdrew from it. Throughout the whole of the way from Little Boggy Creek to Fort Pelly the cart-trail is on the bed of this ancient lake. Ancient lake.

Below Little Boggy Creek the valley of the Assiniboine River becomes deeper and more sharply defined, and its sides are generally wooded, while the bottom-land is either wooded or open. Scarped banks are occasionally seen, composed of Pierre shale with ironstone nodules, or gray till. Several spring creeks join the river from the east in this stretch.

About the middle of the east side of the S.W. ¼ section of Section 14, Township 28, Range 31, are the ruins of an old trading post of the North-west Company. It stood in the bottom of the valley 500 paces east of the river, and fifty paces from the foot of a wooded bank, at the mouth of a dry ravine, on lightly sloping land thirty-five feet above the river. The post was built by Mr. Cuthbert Grant, one of the traders of the North-west Company, previous to the close of the year 1793, and for many years did a large trade in beaver and otter.* Cuthbert Grant's house.

The fort or trading post appears to have covered about a quarter of an acre, in which area are six pits that doubtless represent the old cellars. Beside one of the largest is a heap of boulders that were formerly built into the fireplace of the largest of the houses.

A mile to the south of the old fort, the west bank of the valley is 240 feet high, on the top of which is a level sandy plain stretching out on both sides of the river. On the brow of the bank, a few boulders of gneiss are lying, while below it is a scarped bank forty feet high, apparently composed throughout of reddish sand with a few pebbles. Below Sandy banks.

* The Red River, by J. McDonell. L. R. Masson, Vol. I., pp. 275-285. Montreal, 1888.

this, the hillside is very rough and uneven, the banks, having fallen in a succession of slides, leaving small trough-like valleys above and behind each other. The surface of the slides are sand, but they are doubtless sliding on the soft Pierre shales.

Three miles further south on the east side of the river, a clear brook of cool water six feet wide and six inches deep flows from a wide open valley. The original bottom of this valley is about 120 feet above the bottom of the valley of the Assiniboine. Close to its mouth the brook has cut a V-shaped gorge down through this old bottom land, leaving rugged hills, on the top of which the old terrace can occasionally be detected. On the opposite side of the Assiniboine valley is a sloping terrace at about the same height.

V-shaped gorge.

Two miles further down the Assiniboine, a wide valley drained by a small stream known as "Two Creeks," joins the main valley from the north-west. The valley of the Assiniboine immediately changes its direction towards the south-east, assuming the direction of the valley of Two Creeks. At the same time it has more extensive bottom lands, and the stream which has been sluggish for a long distance, becomes somewhat more rapid. Elm trees are seen in the valley here for the first time.

Two Creeks.

The valley maintains the same character for ten miles, to the mouth of Big Boggy Creek. Many small rills flow down the slopes into the river, and bare slidden banks near the brim of the valley attest to the presence here of the bed of sand previously seen, from under which the rills probably have their sources. The Pierre shales were seen in very few places.

Many springs.

Big Boggy Creek at its mouth is thirteen feet wide and two feet deep with a current of a mile an hour. It flows from a wide valley, the bottom of which seems to be about fifty feet above the level of this river, but like the stream described above, it has cut a narrow V-shaped gorge in the old floor of this valley in descending to its mouth.

Big Boggy Creek.

Below the mouth of Big Boggy Creek the river turns again to the south. It is 100 to 120 feet wide and flows with an easy current. The east side of the valley is generally wooded, while the west side is often bare, or dotted with groves of small poplars. The banks of the channel consist of alluvial sand, but at a few of the outer bends large boulders give evidence of the presence of till, and nodules of ironstone show that the Pierre shales are not far away.

Just south of the middle of Township 25, Range 29, where the valley is 240 feet deep, the higher parts of the east bank show some interesting exposures of till and stratified sands, &c. At one point, below three feet of stratified sand at the surface, are fourteen feet of brownish-gray

Upper and lower till.

unstratified till, holding a number of boulders of gneiss and limestone, many of which are striated by glacier action. In another section twenty-five feet of till were shown. The upper six feet are here separated by a distinguishable colour-line from the lower. Along this line most of the boulders are lying, and in one place the two tills are separated by a thin lenticular bed of sand and gravel. It is also interesting to note that the boulders are all smoothed and striated on the upper surface, while many of them are otherwise rough. The boulders are imbedded for the greater part of their depth in the lower harder till, and when they are undisturbed the striæ appear to trend in a constant direction, viz., S. 75°—80° E.

Pavement of striated boulders.

A similar observation was made on boulders imbedded in the surface of the till near the bank of Silver Creek, a mile east of Binscarth. The place was a borrow-pit north of the railway track, in which many boulders were lying about. All of these were seen to be well polished and striated on one side. Twelve boulders were found in place in the till, and in all the upper surfaces were smoothed, striated and horizontal. The striæ were parallel throughout, trending S. 45° — 55° E. They had the same character, and had clearly been formed in the same way, as the striæ on the limestone surfaces around the great lakes to the north-east. The whole surface of the older till had been passed over by the glacier of the Assiniboine valley moving south-eastward, and the hard boulders had retained the striæ.

Boulders at Silver Creek.

From the above point to the mouth of Shell River the river is from 150 to 200 feet wide, with a very easy current. The banks of its channel are six to ten feet high and composed of stratified alluvial deposits. Wide grassy bottom lands with occasional groves of elm extend across the valley, whose sides are generally also grassy or dotted with groves of poplar in the little ravines. Some nodules of ironstone with a few crystals of selenite are lying on the slopes, having been weathered out of the underlying Pierre shales.

Sloping valley

Shell River flows with a swift current out of a wide V-shaped valley, and across a level flat through a beautiful grove of large elms.

From the mouth of Shell River to the village of Shellmouth the river is rapid; sand and gravel bars stretch out from the points into the stream. In places a wide meadow land fills the bottom of the valley, and in other places a terrace thirty feet above the river skirts its banks to the north. This is the first terrace seen in the valley since leaving the mouth of Little Boggy Creek.

Rapids.

In this piece of river an old location of the Canadian Pacific Railway crosses the valley, the bottom of which is stated upon the profile to be 1,335 feet above the sea.

Old C.P.R.

Shellmouth.

The small village of Shellmouth is situated on the east side of the river, where five beautiful open terraces form a series of steps up the side of the valley.

The country on the top of the bank, about 230 feet above the river, is level and underlaid by sand and gravel with a few boulders, which latter are found in greatest number along the brow of the hill. Here a few stunted oaks are growing. Descending a scrubby slope for 100 feet, a sandy terrace is reached, 625 paces wide on the trail, on which there are no pebbles or large boulders except along its brow, where the land is three or four feet higher than that behind, forming a ridge on which a large number of boulders are scattered. This ridge is precisely similar to the present bank of the river in many places, where the lands back from the stream descend several feet to a hay meadow.

Terraces 130, 95, 80, 55 and 25 feet above the river.

From the brow of this terrace a long slope descends to a sandy flat, the whole distance on the road being 500 paces. The brow of this flat, which is thirty-five feet below the last, or ninety-five feet above the river, is strewn with many small rounded and water-worn boulders up to one foot in greatest diameter. Four hundred paces further west along the road brings one to the edge of a similar terrace eighty feet above the river. The land is mostly sand, but a pit three feet deep on the edge of a terrace shows it to be composed of rounded water-worn gravel, with rounded boulders of gneiss up to eighteen inches in greatest diameter. The gravel shows little or no sign of stratification.

Two hundred and thirty paces, for the most part down a gentle slope, brings one to the edge of a terrace fifty-five feet above the river, and again 225 paces lead to the edge of a low terrace close to the river, fifteen feet above the bottom land, and twenty-five feet above the water.

West bank steep.

The west bank of the valley rises steeply from the alluvial bottom land without any sign of terraces, and at no other place in the whole Assiniboine valley are terraces so beautifully shown as they are at Shellmouth.

For the rest of the distance to Millwood, which is situated five miles south of the limit of the present map, the river is very similar in character throughout.

Lightly undulating country.

Ascending the east side of the valley a mile north of the mouth of Skunk Creek, the country is generally level, though in detail lightly undulating. The surface is sandy and through the sand are scattered a few pebbles, but no boulders. Standing on the brow of the hill lovely prospects of the valley extend to the right and left. The sides are steep and more or less irregular, having been fashioned by ancient land-slides that are now overgrown with grass or coppice, form-

ing a declining series of little rounded or elongated knolls, some of which carry a few small oak trees. No terraces are present here, but one can be seen above the mouth of Thunder Creek. Between the hill-sides, lies a beautiful green alluvial floor half a mile wide through which the river winds, its banks thinly fringed with poplar, elm or willow.

Till. At the top of the bank is a land-slide showing in descending order one foot of sandy loam underlaid by a thin irregular stratum of pebbles and small boulders. Then six feet of a light yellowish-gray unstratified till containing pebbles up to the size of the fist, many of which show clear glacial striæ. Below this is a lenticular mass, fifty feet or more in length, tapering off to both ends, and eight feet thick in the middle, of very irregularly stratified sand and gravel, into which are projecting at the ends bands of unstratified till. The upper part, having a thickness of four feet in the middle, is a soft sand or fine gravel, while the lower four feet is much more compact, and is more closely allied to the till. The whole deposit has possibly been formed by a stream flowing under the ice of the glacier. It is underlaid by at least three feet of light gray till. Lower down the bank Pierre shales were seen.

Included mass of gravel.

A short distance to the south, Smith and Skunk creeks flow into the Assiniboine nearly opposite to each other, the former having deposited a little bar of gravel at its mouth. Skunk Creek has formerly cut out a wide valley, and at and below its mouth the alluvial banks of the river are composed to a considerable extent of stratified gravel, the pebbles of which consist of light gray Odanah (Upper Pierre) shale, which has been washed out of this valley. These gravels are the first indication seen on the river of the presence of Odanah shale on the adjoining higher land. The shale is mixed with many very perfect shells of Unios, pieces of buffalo bones, &c.

Odanah shale.

Millwood shale. Millwood. A short distance below Skunk Creek several exposures of Pierre (Millwood) shales were seen in the banks, but it is not until the village of Millwood is reached, five miles south of the limit of the map which accompanies this report, that a good section can be obtained. Here the Manitoba and North-western Railway crosses the valley, and its many deep cuttings show in all more than 200 feet of a very homogeneous dark-greenish gray clay shale with nodules of calcareous ironstone. Some of these nodules show cone in cone structure, and others contain such typical Pierre fossils as *Scaphites nodosus*, var. *quadrangularis*, *Lucina occidentalis*, *Baculites compressus*, *Pteria linguiformis*, *Inoceramus tenuilineatus*, *I. Sagensis*, var. *Nebrascensis* *Nucula* sp., *Dentalium gracile?*, elytron of *Hylobiites cretaceus* and fragments of fishes.

The lower part of the bank is covered, but probably consists of similar shale, and a well dug by the railway on the flat to a depth of 100 feet, is said to have passed to the bottom through similar shale to that in the bank. This would give a thickness of 350 feet of Lower Pierre (Millwood) shales.

The bed of the river at Millwood is 1,309 feet above the sea.

Wells. West of the valley, along the railway track, the wells dug by the railway company give some interesting sections.

Harrowby. At Harrowby, just on the top of the west bank, the surface is 1,593 feet above the sea, and a well has been dug on a high alluvial plain or terrace that extends from half a mile to a mile back on both sides of the river. It is 100 feet deep; the upper eight feet passes through stratified sand, and the remaining ninety-two feet through dark gray Millwood shales holding large round and dumb-bell shaped concretions of ironstone. Seven miles further west, near the crossing of the old Ellice and Pelly trail, the surface is 1,640 feet above sea level, and a well was dug 163 feet entirely through gray till, to a bed of gravel from which a plentiful supply of water was obtained. The till holds many pebbles and small boulders of gneiss and limestone, most of which are more or less polished and striated.

Langenburg. At Langenburg, where the surface is 1,681 feet above the sea level, a well was dug to a depth of 175 feet, the log stating that 165 feet was through clay and ten feet through sand. The material around the mouth of the well was examined, and found to be a bluish clay, apparently mostly derived from the Millwood shales. It is mixed with small pebbles, and a few boulders of gneiss and limestone, the latter of which are beautifully polished and striated.

Churchbridge. At Churchbridge, where the elevation is 1,740 feet, a well six feet in diameter was dug to a depth of 267 feet. The following is the log as received from G. H. Webster, C.E., engineer of the railway:

Description of material passed through.	Thickness of bed.	Depth of bottom of bed from surface.	Height above sea.
1. Sandy loam	8	8	1,732
2. Clay, with gravel and small stones	12	20	1,720
3. Gray sand	2	22	1,718
4. Rocks and clay, about all rocks	3	25	1,715
5. Blue clay and small stones	7	32	1,708
6. Gray sand	1	33	1,707
7. Soft blue clay with layers of sand 1 inch thick about every 2 feet. No pebbles or boulders	234	267	1,473

In bed No. 5 water was obtained at thirty feet, rising one foot in twelve hours.

In No. 7 small springs of water were struck at eighty and 250 feet. At a depth of 200 feet a well preserved piece of wood six inches in length was found, and has been described by Prof. D. B. Penhallow as a new species of larch under the name *Larix Churchbridgensis.** The same species was also found in southern Manitoba in post-glacial deposits.

This well has not been visited by the writer, but the beds from 2 to 5 would appear to be quite certainly glacial till, while No. 7 would appear to be a great thickness of inter-glacial (or possibly pre-glacial) clays which have been deposited in a valley or lake basin, before the final advance of the ice which distributed the uppermost till, and striated the surfaces of the boulders imbedded in the lower till.

Bird Tail Creek.

A deposit of similar age is shown in the railway cuttings on the east side of the valley of Bird Tail Creek, where twenty-five feet of stratified sand and gravel is overlaid by twenty-five feet of unstratified till with striated pebbles and boulders.

Russell.

At Russell, a terminus of the Manitoba and North-western Railway, six miles east of the Assiniboine, and 1,830 feet above the sea, the country is all thickly covered with drift. A well half a mile south of the station was dug through 100 feet of light gray till, in which were some polished and striated boulders of gneiss 2 x 4 feet in diameter. 400 yards further east in a light rise, the till was but a few feet in depth, below which the light gray Odanah shales were met with.

Barnardo farm.

At Dr. Barnardo's farm, three miles W.S.W. of Russell, and at about the same elevation, a well has been dug 170 feet through the light gray Odanah shales to the top of the soft dark Millwood shales. This would place the base of the Odanah series here at an elevation of about 1,660 feet above the sea. The surface is irregularly undulating, and here and there are ridges of gravel, often interstratified with till, which have probably been formed beneath the ice of the great glacier of the Assiniboine valley.

*A new species of Larix from the Interglacial of Manitoba. By D. P. Penhallow Am. Geol., Vol. IX. p. 368, June, 1892.

DESCRIPTIVE GEOLOGY.

Formations.

The geological terranes referred to in this and the preceding chapter are shown in descending order in the following scheme :—

Recent.
Post-Tertiary—
  Champlain.
  Glacial.
Cretaceous—
  Pierre.
    Odanah.
    Millwood.
  Niobrara.
  Benton.
  Dakota.
Devonian—
  Upper Devonian or Manitoban.
  Middle Devonian or Winnipegosan.
  Lower Devonian, covered or absent.
Silurian—
  Niagara.

Fuller descriptions of these terranes are given in the succeeding chapter on Systematic Geology.

SASKATCHEWAN RIVER.

Mouth of river.

Ascending the Saskatchewan River from the point where it empties into the west side of Lake Winnipeg, the banks for a short distance are low, but they almost immediately rise to a height of fifteen feet and maintain this height up to the foot of the rapids at a distance of two miles and a half from the lake. They are generally sloping and covered with grass, but they appear to be composed entirely of a light yellowish-gray till, while the little beach at the foot of the abruptly sloping bank is strewn with many irregular fragments of white limestone.

Abandoned channel.

Just above the Hudson's Bay Company's post, on the west bank of the river, an old abandoned channel joins the main course of the stream. It varies considerably in width, from a quarter of a mile at its mouth to about 200 yards a mile further to the south, where it again joins the main channel of the river. At this latter point its bed was five feet above the level of the surface of the river in August, 1890. A short

distance from the upper end of the channel a small stream begins to flow down the channel, and after babbling through and among the irregular angular stones with which its floor is covered, falls into the bay at its mouth. In seasons of flood some of the water of the river is said still to flow down this channel. Its banks are from forty to fifty feet high, but are throughout covered with trees or deciduous plants.

On the east side of the old island, which is cut off by this abandoned channel from the high land to the west of it, the river is in some places still cutting down its bank. At one place, a few hundred yards below the head of the old channel, a low exposure of Niagara limestone is seen close to the edge of the river, rising at its highest point to two feet above the water. Its bedding is essentially horizontal, and its surface is smooth and glaciated with strongly marked parallel grooves bearing S. 2° W.

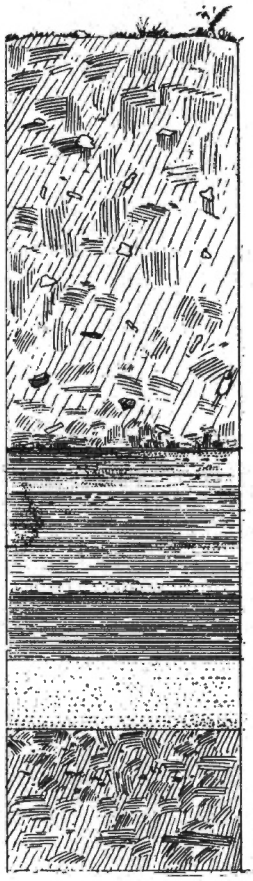
Niagara limestone.

The rock consists of a brecciated magnesian limestone, the pebbles in which are milk-white, very compact, though rather soft, and highly argillaceous, breaking with a vitreous fracture. The matrix, which is much harder but less compact, and often slightly porous, is yellowish-gray, and breaks with a stony fracture. The rock is rather thinly, but irregularly bedded, and along the edge of the water weathers to a light yellow, while the upper part away from the water weathers to bluish-gray. No fossils were found in this band.

Pleistocene beds.

A little further south on the same side of the island a scarped and springy bank thirty-five feet high shows the section of the Pleistocene deposits represented on the following page. The face of the upper portion of the cliff weathers to a milk white. The line between the upper till and the stratified clay is not very sharp, the one appearing to merge almost imperceptibly into the other, while the pebbles become larger and fewer in descending to where the clay is more distinctly stratified. The sand below the clay is very fine at the top, and passes downwards into a fine gravel. The lowest bed of till is partially covered with debris, but both the top and bottom were clearly seen.

Section of Pleistocene at Grand Rapids.



A considerable flow of water rises from the band of sandstone, and the bank below it is generally covered with debris consisting largely of angular fragments of limestone, much of which is derived from close at hand.

The rest of the west bank of this old island, with the exception of the low outcrop of Niagara limestone mentioned above, is covered with debris from these surface deposits, and boulders and pebbles are scattered along the edge of the water. One very large boulder of limestone, fifteen feet in length, is lying in place on the glaciated surface of the limestone, still partly imbedded in the bottom of the

till. It is strongly glaciated, its sides being everywhere scored with striæ.

Following the north bank of the river above the upper end of the old channel to the first prominent point, a thick-bedded buff-coloured dolomite crops out at the edge of the water, holding a large number of *Pentamerus decussatus*, and then crossing to the south side of the river, in a direction 25° south of east the Pentamerus band is again seen with a thickness of two feet. It is exposed at the top of a little cliff, and is underlaid by nine feet of whitish moderately thin-bedded unfossiliferous dolomite. One foot at the bottom is more yellowish and a little thicker bedded than the rest. The brecciated zone is not seen, but is doubtless but little below the beds seen in this cliff. Pentamerus zone.

In the Pentamerus band at the top of the exposure *Pentamerus decussatus* is very abundant, and the following other fossils are found associated with it, viz.: *Favosites Niagarensis, Alveolites Niagarensis, Lyellia papillata? Halysites catenulatus, Orthis* sp., *Euomphalus* sp.

Following up the south bank of the river for a quarter of a mile, the Pentamerus band, which has a total thickness of from three to four feet, disappears beneath the level of the water, and the cliff dies away and leaves a willow flat that may be the lower end of an old channel on the south side of the river. In one place, however, east of this flat the Pentamerus band is overlaid by three feet of white moderately thin-bedded limestone. Continuing to ascend the course of the stream, soft yellow or white argillaceous limestones are occasionally exposed on both banks up to within a short distance of the foot of the old portage. It is difficult to give an exact section of these beds, as where they are unprotected by overlying harder rocks they have been more or less completely removed during Pleistocene times, and where so protected the foot of the cliff is buried in a talus of angular fragments from the dolomite above. They would appear to be from forty to fifty feet thick, and the following is the ascending section as seen, the width of the first gap being uncertain. Section below old portage.

Three feet of white moderately thin-bedded limestone (mentioned above).

Ten ? feet covered.

Eight feet of a soft light yellow argillaceous limestone, generally porous and containing a large number of impressions of salt crystals. In places the bedding is moderately even and horizontal, but generally it is hardly discernable and the rock breaks into very irregular lumpy pieces. Lying on the shore, and apparently derived from this band, are some nodules of marcasite, and red masses of iron-stone.

Fossils are not plentiful on the south side of the river where this band is best exposed, but a low exposure on the north bank that seems to be a continuation of that on the south bank contains *Strophomena acanthoptera, Leptocœlia* and *Leperditia*.

Six feet covered.

Section below old portage.

Fifteen feet of a thin-bedded white horizontal chalky limestone, in places argillaceous, very light and breaking regularly when struck with the hammer. It has a more or less granular structure, occasionally approaching a sandstone in appearance. One bed near the top was strongly ripple marked, and on the edges of slabs broken from this bed the action of the water that covered these ripple marks is seen to have extended down from an eighth to a quarter of an inch, and to be defined by a moderately even horizontal line. A thin band a few feet below the top was found to contain a considerable number of fossils, among which the following have been recognized:—*Favosites Niagarensis*, *Leptocœlia* sp., *Rhynchonella*, sp., *Pterinea aviculoidea?*, *Pleurotomaria occidens?*, *Pleurotomaria* sp., *Orthoceras* sp., *Gomphoceras parvulum*, *Leperditia cœca*, and *L. Hisingeri*, vars. *egena* and *fabulina*.

Dolomites.

The white Lower Niagara limestone is sharply overlaid by a hard, tough, light yellowish dolomitic limestone, rather indistinctly bedded. It is generally clearly fragmental, and towards the base contains a large number of impressions of salt crystals. Fossils appear to be moderately plentiful, but they are very difficult to break out and consequently few were collected. Crinoid stems are very abundant, and with them were *Favosites Gothlandica*, *Zaphrentis* sp., and *Strophomena acanthoptera*.

This crinoidal limestone has a total thickness of ten feet and grades up into, and is overlaid by from twenty to thirty feet of a hard brittle yellow dolomite, everywhere evenly bedded and often breaking into thin slabs. The only distinct fossil is a large Stromatoporoid, which occurs most abundantly in the upper strata and often gives the surface the appearance of many closely adjoining low domes. The rock is much jointed and breaks with a smooth porcellanous fracture.

Gorge at Grand Rapids

These dolomitic limestones form the sides of the gorge through which the Saskatchewan flows at the Grand Rapids, standing in abrupt cliffs that often overhang the torrent below. On the south side the foot of the cliff is in places piled with a talus of angular fragments, while on the north side it descends abruptly into the water.

Tramway.

At the upper end of the rapids these compact dolomitic limestone are overlaid by a porous yellow dolomite, generally in moderately thin but uneven beds, and containing many impressions of salt crystals. No fossils were obtained here, but on the tramway similar rock is exposed at a number of places near the top of the grade, and at heights rising to forty feet above the level of the top of the compact dolomite at the head of the rapids. It here contains *Lyellia papillata?* and several other species of corals, with some large Stromatoporoids. It is here best exposed in a cut through two gravel ridges on the brow of a long slope facing towards the east.

About half-way across the tramway a slight surface outcrop exposes two feet of horizontal, gray, white-weathering, thick-bedded, tough but

rather porous dolomitic limestone, and immediately adjoining is a coarse breccia, in which the pebbles are derived from the adjoining rock, while the matrix is dolomite containing a large quantity of coarse well-rounded quartz sand. It would appear probable from its very local occurrence that this is a fault breccia, in which case the origin of the sand is an interesting question, as the only sands of the same character known in the region are the St. Peter's Sandstone below the Trenton, and the Dakota Sandstone at the base of the Cretaceous, though the nearest point at which the latter terrane has been actually observed, lies seventy-five miles to the south-west.

As will be seen by referring to page 182, a somewhat similar breccia occurs at Point Wilkins, on the west side of Dawson Bay, the sand in which has undoubtedly been derived from the base of the Cretaceous. As the sand is much more likely to have run down from above, rather than to have been squeezed up from below, its presence here may denote the former existence of the Dakota Sandstone previous to the wearing back by erosion of the great Manitoba escarpment.

River above Grand Rapids

Ascending the river from the upper end of the tramway, the banks are at first low, or rise in cliffs of glacial and alluvial deposits, but at a distance of two miles and three-quarters, Niagara limestone again makes its appearance on both banks of the stream. On the north side it is a thin-bedded, yellowish-gray, compact, dolomitic limestone very like the beds at the Grand Rapids, and like in them, the surface rises in little low domes, probably from the presence of large Stromatoporoids. On the south bank is a cliff eight feet in height of an orange-gray dolomitic limestone, both thin and thick-bedded. It is very hard and compact, many of the loose slabs ringing sharply when struck with the hammer.

Roche-rouge.

Half a mile further up the river a little cliff six feet in height projects into the stream, and the water rushes past its base with considerable velocity. Its top is a small open meadow covered with grass and strawberry vines. It is composed of horizontal, hard, compact, resonant dolomitic limestone, mostly in beds from half to three-quarters of an inch in thickness. Towards the bottom the rock is rather thick-bedded, not so compact and contains Stromatoporoids, Leperditiæ and other fossils. The weathered surface is generally white, but a new fracture is buff, and where it has been heated by forest fires it is a bright red. The fracture is generally stony, but in some of the larger pieces cut by veins of calcite it is conchoidal.

For the next half mile the shore is composed of similar rock, in places rising into little cliffs, and in other places forming a wide flat, strewn with angular fragments torn off by the ice.

Roche-rouge

One bed was found to contain a great number of cavities out of which salt crystals had been dissolved. The salt has originally composed about a sixth of the mass of this bed.

Another stratum, which is often quite red, contains a great number of specimens of *Isochilina grandis*, var. *latimarginata*, with an occasional example of *Leperditia phaseolus*, along with crinoid stems, *Leptocœlia* sp., and the tail of a *Dalmanites?* In contiguous beds were found *Stromatopora?* sp., *Zaphrentis* sp., *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Lyellia papillata?* and *Strophomena acanthoptera*.

Fossils.

A short distance further up the stream a low cliff, half hidden by the woods along the shore, shows at the bottom compact thin-bedded dolomite similar to the last, overlaid by seven feet of thick-bedded yellow porous dolomite, weathering with a rough pitted face. The rock is brought up by a very light anticline in the centre of which six feet of the thin-bedded dolomites are exposed.

The bank of the river north of Roche Rouge Rapids is an abrupt cliff ten to fifteen feet high, and appears to be composed chiefly of white till with boulders, with a narrow ledge of limestone close to the edge of the water.

Cross Lake Rapid.

At the foot of Cross Lake Rapids a rather conspicuous point projects from the south bank and forms a cliff 150 yards long and ten to fourteen feet high. The limestone composing it is practically horizontal. Four feet at the bottom is a compact hard yellowish-gray dolomitic limestone in thin regular beds, and this is overlaid by ten feet of a thicker and less evenly bedded dolomitic limestone. The upper four feet of this latter bed weathers with a moderately even face. The lower six feet, lying above the slaty dolomite, is very uneven in texture, having compact streaks through it, while much of it is soft and rotten, and generally of a lighter colour than the rest; it weathers with a very rough face and often has the appearance of a conglomerate on account of the presence of many nodules that when broken show the structure of Favosites or Stromatopora.

Fossils.

This nodular band contains a considerable number of fossils, of which the following have been recognized: *Stromatopora?* sp., *Calapœcia* sp., *Zaphrentis Racinensis?*, *Cyathoxonia Wisconsensis?*, *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Halysites catenulatus*, *Lyellia papillata?* crinoid stems, a polyzoon, *Trematospira formosa?*, *Murchisonia* sp., *Pleurotomaria Hoyi?*, *Orthoceras* sp., *Isochilina*, sp.

At the upper end of Cross Lake Rapids, where the river flows out of Cross Lake, a very similar cliff forms a prominent feature on the

south shore. It consists of horizontal buff-coloured, dolomitic limestone, the top beds of which are thick, compact, and very hard, while four feet at the bottom are very soft, like the upper beds at the foot of the rapids. The harder beds contain a few imperfectly preserved fossils, and also some large and regularly preserved casts of single crystals of salt.

Cross Lake.

On the south shore of Cross Lake there are many little cliffs of apparently similar limestone. One of these, near the west side, was found to consist of four feet of thick-bedded yellowish, rotten, dolomitic limestone similar to that at the last rapids, and containing a few fossils such as *Stromatopora?* sp., *Favosites Niagarensis*, crinoid stems, *Strophomena acanthoptera*, &c. It is underlaid by compact thinner-bedded dolomitic limestone apparently holding no fossils.

Demi-charge Rapid.

At Demi-charge Rapid similar hard dolomite forms low cliffs on both banks, and just above the rapid a cliff on the south shore rises to a height of from fifteen to twenty feet, composed throughout of light yellowish-gray horizontal dolomitic limestone, both thick and thin-bedded, and generally hard and compact. The only fossil seen was the common *Strophomena*. A little higher up the river a cliff eight feet high faces the stream, above which is a terrace, apparently an old shore line, extending back to the foot of a cliff twelve feet high, and now overgrown with trees. The foot of the lower cliff is strewn with sharp angular fragments broken from its face. The bottom bed is filled with shot-like concretions, which weather into little pits.

On the west side of a small lake-like expansion about a mile and a half further up the stream, a very similar hill is seen with a cliff ten feet high facing the water, and another cliff rising ten feet higher behind a terrace in the poplar woods. The rock at the bottom is a thin-bedded dolomitic limestone, above which is a thick-bedded, rotten, dolomitic limestone, and this again is overlaid by a harder compact evenly bedded dolomitic limestone. Some of the middle beds contain a few fossils such as *Strophomena acanthoptera*, *Rhynchonella*, *Leptocœlia*, &c.

The Narrows.

Also at the north-east point of land below "the Narrows" low cliffs of similar thin-bedded dolomitic limestone occupy the shore for several hundred feet.

Cedar Lake.

South-westward from "the Narrows," which is accounted as the eastern extremity of Cedar Lake, a gradually widening arm extends for twelve miles to the main body of the lake. It is dotted with many beautiful rocky islands, and while the north shore is generally low and wooded, the south shore rises in many places in prominent cliffs from fifteen to twenty-five feet in height.

Rocky islands. The rock on both the islands and the shore is very much the same throughout, consisting of light yellow, very hard and compact dolomitic limestone varying greatly in the thickness of the beds. The base of the cliff is generally covered with a pile of large angular blocks fallen from the thicker beds towards the top. The summits of the cliffs are generally level, but do not show glacial striæ, as they have evidently been eroded by meteoric agencies, while some of the rocky islands that rise but a very few feet above the water, and from whose surface the till has probably been very lately removed, show beautiful glacial striæ bearing S. 18° W. Very few fossils were found in these rocks, the only one that was recognized being the common *Strophomena acanthoptera.*

Fort Island. From Rabbit Point westward, the south shore alone was examined, and no Palæozoic rocks were seen between that point and Fort Island. At the north point of this island a little vertical cliff six feet high, composed of horizontal light orange-yellow porous dolomite in heavy even beds, rises from the edge of the water. It contains a considerale number of fossils, of which the following were collected: *Cyathaxonia Wisconsinensis? Zaphrentis Racinensis? Omphyma?* sp., *Alveolites Niagarensis, Halysites catenulatus, Strophomena acanthoptera, Leptocœlia?* sp., *Meristella?* sp., *Trematospira?* sp., *Orthoceras* sp., and *Leperditia Whiteavesii.*

West shore of Cedar Lake. From Fort Island westward many of the islands around the mouth of the Saskatchewan, as well as points on the shore, both to the north and south, are composed of similar dolomite. On a prominent point projecting from the south shore, the rock is a light coloured dolomite, yellow in places where it is much acted on by the water. In some places it is thin-bedded and almost slate-like, but generally the structure is concretionary on a large scale, so that the surface has a mammillated appearance, the domes being from six to twelve feet in diameter, and in them the thin-bedding is lost and the rock becomes somewhat porous. They inclose such fossils as *Favosites Niagarensis?, Halysites catenulatus, Strophomena acanthoptera, Rhynchonella altiplicata?, Atrypa reticularis, Polytropis,* sp.

The shore is here piled with great angular blocks from three to four feet in thickness that have evidently been broken from a bed just below the level of the water and piled up into their present position by the ice.

Chemahawin. Chemahawin, where the Hudson's Bay Co. have a trading post, was the most westerly point on the Saskatchewan River reached by the expedition. In its immediate vicinity from eight to ten feet of horizontally bedded dolomite outcrops on the bank. It is generally

light gray, and sometimes compact, but it is often yellow and porous, and is throughout very thick-bedded. A careful search revealed the presence of such fossils as *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Halysites catenulatus*, *Strophomena acanthoptera*, *Leptocœlia*, sp., *Orthoceras* sp., *Illœnus* sp., and *Leperditia Whiteavesii*.

Leaving Cedar Lake at its south-western angle, a winter trail, known as the Western Mossy Portage, leads through a thinly wooded tamarack swamp on a gently rising plain to the shore of Lake Winnipegosis.

Lake Winnipegosis.

Following the shore eastward, no Palæozoic rocks are seen up to the north-east angle of the lake, but on the north-west point of Ami Island flat-lying and thin-bedded yellowish magnesian limestone of Niagara age is seen for the first time. Following the shore of the island this limestone, which is at first slightly porous, becomes hard, thin-bedded and flint-like, and the bedding becomes wavy. In places it contains large nodules of gray chert. Probably from ten to fifteen feet of rock in all is exposed on this island. It contains a considerable number of species of fossils among which *Strophomena acanthoptera* is the most abundant, while *Pterinea* sp., *Grammysia ?* sp., *Murchisonia* sp., and *Pleurotomaria ?* sp., also occur. North-east shore.

East of Ami Island the beach is flat and sandy, but generally scattered over with fragments of dolomite. Some of these are Silurian and doubtless of more or less local origin, while others are Devonian, and contain such typical fossils as *Stringocephalus Burtini*. Long Point peninsula.

These are evidently transported masses, and as the direction of glacial transportation is from N. 20° E., as shown by glacial grooves and striæ in the immediate vicinity, they would prove the existence of the Stringocephalus dolomite in the unknown area between this point and the south end of Cross Lake during the latest glacial times, and it is not improbable that an outlier of this dolomite still exists, and forms a capping to the high land seen in that direction. On Ami Island boulders of the Pentamerus band in the Niagara series are also found, having been brought from the same direction, and with them are small rounded masses of white sandstone holding nodules of Marcasite. These are similar to the nodules found on Pemican Island described on page 169, and like them are not improbably derived from an outlier of Dakota sandstone in the immediate vicinity. In view of the fact that Marcasite readily undergoes decomposition into soluble sulphate of iron, which would soon be washed away by the waves Boulders. Nodules of Marcasite.

it would appear that these nodules have only recently been shoved up on the beach, and could not have been transported from the north so long ago as the glacial age. We must, therefore, infer that a small outlier of Dakota sandstone exists beneath the level of the water on the south side of this island, and that it has been protected from destruction, at the time when the Laurentide glacier passed southward over the country, by the shelter of the island to the north of it, and that it is even now touched and scraped by the lake ice only in seasons of extreme low water, such as was the summer of 1889.

Low sloping rock.

Returning to the shore at a point opposite two small islands, originally bedded rock outcrops at the edge of the water, consisting of a fine-grained yellow, moderately compact magnesian limestone, fairly thickly and evenly bedded, and breaking under the hammer in any desired direction.

Following the shore southward the beach is strewn with angular fragments of magnesian limestone, similar to that already seen, broken by the ice and frost from the beds below. Some chalybeate springs flow out on the beach, and in the vicinity is a light yellowish or pinkish dolomite holding typical Niagara fossils, as well as chert concretions.

At lat. 52° 54′ 15″ in a little bay just north of a point of land, the beach consists of a light gray thin-bedded compact dolomite in which the impressions of ostracods are very numerous. The beds have a slight dip S. 80° W. and are very much cut by parallel jointage planes running from south-west to west. The following fossils were found in this dolomite: *Streptelasma* sp., *Strophomena acanthoptera*, *Rhynchonella* sp., *Ilionia?* sp., two species of *Murchisonia*, *Pleurotomaria* sp., *Orthoceras* sp., *Isochilina grandis*, var. *latimarginata*, *Leperditia Hisingeri*, and its vars. *fabulina* and *gibbera*, *L. marginata*, and *Acidaspis perarmata*.

Fossils.

Massive dolomite.

At the point itself a massive porous dolomite from eight to ten inches in thickness makes its appearance, being apparently about three feet above the strata just mentioned. It is apparently made up largely of remains of Stromatoporoids and contains many large concretionary nodules of chert. Continuing further south this layer is overlaid by a few feet of similar but thinner bedded dolomite, the bedding planes of which are generally rough and irregular. The most common fossil here is *Strophomena acanthoptera*.

Thin-bedded dolomite.

In lat. 52° 52′ 30″ the shore is composed of thinly stratified dolomite holding *Strophomena acanthoptera*. The beds are generally undulating and some are slightly porous, while others are very compact and porcellanous. They all appear to dip lightly out into the lake in a direction S. 85° W., and the bottom for a long distance is a gently inclining surface of smooth rock.

Similar rock forms or underlies the beach all the way to the point of the peninsula, generally thin and evenly bedded and broken into sharp angular fragments by jointage planes, which are often arranged in concentric circles.

For a mile and a quarter up from the point, on the east side of the peninsula, the shore is low and the water off it is very shallow, and then for three-quarters of a mile the Niagara rocks again make their appearance. At first is a low exposure on the beach showing two feet of light yellow porous dolomite in rather thick beds, in which neither fossils nor chert nodules were seen. 100 yards to the south of this exposure is a spring surrounded by a red slime. The water tastes distinctly of common salt and sulphuretted hydrogen.

Nodules of chert.

At a point north of this portion of the shore the rock is thick-bedded, holding a large number of nodules of chert, being apparently a continuation of the cherty dolomite seen in lat. 52° 54′ 15″ on the opposite side of the peninsula. This would indicate a strike of N. 20° W. for these rocks, which agrees fairly well with that which would be deduced from the dips given above.

The shores of the deep bay to the east of this peninsula are generally low and without rock exposures, while across its north end extends the high ridge that has continued quite unbroken from the northern point of the lake west of Western Mossy Portage.

Light anticline.

At a prominent point on the east side of the bay, in lat. 52° 53′ 10″, Silurian dolomite again makes its appearance on the shore. It is yellowish-gray, more or less compact and thick-bedded, and rises in a light anticline striking S. 50° W., though the general dip of the beds also appears to be in that direction at a low angle. Here and there throughout the rock are small cavities, the sides of which are lined with loose semi-crystalline dolomite. Small nodules of chert are not uncommon, but other fossils than *Strophomena acanthoptera* are very rare.

Two miles to the southward a rather thin and not very evenly bedded dolomite underlies the beach. It is in places of a light colour, more or less coarse-grained, and contains nodules of chert, with *Strophomena acanthoptera* and other fossils, while in other places it is very compact and much fractured, and contains *Isochilina grandis*, var. *latimarginata* and other ostracods, with a species of *Proetus*.

The beds are evidently the same as those outcropping in lat. 52° 54′ 15″ on the west side of Long Point peninsula, and a line connecting the two points would indicate a strike of N. 40° W. This varies considerably from the strike previously obtained and serves as an instance of the fact that neither strikes nor dips are at all constant in detail in these flat-lying beds.

Beach of angular pebbles.

A mile further to the south, and near lat. 52° 50′, the shore is composed of thin-bedded hard dolomite cut by many jointage planes, and the beach is scattered with angular fragments of the same rock, but near the south end of this exposure the dolomite becomes very porous and uneven and contains a considerable number of fossils, most of which were too fragile to permit of being broken out, but concretions of chert are almost entirely absent. Among the fossils *Strophomena acanthoptera* was the most common, while species of *Murchisonia*, *Orthoceras*, &c., were also collected.

A short distance further to the south thin-bedded dolomite is again seen, and the rest of the shore as far as the point consists of angular fragments of dolomite scattered through a matrix of soft clayey sand flattened and grooved by the shoving of the ice in spring.

South of the point the shore turns eastward for two miles and a half at right angles to the direction of glaciation, and then turns again and continues parallel to its former direction.

Vesicular dolomite.

In lat. 52° 46′ light gray porous or almost vesicular dolomitic limestone makes its appearance in beds of from half an inch to an inch in thickness. It continues for a mile along the shore and becomes quite fossiliferous, containing large numbers of *Strophomena acanthoptera*, associated with *Rhynchonella* sp., *Murchisonia* sp., *Isochilina grandis*, var. *latimarginata*, and *Leperditia* sp. The beds dip uniformly N. 65° W. into the lake at an angle of two or three degrees.

At a point a mile to the north these beds are hardened and very much cracked by a light anticline striking about east and west, and are overlaid by a foot or two of thin-bedded compact slate-like dolomite also holding *Strophomena acanthoptera*, which breaks into small rectangular blocks, covering the beach with a rough debris.

The porous dolomite continues to compose the shore to lat. 52° 44′ when there is again a sharp bend to the east.

Goose Islands.

Returning northward to Goose Islands, the north end is found to be composed of porous dolomite similar to that on the shore opposite, with a very light dip in a westerly direction, and the north end of the middle island is also composed of the same dolomite, with *Strophomena acanthoptera*, while the rest of the islands consist of sand, clay and boulders, these latter being more numerous than on any part of the shore to the north.

Further south, in lat. 52° 42′, the shore is composed of similar flat-lying, moderately thin-bedded dolomite, and a mile further south similar rock is again exposed on the shore, and on a horse-shoe-shaped island a mile off the shore. No fossils of any kind were found.

The shore between and around these isolated exposures was scattered with angular fragments of similar rock, and in some of these fragments were ostracods similar to those collected further north.

Pickerel Creek

A short distance north of the mouth of a creek that flows from Pickerel Lake, and empties into Winnipegosis Lake in lat. 52° 36′ 46″, the beach is composed of a light gray thin-bedded dolomite, with a dip of 2° a little south of west. The surface is undulating, rising into little rounded mamillæ. The beds vary from the thickness of paper up to half an inch, becoming virtually a slaty dolomitic shale. The colour is light gray or bluish-gray, often streaked with red or pink. It is very compact and brittle and cut by many fissures, owing to which it readily breaks into small fragments, with which the beach is thickly strewn.

Oolitic dolomite.

Just south of the mouth of the brook a bed of dolomite half an inch in thickness makes its appearance, in which are many white calcareous dots, which rapidly weather out and give the weathered surface of the rock a very pitted appearance. This bed is very similar to that at Demi-charge Rapid mentioned on page 151.

Similar rock can be seen at salient points along the shore down to lat. 52° 33′ 40″. Fossils were carefully searched for throughout, but only very obscure traces were discovered.

Thence southward to lat. 52° 30′ 30″, the shore is low and flat, scattered with angular fragments of pink and white thin-bedded dolomite, and boulders of gneiss become much more numerous.

Vesicular dolomite.

Here the shore bends to the west of south, parallel to the line of glacial transportation, but just at the bend is a low exposure of light gray and very vesicular dolomite in a bed two inches thick, dipping a little north of west at an angle of 5°. The dolomite is generally tough and compact between the vesicles, and the bed is generally darkened, possibly from the presence of a certain amount of carbonaceous material. The vesicles would appear to have been caused by the solution of crystals of common salt that have been included in the rock. No fossils could be found, and the rock is not unlike that of the Stringocephalus zone of the Devonian shortly to be described from other parts of the lake, but in the absence of clear evidence it will be safer to consider it as a band in the upper portion of the Silurian or near the base of the Guelph.

For the next five miles and a half towards the south, the shore is without rock exposures, and is scattered with more or less angular fragments of thin and irregularly bedded dolomite, all of which appear to be of Silurian age, no Devonian fossils being found. This tends to

support the conclusion that no Devonian strata have yet made their appearance near the lake shore to the north, as that is the direction from which boulders have been transported.

Devonian rocks.

At a rounded point opposite a long island, in lat. 52° 26′ 30″, the beach is composed of angular debris, much of which is a light brownish-gray impure dolomite that has probably been broken from bedded rock in the immediate vicinity. It is finely crystalline and generally rather compact, though in places broken by little vesicles made by the solution of salt crystals. It does not effervesce in cold weak hydrochloric acid, but in boiling acid it dissolves readily, leaving a quantity of dark brown residue. A few obscure fossils, such as brachiopods and gasteropods, were found in it, but they were not sufficiently well preserved to determine its taxonomic position. The rock itself is somewhat similar to a bed underlying the Stringocephalus zone found at the base of a cliff in Dawson Bay, and which is clearly of Devonian age. Therefore as the rock is of rather peculiar character, in default of other evidence, it is here placed in the Devonian, and its parent bed is doubtless in the immediate vicinity.

Very shallow water.

To the southward the beach continues exceedingly low, and the water is so shallow that it cannot be navigated near the shore, even with a canoe, without considerable difficulty. There is no sign of the Palæozoic rocks down to lat. 52° 23′, where a hill rises back from the shore to a height of thirty-five feet above the water, its lightly rounded crest being composed of more or less water-worn pebbles, chiefly of white limestone, though a few are of gneiss. On its side, sloping towards the lake, is a ridge fourteen feet above the water level, and this ridge, with the present beach, is composed almost entirely of large or small pebbles of a light brownish vesicular semi-crystalline dolomite, weathering into very typical irregular roundish nodose masses like the rock at Devil's Point. No rock was seen in place.

Island Z.

For six miles and a half further to the south the shore is very low, and scattered with loose fragments of nodose dolomite, and thin slabs of harder, more compact, probably Niagara dolomite. The north shore of Island Z, lying in north latitude 52° 18′ 30″, appears clearly to be composed of Monroe Point beds, for while no rock is seen in place, the shore is strewn with angular masses of cream-coloured tough vesicular dolomitic limestone holding a number of fossils such as crinoid stems, *Astræospongia Hamiltonensis*, *Spirorbis omphalodes*, *Pinacotrypa marginata*, *Fenestella vera*, *F. dispanda*, *Productella subaculeata*, *Conocardium Ohioense*, *Leperditia ? exigua*, and *Proetus mundulus*.

South of this island the shore is thickly strewn with boulders of gneiss and dolomite, being often backed by an ice-shoved boulder

wall, and no rock is seen in place for ten miles until latitude 52° 10′ 20″ is reached, where a hill rises by an easy slope from the edge of the water to a height of sixty feet, its sides being strewn with dead birch, spruce and poplar. Its crest is slightly rolling parallel to the shore, and is covered with pebbles and rounded cobbles, and its western face with large masses, possibly some of them being in place, of a thick-bedded light yellowish-gray porous and vesicular dolomite, in which were but few and ill-defined fragments of fossils. The rock is, however, almost precisely similar to that on the Island off Whiteaves Point in Dawson Bay, belonging to the lower part of the Stringocephalus zone. Rocky hill.

Close to the edge of the water, a low cliff of a light yellow soft porous dolomitic limestone, chiefly characterised by the presence of a large number of fragments of stems, plates and pinnules of crinoids, extends for 100 yards along the beach. It is in beds of from one to three inches in thickness, and is generally horizontal, but in some places it is tilted to the south, at angles as high as eight degrees, to a light fault, beyond which the beds are again horizontal.

Five miles further south, Point Brabant overlooks the lake from behind a row of large wide-spreading elms, its base being generally ten feet above the water, and its crest at its highest part twenty-six feet higher. At the first good exposure, the lower sixteen feet of the cliff consists of a hard, compact, light yellowish-gray dolomite, resounding when struck and breaking with an irregular fracture. Near the middle of this band, at nine feet from the bottom, is a thin bed of clay shale. The dolomite is not very fossiliferous, but the following species were collected from it. *Cyathophyllum vermiculare*, var. *præcursor*, *Alveolites* like *cryptodens*, *Productella subaculeata*, *Spirifera Richardsonii*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *A. reticularis*, var. *aspera*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus* and *Orthoceras Hindii*. Point Brabant. Fossils.

The upper ten feet of the cliff is a somewhat similar dolomite, but contains very few traces of fossils.

The beds appear to be in general horizontal, but twenty-five paces further south they are broken by a light fault with a downthrow of two feet to the north.

For the next 300 paces the beds decline slightly to the south, parallel with the decline in the top of the cliff. On the beach were scattered a few fragments of a limestone conglomerate, probably from beds near the bottom of the cliff. Section along the shore.

Point Brabant.

In the next 110 paces the beds of dolomite dip fifteen feet to the south. In this latter stretch the beds are very hard and compact, but much broken by little joints, so that they have been worn into caverns by the waves. Some thin beds of clay run through these lower beds.

In the next fifteen paces the cliff is fifteen feet high, and the rock is considerably broken, but it appears to be rather shaly towards the top.

In the next twenty-five paces the rock dips six feet, and here shows a cliff twenty feet high, the beds being white magnesian limestone, occasionally stained with dull pink, and holding numerous *Atrypas*, &c.

At this point there is a fault with a downthrow to the south. On the opposite side of the fault twenty feet of light red and gray shale is exposed, dipping S. 25° E. at an angle of 45°.

Throughout this distance it would appear that about thirty feet in all of dolomitic limestone, and twenty feet of red and gray shale is exposed, the latter being higher than the former, and having been dropped into its present position by the last-named fault.

For about 200 paces the shore is rather low to an exposure of a yellow semi-crystalline dolomite through which are running many round tubular cavities that possibly represent natural moulds of *Pachypora polymorpha* or a similar coral that has entirely or almost entirely decayed away. The exact position of this bed remains undetermined.

For the next 240 paces the bank is composed entirely of till and boulders, and is about three feet in height. At this point it rises to a height of ten feet, consisting at the bottom of six feet of yellow argillaceous limestone, overlaid by four feet of white limestone.

For 100 paces similar rock is practically horizontal, at the end of the distance the cliff consisting of four feet of brittle argillaceous limestone, overlaid by six feet of thick-bedded white limestone.

Continuing down the shore for forty paces a sharp anticline suddenly brings up four feet of a light yellowish-red calcareous argillite.

Ten paces further the cliff is twelve feet high and is composed of eight feet of yellow and pink, hard, compact often thin and irregularly bedded argillaceous limestone, holding specimens of *Atrypa*, &c., overlaid by four feet of white thick-bedded limestone.

For the next thirty-five paces the beds are difficult to follow as they are a good deal crumpled, but they appear to have a light dip of about three feet to the north. Here there is an almost vertical fault striking S. 65° E. with a downthrow to the south, probably of not more than five feet. On the south side of it is a cliff of limestone eleven

feet in height, with the friable limestone at the bottom, while on the north side are six feet of light gray argillaceous limestone, becoming almost a clay shale at the top, where it is also of a pinkish colour.

Sixty paces further the cliff consists of six feet of hard limestone, overlaid by three feet of a light pink hard calcareous shale.

Thirty-five paces further, the section is terminated in two feet of a white thick-bedded limestone holding *Atrypa reticularis*, *Atrypa aspera*, *Paracyclas elliptica*, &c. The beds are practically horizontal, though possibly with a very light dip towards the north.

South of Point Brabant, Mr. Dowling reports that the shore is scattered with boulders, and marsh often stretches for a considerable distance inland, no rock in place being seen till Net Point is reached in north latitude 51° 54′ where there is a low outcrop of three feet of cream-coloured tough dolomite dipping north at an angle of 10°. It evidently belongs to the Stringocephalus zone, and contains a few fossils such as *Murchisonia brevispira*, *Eunema turbinata* and *Macrochilina* sp. Net Point.

In latitude 51° 47′ 20″ a low exposure was also observed by Mr. Dowling below the surface of the water, but its character could not be determined.

Descending to the south end of the lake, and beginning on the west side of the point west of Meadow Portage, a low anticline brings a hard limestone three feet above the water, the outcrop extending seventy paces along the shore. The strike of the anticline is N. 30° W., and the dip about 3° away from the middle on each side. The rock consists of a yellow hard fine-grained semi-crystalline highly dolomitic limestone, in which are many vesicular cavities apparently caused by the former presence of crystals of common salt. South end of lake.

No fossils were seen except a wide-spreading Stromatoporoid, but from the position and character of the rock it is evident that it belongs to the Winnipegosan formation of the Devonian.

Five-eighths of a mile further west along the shore, a thin-bedded compact limestone is exposed for 150 feet. It has a dip of 5° S. 55° W., exposing in all twelve feet. Averaging the dip between this and the last exposure as 4°, the total thickness of beds covered between the two points would be 230 feet. The dip may, however, not be persistent, and small faults are not unlikely to have occurred in the covered interval.

The rock is a somewhat magnesian limestone of a light gray or pinkish colour, and some of the beds contain large numbers of *Atrypa reticularis*, while *Paracyclas elliptica*, *Omphalocirrus Manitobensis*, *Euomphalus subtrigonalis*, and *Loxonema altivolvis* were also

found. It represents the lower beds of the Manitoban formation of the Devonian.

Charlie Island

Four miles further west, on Charlie Island, several exposures of similar Manitoban limestone may be seen in cliffs rising at the north end to a height of ten feet, generally brought up by anticlines with an average strike of N. 45° W. The cliff at the north end of the island shows three feet of a compact, thick, and regularly bedded limestone, underlaid by nine feet of a compact but irregularly bedded limestone, which breaks readily into small fragments under the action of the water. The stratification is undulating and the main anticline runs S. 45° W., from which the beds dip outwards at first at an angle of 25°, which, however, rapidly decreases.

At the north end of a small island a few yards to the west, a cliff four feet in height shows the lowest of the above beds in an anticline striking N. 55° W., with the beds dipping at first 12° from the middle line. 300 yards further south, on the west side of CharlieIsland, three feet of similar beds are exposed.

On the east side of the island several exposures of similar limestone form cliffs just behind the beach, one of which shows twelve feet of strata. They are brought up by an anticline striking N. 30° W., from the east of which the beds dip away at first at an angle of 12°.

On a small island north of Charlie Island, similar white limestone rises in little cliffs, four feet above the water.

In all these exposures fossils are moderately plentiful and among the most common are *Cyathophyllum vermiculare*, var. *præcursor*, *C. petraoides*, *Alveolites* like *cryptodens*, crinoidal columns, *Productella subaculeata*, *Strophodonta arcuata*, *Atrypa reticularis*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Euomphalus subtrigonalis*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Orthoceras Hindii*, *Ptyctodus calceolus*.

Snake Island, north end.

Leaving Charlie Island and crossing two miles of open water in a north-westerly direction we reach Snake Island, which is a long, narrow and almost bifid island lying north and south. Beginning at its northern end and proceeding first west and then south, a cliff 10 feet high of white, thin-bedded, well stratified limestone is found to extend along the shore for 200 yards. At the east end of the cliff the beds rise from the edge of the water with a dip of 4° S. 85° E. Towards the middle the beds are more irregular and break away in small fragments, while at the west, they are even and about horizontal, and then with a light dip descend to the edge of the water.

230 paces S. 35° W. the same beds again appear on the shore and continue to rise for eighty-five paces, where the cliff is 17 feet 6 inches

in height. This point appears to be the centre of a domed anticline, as the rock dips from it in both directions along the shore, and at the same time back towards the centre of the island. Eighty-five paces further south-west along the shore the cliff is only six feet high, its base being three feet above the water, and the beds appear from the lake to be nearly horizontal, while they dip back at a low angle. Domed anticline.

Seventy paces further a continued low dip has caused the beds to disappear below the gravel beach, four feet above the water.

In the highest part of the cliff, the bottom being about three feet above the water, the rock is a white limestone very much the same as that seen at Charlie Island. For six feet at the bottom, the beds are more brittle than those higher up the cliff, but they are not worn into little caves such as are seen at the foot of some of the cliffs on the former island. All the beds are cut by almost vertical jointage planes running from top to bottom.

The taxonomic position of the beds here seen would appear to be near the base of the Manitoban formation and a little above those outcropping on Charlie Island. A few species of fossils, such as *Atrypa reticularis*, *Atrypa aspera* and *Paracyclas elliptica* are moderately plentiful, but with these were also found *Cyathophyllum vermiculare*, var. *prœcursor*, *Alveolites vallorum*, *Orthis striatula*, *Cyrtina Hamiltonensis*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Euomphalus subtrigonalis*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Orthoceras Hindii*, *Gomphoceras Manitobense*, *Cyrtoceras occidentale*, *Gyroceras submamillatum*, *Dinichthys Canadensis*. Fossils.

On the west shore of the southern expansion of the island is a low exposure of similar white thin-bedded limestone dipping regularly S. 45° W., at an angle in places as high as 30°. About twelve feet in all is seen. It contains many of the fossils mentioned above, along with *Cyathophyllum profundum* (var.), *Alveolites* like *cryptodens*, *Stromatopora Hupschii*, *Productella subaculeata*. South end.

Snake Island is classic ground in the history of western geology. It was here that Prof. H. Y. Hind, in 1858, made the collection of fossils that first determined the existence of Devonian in Manitoba. The species then collected are all included in the above list with the exception of *Orthis striatula* which has not been found by the writer.* First record of Devonian in Manitoba.

In the early part of the same year Mr. A. W. Wells, acting as assistant to S. J. Dawson, visited the island and states that the rock

* See Rep. on Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind, 4to, Toronto, 1859, p. 93, and App. by Mr. E. Billings, pp. 186–7.

is "a whitish limestone, full of organic remains,* but their character was not determined.

Point south of Snake Island.

Leaving Snake Island and crossing two miles of open water, a point is reached where similar white Manitoban limestone containing the same fossils, forms the beach for a short distance, dipping at an angle of 4° down to, and beneath the surface of the water.

At another point three-quarters of a mile further south similar limestone dips S. 85° E. at an angle of 5°, and three-quarters of a mile still further south at the bottom of a bay it is dipping S. 65° E. at an angle of 4°, and on a long point forming the south boundary of the bay it is dipping S. 35° E. at an angle of 7°.

The shore in this vicinity is low, and often guarded by an embankment of boulders, behind which is a broad expanse of marsh.

Two miles west of Snake Island a long point projects towards the north, and on its west side is a slight exposure of similar limestone holding some of the same fossils, and dipping S. 85° W. at an angle of 5°.

Mossy River.

The only remaining exposures discovered near the south end of Lake Winnipegosis are on Mossy River, one at the crossing of the old Canadian Pacific Railway location, a mile up from the mouth of the river, and the other a little higher up.

Pink-tinted limestone.

The former outcrop shows, for a distance of thirty-five paces on the west bank of the river, a white or pink-tinted limestone. It is thin-bedded and rings when struck with the hammer, being very similar in character to the rock seen on Manitoba Island. In the middle of the exposure it is much broken, and the fractures are often filled with crystals of calcite, but at both ends it has a fairly regular dip of 30° to 40° in a direction S. 5° W. About four or five feet in all of the rock is exposed. The beds are not very fossiliferous, the only distinguishable form being *Cyrtina Hamiltonensis*. Similar rock extends for twenty paces along the east bank of the stream, a few yards higher up. It is here dipping S. 20° E. at an angle of 8°.

From a quarter to half a mile further up the river, on the west bank, is a cliff about sixty yards long and from eight to nine feet high, consisting of white limestone similar to the last, thin-bedded, the bedding being often distinctly shown by fine lines of coloration. The face of the cliff, which runs S. 15° E., is parallel to the strike of the beds, which appear to have a dip of 12° N. 75° E., though they are very undulating. The lower beds break somewhat irregularly, and weather to a light brown. No determinable fossils were found, but the rock is

* App. (No. 36) to the 17th vol. of the Journals of the Legislative Assembly of the Province of Canada. Report of S. J. Dawson, Esq., C.E., p. 7.

doubtless of the same age as that a little further down the river, and appears to represent some of the higher beds of the Manitoban formation, such as are seen at Point Wilkins, and on some of the islands in Swan Lake.

The rest of the banks of Mossy River and the shores of Lake Dauphin are composed entirely of glacial and alluvial deposits.

From the mouth of Mossy River the western margin of Lake Winnipegosis is low, and shielded by a wall of boulders of gneiss and dolomite, behind which is a grassy meadow stretching back to a poplar forest.

Monkman's Salt Springs.

At Monkman's Salt Springs, the shore is straight, and composed of small boulders and pebbles of gneiss and limestone, rising, 100 feet back from the water's edge, in a low ridge of rounded gravel, wooded with a few small willows. Behind this a grassy prairie runs N. 65° W. 460 paces, rising in the distance about eight feet. To the north is a grove of poplar and small oak, while to the south the poplar soon becomes mixed with a little spruce.

At the end of the above distance a slight grassy knoll fifty feet in diameter rises eighteen inches above the general surrounding level. In the centre of this knoll are several irregular holes surrounded by a red incrustration and filled with a clear brine, which rises from several small springs in the bottom of the holes. The springs flow in all about fourteen to twenty gallons of brine an hour, which flows out over the surrounding land and evaporates or sinks into the ground. (The temperature of the water on July 1st was 42° F., and the salinometer showed a salinity of 10 per cent.) Bubbles of colourless, odourless and unimflammable gas rise every few minutes in this spring, especially when the surrounding sod is pressed down by walking over it. The water has been analyzed by Mr. Hoffmann of the Geological Survey and found to contain 1347·08 grains of common salt to the imperial gallon.

West of the above spring is a flat, somewhat in the form of a circle, a quarter of a mile in diameter, almost totally devoid of vegetation. It is bounded on the north by open woods of poplar and oak, and on the south by a forest of spruce. On the west, in which direction the land declines very slightly, beyond two small groves of poplar is a low-lying meadow stretching to the north and south. In this meadow, half a mile from the first spring in a south-westerly direction is a small marshy lake, which stretches three-quarters of a mile to the south, and in which the water is slightly brackish. On the above arid flat are the ruins of several old houses, and lying about are a number of broken and rusted iron pans in which salt was

Ruins of houses.

Monkman's Salt Springs. (Contd.)

formerly made for the use of the Red River settlement. Several wells have also been dug here in the clay or till, and the cribbing around them is still almost unbroken. They are now full of salt water, and in one of them, which is ten feet deep, and lying S. 65° W. from the spring above-mentioned, the water was standing at 72° F. and had a salinity of 18 per cent. This water was found by Mr. Hoffmann to contain 3099·41 grains of common salt to the imperial gallon. In another well close by, the water is 70° F., and has a per cent salinity of 6. Many shallow pits in the vicinity contain water ranging in salinity from 16 to 24 per cent, the latter being the highest, but perhaps the most common. In places where the ground has been overflowed, there is a light crust of salt on the surface.

No rock is seen in place in the vicinity of these springs, and they appear to rise through the general covering of till.

Cliff of limestone.

For some distance northward the shore is low and without rock exposures, the prominent points being composed of transported boulders, but in the bottom of a little protected bay in latitude 51° 54′ a beach of limestone pebbles, thirty feet wide, slopes up for four feet to the base of a little cliff of limestone three feet in height. The water off the shore is deep, with a soft muddy bottom.

The rock is a fine and even-grained light yellow argillaceous limestone, obscurely stratified, the layers being in the main horizontal, but locally undulating, without jointage planes, but breaking into very irregular fragments. The upper bed is hard and compact, but traversed by many thin veins of calcite, and weathers to a pure white. Below this hard bed is two feet of a yellowish soft clayey limestone, running into an irregular semi-nodular limestone.

No fossils were found, but the rock doubtless forms a portion of the argillaceous band near the base of the Manitoban formation, and underlying the limestone of Snake Island and other localities.

Gravel hook.

The north-eastern side of the bay is bounded by a hook of rounded limestone gravel, rising eight feet above the water; and extending northward is a gravel embankment, the pebbles in which become gradually coarser to a point just opposite the north end of the bay, where a thick-bedded, tough and very vesicular dolomite is exposed for two feet above the water, having a dip 7° N. 70° W., exposing in all beds to the thickness of 6 feet 6 inches.

This same band of rock again appears on the shore a short distance south of Weston Point, having there a dip of 3° to 5° in a direction S. 60° W. These two exposures belong to the Stringocephalus zone of the Winnipegosan formation and contain such typical fossils as *Atrypa*

reticularis, *Pentamerus comis*, *Stringocephalus Burtini*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Murchisonia turbinata* and *M. Dowlingii*. Winnipegosan fossils.

Half-way between these two exposures is a cliff showing five feet of white limestone dipping N. 55° W. at an angle of 3°, filled with Atrypas, &c., and representing the lower limestone of the Manitoban formation.

To the westward of Weston Point an island about half a mile in length extends nearly north and south parallel to the shore. Along its eastern side is a cliff ten feet in height of white thick-bedded limestone, the upper six feet being very compact and massive, while the four feet below are more friable, and break easily into irregular fragments. The bedding is almost horizontal, but undulates slightly. Weston Point Island.

On the north end of the island a cliff of similar limestone rises to a height of eight feet abruptly out of the lake, the beds dipping at an angle of 10° S. 40° W.

Both these exposures belong to the lower portion of the Manitoban formation and contain great numbers of *Atrypa reticularis* and *Atrypa aspera*, associated with such fossils as *Productella subaculeata*, *Spirifera fimbriata*, *Cyrtina Hamiltonensis*, *Pentamerus comis*, *Actinopteria Boydii*, *Modiomorpha tumida*, *Paracyclas elliptica*, *Bellerophon Pelops*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Orthoceras Hindii*, and *Gyroceras submamillatum*. Manitoban fossils.

The shore from Weston Point to Red Deer Point is low, and skirted by a beach of gravel or boulders, behind which a meadow of greater or less width is usually found stretching back to a forest of spruce and poplar. East of Red Deer Point is South Manitou Island, on the shores of which are several exposures of Manitoban limestone, which may be described in detail as follows.

Near the south end of the west side of the island, at the back of a narrow gravel beach rising to a height of two feet above the lake, is a low cliff four feet high, of a white thick-bedded compact limestone, containing such fossils as *Atrypa reticularis*, *Atrypa aspera*, *Cyrtina Hamiltonensis*, *Paracyclas elliptica*, *Raphistoma Tyrrellii* and *Loxonema altivolvis*. It is almost undisturbed and horizontal, though having a very light dip to the south, exposing in all six feet of strata in the cliff. South Manitou Island. South end.

Opposite this point, but on the east side of the island, similar cliffs, seven feet in height, expose in all nine feet of the same white thick-bedded compact limestone. The rock strikes along the shore in a direction N. 15° W. and dips S. 75° W. at angles varying from 18° to 24°, varying a little in direction with slight irregularities in the strike. It also contains numerous fossils of the same species as those at the previous

South Manitou Island. (Contd.)

locality, though with them are also found *Bellerophon Pelops* and *Cyathophyllum vermiculare.*

North of this cliff the shore is strewn with boulders for a short distance, and then a beach ridge of limestone gravel forms a long sweeping curve in front of a low meadow to the north-east point of the island, which is piled ten feet high with large round water-worn boulders of gneiss.

North end.

Half a mile west of this point, on the north side of the island, a light anticline with a strike N. 45° W. brings white limestone, similar to that last seen, three feet above the water, and from here westward, for a distance of about 600 paces, to the north-western angle of the island rock in low cliffs is more or less continuously exposed. It is very much

Small faults.

tilted and broken by small faults, but the beds at the west end of the beach are of the same age as those at the east end. The strata consist at the bottom of twelve feet of thick-bedded white limestone similar to that last seen. From it the following fossils were obtained, viz.: *Cyathophyllum vermiculare*, var. *præcursor*, *Alveolites* like *cryptodens*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *Spathella subelliptica*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Loxonema altivolvis*, *Hyotithes alatus*, *Orthoceras Hindii*, *Gomphoceras Manitobense*, *Gyroceras submamillatum*, and *Aspidichthys notabilis.* This limestone is

Red and yellow argillite.

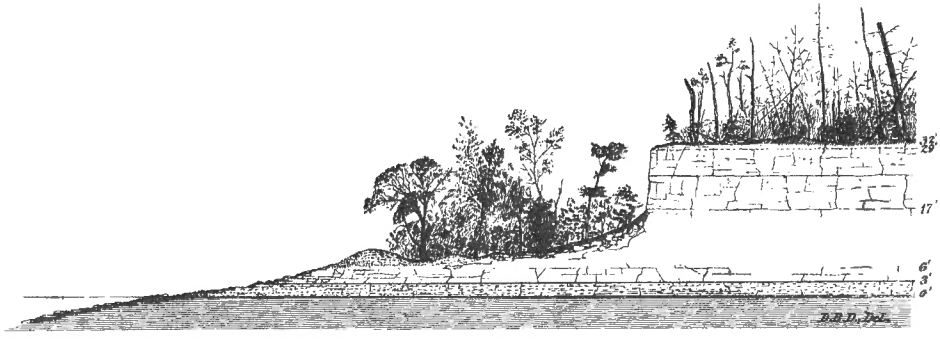
seen to be conformably overlaid in places by at least six feet of pink-tinted irregularly fractured very calcareous argillite more or less compact and lying in beds of varying thickness. In one place also a bed of yellow and much fractured, thick bedded calcareous argillite, or argillaceous limestone, very similar to that outcropping at the southern exposure near Weston Point, is let down by a small fault against the underlying limestone. This bed may overlie the pink argillite, and its position is probably close above the six feet of strata recorded. Five feet of these yellow beds were seen. No fossils were seen in the argillaceous zone except a few fragments of small crinoid stems. (See Fig. I plate).

Beyond South Manitou Island the shores of Sagemace Bay, and the lake to near north latitude 52° 40′, are low and no exposures of the underlying rock could be found.

Birch Island.

Birch Island also has a shore very similar in character, except at its north-eastern extremity, where a little vertical cliff of Devonian dolomite, several hundred paces long looks out over the lake across a shelving beach of rounded pebbles. The top of the cliff at its highest point is level and ten feet above the water. There is here exposed in all twelve feet of yellow argillaceous dolomite in nearly horizontal beds from two to eight inches in thickness, but often broken by fractures to

North End, South Manitou Island. Lake Winnipegosis
Horizontal Scale: 160 ft. to an inch.
Vertical Scale: 55 ft. to an inch.



Devil's Point. Lake Winnipegosis
Ancient cliff of porous dolomite, with red shale at water's edge.
Scale: 40 feet to an inch.

such an extent that the stratification is greatly obscured. The rock is porous and semi-crystalline, and often traversed by holes or cavities which at one time probably held fossils which have since been dissolved, and the only fossil found was a specimen of *Pentamerus comis.*

This rock usually weathers with a rough irregular knobby surface that is locally characteristic in any places where the rock is not subjected to much wear.

This Birch-Island dolomite is the lowest series of beds that have been definitely determined in Manitoba to be of Devonian age, but between them and the underlying Silurian there is a gap probably representing from fifty to a hundred feet of strata that have not yet been seen, and the country where these rocks would have been supposed to outcrop is now covered by the north-eastern portion of Lake Winnipegosis.

Hill Island. On Hill Island, a cliff rises at its northern end to a height of twenty feet above the top of the sloping beach of gneiss boulders, or about twenty-six feet above the surface of the lake. The cliff is behind a belt of large spruce and poplar, is not now being actively worn by the waves, and is much covered by debris, but twelve feet of the thick-bedded horizontal porous semi-crystalline dolomite was measured. South of the cliff is a tail deposit of till with striated pebbles, and on the sloping surface of this till are two deposits of rounded gravel representing stages in the recession of the water of the lake, one twelve, and the other twenty-two feet above the present surface of the lake.

Proceeding north-westward from the cliffs on Birch Island, the presence of the same beds is indicated in North Manitou Island, where large angular masses are scattered over the heap of boulders of gneiss. Similar rock is also shown to outcrop on, or in the vicinity of a hill north-west of Fox Point, where a ridge with a crest twenty-eight feet above the lake is largely composed of rounded masses of similar porous massive granular dolomite, in which, however, a few fossils were found, consisting of *Atrypa reticularis, Atrypa aspera, Actinocystis variabilis, Productella subaculeata,* crinoid stems, &c. Fox Point.

Pemmican Island. On the east side of Pemmican Island there is a cliff forty feet in height, situated like many of the other cliffs in this portion of the lake, behind a row of trees that here consist of poplar, elm and maple. On the top is eight feet of limestone gravel in a sandy matrix, below which is exposed sixteen feet of yellow, granular horizontal Birch Island dolomite, as in most of the other places, it appears to be unfossiliferous. From the base of the exposed cliff, sixteen feet above the water, the shore is generally covered with boulders and small stones, but under these is a compact red clay, not improbably representing

Pemmican Island. (Contd.)

the outcrop of a bed of soft red argillite that may form the terrane underlying the Birch Island dolomite, and if this be the case the ease with which it would yield to eroding agencies would account for its general absence in natural sections.

Lignite.

On the beach are also scattered a number of fragments of lignite, and concretionary nodules of Marcasite, but the former, and probably also the latter, are undoubtedly of Cretaceous age, and would seem to be derived from an outlier of Dakota sandstone deposited in a hollow of the Devonian rocks and protected by the shelter of the cliff from destruction in either glacial or preglacial times.

A low outcrop of rock, probably slightly higher than that on Pemmican Island, occurs on the west shore of the lake in latitude 52° 45′.

Devils Point.

But the most interesting and instructive exposure of the rocks of this series is found on the west side of Devils Point, where a red clay, similar to that on Pemmican Island, makes its appearance in places close to the edge of the water, and on the beach are lying a number of spherical nodules of marcasite. The lowest beds definitely seen in place, however, are slightly undulating white porous and vesicular dolomites, regularly bedded, and containing a large number of fossils. These white dolomites are seen to have a thickness of three feet, and are probably immediately underlaid by red argillites. The following is a list of the fossils obtained from this band: *Atrypa reticularis*, *Pentamerus comis*, *Productella subaculeata*, *Orthis Manitobensis*, *Streptorhynchus Chemungensis*, *Spirifera Richardsonii*, *Modiomorpha parvula*, *Macrodon pygmæus*, *Anodontopsis affinis*, *Paracyclas elliptica*, *Paracyclas antiqua*, *Cypricardinia planulata*, *Dentalium antiquum*, *Bellerophon Pelops*, *Straparollina obtusa ?*, *Loxonema gracillum*, *Hyolithes alatus*, and *Proetus mundulus ?*

Conformably overlying this white dolomite three feet of yellow porous dolomite is exposed, weathering with a rough nodular surface and apparently devoid of fossils. Above this, eleven feet is covered by beach deposits and debris fallen from the cliff, which is hidden behind a row of poplars. This cliff shows twelve feet of the rough yellow porous unfossiliferous dolomite in horizontal beds, overlaid by one foot of limestone gravel. From the summit of the cliff the land rises gently for a short distance and then more rapidly to the summit of a gravel ridge forty-five feet in all above the water. The whole of the surface is underlaid by more or less water-worn fragments of the limestone of the cliff.

Grand Island.

Crossing the strait to the west side of Grand Island, a cliff is also found within the edge of the timber, rising to a height of fifty feet above the water. The face of the cliff is for the most part covered with

slides and overgrown with bushes, but at its foot red clay forms a considerable portion of the shore, indicating the presence of the red argillite; the top of the cliff is composed of twelve feet of rough yellow porous dolomite, apparently quite unfossiliferous. On its summit is a gravel ridge at an elevation of fifty-five feet above the water.

Cormorant Islands.

On the east side of Cormorant Island a number of rounded nodules of marcasite are scattered among the gneissic boulders, having doubtless been ploughed up by the glacier from some outlier of the red argillite in the vicinity.

Island off Channel Island.

The last place at which this band was definitely recognized was on the eastern side of a small island lying east of Channel Island, where the ice has shoved up a large number of irregular angular fragments from the parent bed just beneath the surface of the water. It is here a rough yellow porous dolomite, the same as the higher beds at Devils Point, and like them appears to be entirely unfossiliferous.

Lying west-south-westward from the line of outcrop of the Birch Island dolomites is a belt of country, from twelve to fourteen miles in width, that lies a little higher than the country on both sides of it and possesses a much larger land area. On this higher belt rock exposures are almost entirely absent, the surface being more or less completely covered with till. The higher portion of the Winnipegosan horizon is, however, indicated by the presence of unworn pieces of dolomite, with fossils already recorded, on a small island south-east of Birch Island, and exposures of the lower portion of the Manitoban limestone are seen on the west sides of Pelican and Cameron bays. The former exposure is in latitude 52° 44′ 30″ and consists of a cliff extending 200 paces along the shore and rising twenty-six and a half feet above the water. The rock is brought up by a low anticline striking N. 10° E. and forms a ridge that can be followed for some distance into the woods. The upper six feet is a white slightly argillaceous limestone containing a large number of *Atrypa reticularis*, *Atrypa aspera* and *Paracyclas elliptica*, and a few specimens of *Bellerophon Pelops*, *Pentamerus comis* and *Proetus mundulus?* Below this is a yellowish and much more friable limestone, breaking into angular fragments, and apparently unfossiliferous.

Pelican Bay.

Cameron Bay.

The other exposure is on the west side of Cameron Bay, where a cliff rises thirty-seven feet above the surface of the lake. It is almost hidden behind a narrow belt of poplar growing on a gentle slope, which, at a height of eleven feet above the water, is piled with nine feet of irregular rock debris. Above this rises an almost vertical wall for fifteen feet, composed of light buff argillaceous limestone. It is horizontally and evenly bedded, is compact and even-grained, and breaks

regularly when struck with the hammer, the beds being very sonorous. It is very similar to the rock seen on the shore of Red Deer Peninsula, three miles south of Weston Point, and to some of the rock at Point Brabant on the east shore of the lake and represents the base of the Manitoban formation.

The lowest beds exposed in the cliff, for a thickness of three feet are very fossiliferous, and contain a great number of *Atrypa reticularis*, and crinoid stems, associated with *Cyathophyllum Athabascense*, var., *Productella subaculeata*, *Cyrtina Hamiltonensis*, *Atrypa aspera*, *Keferstеinia subovata*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Orthoceras Hindii*, *Gomphoceras Manitobense*, and *Proetus mundulus*. The upper beds also contain a few similar fossils scattered through them, but not in any great abundance. The foot of the cliff is springy, and the water flowing from it is quite fresh.

Line of low country.

West-south-west of the belt of slightly higher land, which appears to be a more or less irregular broad synclinal trough, is another linear area eroded out into rather deep hollows, which on the map can be traced through the western and north-western arms of Lake Manitoba, through the open part of Lake Winnipegosis between Red Deer Point and Birch Island, and onward through Pelican Lake and Dawson bays. This area contains by far the greatest number of rock exposures in the whole district. Those in the most southern portions have already been described, and while several were reported on Pelican Lake, it was found impossible to visit them. Those on Dawson Bay therefore alone remain to be described, and on account of the irregular and almost unconnected character of the outcrops it will be impossible to describe them otherwise than in geographical succession.

Dawson Bay.

Island north of Whiteaves Point.

Beginning on the east side of the bay the most conspicuous feature is an island a mile and a half north of Whiteaves Point which rises abruptly out of the lake. On the west side of this island the waves beat against the foot of a vertical cliff of white dolomite that overlooks the lake, with a total height of forty-one feet. Its summit is rough and broken, and apparently water-worn, with a covering of moss along the front, while further back, where the surface is two or three feet higher, it is covered with a thick growth of choke cherry, ash-leaved maple, &c. From here the surface declines to the east side of the island, and at length drops in a low cliff to the water. Towards the south the surface slopes gradually to the water's edge and the island termi-

nates in a bar of irregularly rounded gravel extending towards the south-west.

The cliff, shown on the plate in front of this report, is composed of a very thick-bedded or massive white exceedingly tough dolomite, occasionally somewhat crystalline, but never harsh or rough. The bedding is not always distinctly marked, but the hill is clearly shown to be brought up by a rather sharp anticline with a strike S. 85° W., and the rock dips off towards each end at angles varying from 25° to 30°. In the middle of the cliff, where the stratification is horizontal, thirty-nine feet of rock in all are seen. The rock is cut by numerous jointage planes that run from the top to the bottom of the exposure. A number of faults have occurred along these jointage planes, so that it is difficult to measure the exact thickness of beds exposed. If these faults were left out of account, the total thickness of strata, here seen, would be 100 feet, but it is doubtful whether a much greater thickness is brought under observation than the thirty-nine feet occupying the middle of the cliff. The thickness of beds exposed may, however, amount to fifty or sixty feet. Cliff of dolomite.

The lowest beds, about ten feet in all, are not so thick-bedded as the rest, break down more readily, and contain a large number of stems of Crinoids. Above this are ten feet rather barren of fossils, and then there is a very massive band from which large angular masses have fallen and are lying at the foot of the cliff. This band is rather rich in fossils, and from it the following species have been collected: *Sphærospongia tessellata*, *Favosites Gothlandica*, *Pachypora cervicornis*, *Alveolites* like *cryptodens*, *Stromatopora Bücheliensis*, *S. Hüpschii*, *Ctenocrinus* sp., *Spirorbis omphalodes*, *Pinacotrypa marginata*, *Cystodictya Hamiltonensis*, *Fenestella vera*, *F. dispanda*, *Polypora Manitobensis*, *Productella subaculeata*, *Orthis Manitobensis*, *Streptorhynchus Chemungensis*, *Strophodonta interstrialis*, *Strophodonta arcuata*, *Spirifera fimbriata*, *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Actinopteria Boydii*, *Nucula Manitobensis*, *Dentalium antiquum*, *Pleurotomaria Spenceri*, *Euomphalus annulatus*, *Platyceras parvulum*, *Orthoceras Tyrrellii*, *Gyroceras filitextum*, *Isochilina Dawsoni*, *Elpe Tyrrellii*, *Bronteus Manitobensis*, *Cyphaspis bellula*, and *Proetus mundulus*. Fossils.

Whiteaves Point is a cliff twenty-one feet in height extending for a mile along the shore, and rising to a total height of thirty-one feet above the water. In front of it is a strip of land fifty feet in width wooded with fine large elms, between which and the water is a low beach of irregular fragments of limestone. The summit of the cliff is rather rough and wooded with small poplar. Whiteave Point.

The rock is a white compact, uncrystalline, dolomite not very thickly or evenly bedded, but breaking readily into irregular fragments. Though the stratification is essentially horizontal, it is cut by numerous jointage planes, along which the rock appears to have slidden to some extent. It probably represents the highest beds seen at the island just described, or possibly beds somewhat higher.

In places it contains a large number of beautifully preserved fossils, among which the most common and conspicuous are *Stringocephalus Burtini*, *Orthoceras Tyrrellii* and *Gyroceras Canadense*. With these are associated many of the species found at the small island, and in addition the following species : *Cyathophyllum Anna*, *Actinocystis variabilis*, *Actinostroma Tyrrellii*, *Atrypa aspera*, *Pterinea lobata*, *Modiomorpha attenuata*, *M. compressa*, *Conocardium Ohioense*, *Cardiopsis tenuicostata*, *Orthonota corrugata*, *Pleurotomaria goniostoma*, *Murchisonia Dowlingii*, *Bellerophon Pelops*, *Eunema brevispira*, *Astralites fimbriatus*, *Omphalocirrus Manitobensis*, *Naticopsis inornata*, *Hyolithes alatus*, and *Homaloceras planatum*.

Islands south-west of Whiteaves Point.

South-west of Whiteaves Point are a number of lovely wooded islands rising out of moderately deep water, on several of which exposures of dolomite and limestone are to be seen. The first of these lies a little more than a mile from the point, on the north end of which is a hill twenty feet in height. This hill is largely covered with an herbaceous growth, but an irregular rocky knob shows it to be composed of cream-white dolomite containing a great number of masses of *Actinostroma expansum ;* and at the edge of the water is a more or less thin and regularly bedded hard white dolomite, poor in fossils, though containing some very large stems of Crinoids. The stratification appears to be essentially horizontal, though the more massive portions in the hill are much shattered, probably by a small fault, so that it is difficult to detect any stratification. Large Crinoid stems and the tail of a *Proetus* were found in these beds.

The shore on the north end consists of fragments of dolomite broken by the ice from the rock immediately below it, behind which are rough irregular masses fallen from the crag. The rest of the island is surrounded by a beach of more or less rounded fragments of dolomite entirely or almost entirely derived from the rock of the island itself, and containing the following fossils, viz. : *Sphærospongia tessellata*, *Cystiphyllum profundum*, *Favosites Gothlandica*, *Pachypora cervicornis*, *Cystodictya Hamiltonensis*, *Polypora Manitobensis*, *Orthis Manitobensis*, *Strophodonta interstrialis*, *Spirifera fimbriata*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Myalina inflata*, *Macrodon pygmæus*, *Orthonota corrugata*,

Pleurotomaria Spenceri, Eunema speciosum, Omphalocirrus Manitobensis, Straparollina obtusa, Platyceras parvulum, Macrochilina subcostata, Bronteus Manitobensis, and *Cyphaspis bellula.*

A mile further west lies a somewhat larger island, on the north-west side of which an abrupt vertical cliff of light grey dolomite, with a slightly porous and semi-crystalline texture, rises to a height of forty-three feet above the water. It is eaten out by the waves to a height of ten feet, and above is covered with light brown lichen. The foot of the cliff is covered with large angular blocks fallen from its face, while the summit is overgrown with grass and small sage-bush.

Anticline.

The rock is brought up by a rather sharp anticline with a strike N. 40° E. At the eastern end is a fault with a dip of 40° striking N. 35° E., and with a throw to the north probably of about ten feet. West of this the rock rises with a dip of 27°, which rapidly lessens till in the middle and highest part of the cliff the stratification is practically horizontal. To the south the beds are cut off abruptly by a fault, south of which for seventy-five feet the beds are very irregularly disposed, and beyond which they disappear. There would appear to be a light throw to the south in this latter fault.

In the middle of the cliff the lower beds are white dolomite, thinly and more or less irregularly bedded, and apparently not containing many fossils. Above this is a similar but thick-bedded dolomite containing numbers of *Actinostroma fenestratum.* The broken dolomite to the south of the fault is of a slightly yellow colour, and from it the following fossils were obtained: *Sphærospongia tessellata, Actinocystis variabilis, Favosites Gothlandica, Pachypora cervicornis, Alveolites vallorum, Ctenocrinus* sp., *Atrypa reticularis, Pentamerus comis, Stringocephalus Burtini, Terebratula Sullivanti, Pterinea lobata, Myalina inflata, Goniophora perangulata, Pleurotomaria Simpsoni, Murchisonia turbinata, M. Dowlingii, Porcellia striata, Eunema speciosum, Euomphalus annulatus, Omphalocirrus Manitobensis, Straparollina obtusa, Pseudophorus tectiformis, Loxonema cingulatum, Cyrtoceras occidentale, Gyroceras Canadense, Cyphaspis bellula,* and *Proetus mundulus.*

Islands of pebbles.

To the west of this island lie two other small islands thickly wooded with elm and poplar. Both are low and no rock is seen on them in place, but on the north side of the larger one the pebbles are angular, and little, or not at all, rounded by the water, and would appear to have been shoved up by the ice from a bed of rock beneath the surface of the water. Behind the beach they are piled into a high ridge by the ice. These pebbles consist of white dolomite like the last, and contain quite a large number of the same fossils. On the east side of the island the

pebbles are much more rounded, and are piled in a ridge ten feet in height by the combined action of waves and ice.

A mile south of the last rocky island is a larger island on the north-east side of which is a vertical cliff twenty-five feet high from top to bottom, the latter being some distance back from the then level of the water and about two feet above it. The crest of the hill is three feet above the brow of the cliff and is wooded with small poplar. The rock is a cream-white vesicular dolomite, and in places appears to be largely made up of *Actinostroma fenestratum*, *Actinostroma Tyrrellii* and *Stromatopora Bücheliensis ?* Besides these, twenty-three other species were collected similar to those found at the previously described exposures in the bay, and characteristic of the Stringocephalus zone. The bedding in several places appears to be approximately horizontal, but it is cut by several jointage planes along which slight faults have occurred. It is impossible to say how much rock is exposed, but possibly not much more than twenty-five feet.

Beardy Island.

Adjoining this island is a large boot-shaped island, the largest island in the bay, known as Beardy Island. On its south shore, close to the margin of the lake, a soft, cream-coloured, porous, saccharine dolomite is seen apparently in place, and large angular blocks of the same dolomite are piled on the shore. It is thick and more or less irregularly bedded, and the only fossil detected was a large nodose Stromatoporoid. This bed would appear to represent the top of the Winnipegosan series, for on the opposite side of the island, and but a short distance away, a hill rises to a height of twenty feet, on the face of which, just within the edge of the woods, is a cliff sixteen feet in height. This cliff, and the gently sloping beach of shelving rock at its foot is composed of thin-bedded white argillaceous limestone containing a large number of *Atrypa reticularis* and *Atrypa aspera*, associated with the following other fossils, viz.: *Paracyclas elliptica*, *Kefersteinia subovata*, *Raphistoma Tyrrellii*, *Porcellia Manitobensis*, *Euomphalus subtrigonalis*, *Hyolithes alatus*, crinoid stems, and *Cyathophyllum Waskasense*. The bedding is nearly horizontal, and the rock overlies the harsh dolomite seen on the south side of the island and represents the lower portion of the Manitoban series.

Turning now into the bay south-west of Beardy Island, the south shore is generally low and scattered with irregular fragments of limestone and dolomite, while long bars composed of similar pebbles run out into the shallow water.

Near Bell River.

Towards the west end of this shore, and a mile east of the mouth of Bell River, a cliff from twenty to twenty-five feet in height extends for a quarter of a mile within the edge of the woods, but so much debris

has fallen and covered its face, and it is so thickly overgrown with trees and bushes that it is difficult to determine accurately the thickness of the beds composing it. However, the following characters were observed. The hill is caused by the bulging up of the rock shown by a light dip away from the centre in three directions, while the lake has cut across the front and obscured the dip that may exist towards the north.

Argillaceous limestone.

At both ends of the cliff the upper beds are composed of light gray slightly argillaceous limestone containing a large number of *Atrypa reticularis* and *Atrypa aspera*, associated with *Spirifera Richardsonii*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Omphalocirrus Manitobensis*, *Euomphalus subtrigonalis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Actinoceras Hindii*, and *Alveolites Rœmeri*. These represent the beds seen at Beardy Island, and eight feet or more are here exposed. They are underlaid by seven feet of a rather soft light bluish-gray calcareous argillite, in which are little masses of soft hematite, possibly caused by the decay or alteration of crystalline aggregates of pyrite. The argillite is cut by occasional veins of finely crystalline calcite, and towards the bottom contains a few nodules of hard limestone, while a foot at the top is generally harder than the rest. It appeared to be quite unfossiliferous. Its exposed face is weathered with smoothly rounded contours, and the debris falling from this portion of the cliff breaks into thin shaly fragments.

Contact of Manitoban and Winnipegosan Formations near the mouth of Bell River.

12

This band is underlaid by two feet or more of a light bluish-gray unfossiliferous limestone.

Below this, the section is obscured for twelve feet by slides and vegetation, and then a light yellow soft gray clay is seen cropping from the side of the bank. It is again covered for nine feet, and then there is a slight exposure of a rather soft red calcareous argillite.

Below this outcrop of red argillite the hill is covered by debris for sixteen feet to the top of

the low beach, where a yellow, saccharine, porous dolomitic limestone makes its appearance for a short distance, and from which flow springs of strong brine.

Below the saccharine dolomitic limestone, and right on the margin of the lake is a light brown or almost white, very slightly crystalline and tough dolomite. It is generally compact, but in some places is slightly porous, while in others it shows little rectangular cavities left by the solution of tabular crystals of salt. This dolomite did not appear to contain any fossils, but it and the saccharine dolomitic limestone undoubtedly represent the top of the Winnipegosan formation, while the argillite above represents the base of the Manitoban.

Contact of Manitoban and Winnipegosan formation.

On a long point, a mile further towards the north-west, a low exposure of rather granular vesicular dolomite of the Winnipegosan formation outcrops with a dip of 5° S. 35° W., and behind it the point is heaped high with irregular fragments which have doubtless been recently broken from the rock, and shoved up by the ice. These contain a few fossils, such as *Pentamerus comis*, *Stringocephalus Burtini*, *Eunema brevispira*, &c. Proceeding S. 30° W. down the shore for 500 feet, white, friable, argillaceous limestones holding *Atrypa reticularis*, *A. aspera*, *Bellerophon Pelops*, *Hyolithes alatus*, &c., make their appearance dipping S. 75° W. 25°, and from this point they form a low cliff a little back in the woods, running southward for a quarter of a mile parallel to the shore, where it flattens out. These represent the several beds recorded in the section on the preceding page.

On the opposite side of the little bay at the mouth of Bell River, a hill rises to a height of 100 feet above the water, and across the end of this hill the waves have cut a cliff thirty feet high. The upper twelve feet of this cliff is composed of white, friable limestone, the same as that outcropping across the bay. It contains the following fossils : *Atrypa reticularis*, *Spirifera Richardsonii*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Gomphoceras Manitobense*, *Favosites Gothlandica* and *Alveolites vallorum*.

For eighteen feet below this, in the middle of the anticline, the section is covered with debris and overgrown with brush.

A light dip carries the beds up and back from the face of the cliff, but the beds on the top of the hill are still a little higher and are composed of hard gray limestone containing a large number of *Atrypa reticularis*, *Atrypa aspera*, and *Paracyclas elliptica*.

Two miles and three-quarters north of the mouth of Bell River is a bare flat, over which a small brook flows into the lake, behind which

are some ridges of impure sand. The creek when examined on the 1st of August, 1889, was flowing sixty gallons a minute and the water was very saline, containing about six-sevenths of a pound of common salt to the gallon, which would give a total discharge by the brook of about thirty-seven tons of salt every twenty-four hours. The summer of 1889 was a particularly dry one and during ordinary seasons, with an average amount of rainfall, the brine would doubtless be somewhat weaker, but on the other hand the quantity of brine discharged and probably of salt also would be greater. This brook flows from several springs a mile or more further inland, which are described elsewhere. Brook of salt water.

A mile east of the mouth of the briny creek, on the west side of a point, is a low exposure of from fifteen to twenty feet of white porous and vesicular dolomite dipping N. 70° E. at angles varying from 0° up to 12°. It contains a few characteristic Winnipegosan fossils, and a small amount of brine is flowing from it. On the east side of the point a low anticline forms a hill thirty feet in height, the rock dipping southward at an angle of 15° and northward at an angle of 3°. The bottom beds are hidden by debris, but at the top twelve feet are seen consisting of gray limestone containing fossils, overlying nine feet of evenly bedded, light yellow limestone holding a few Atrypas, which again overlies a light blue-gray shale. The fossils in the upper band consist of *Cyathophyllum Anna*, *Atrypa reticularis*, *Atrypa aspera*, *Productella subaculeata*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Hyolithes alatus*, and *Gyroceras Canadense*. Point north of Bell River.

North and east of this cliff the shore is generally low and the land behind it rises gently to a few feet above the water. In some places a wall of boulders lines the shore. No rock is seen in place, but brine springs rise to the surface, apparently through a light covering of till, and many of the boulders and masses of rock in this vicinity are composed of Stringocephalus dolomite.

Three miles north of Salt Point, an island about a mile in length, and of a somewhat oval shape, rises conspicuously out of the lake. The south and west shores of this island are composed of well rounded water-worn pebbles of dolomite, while to the north, and hidden behind a belt of trees, is a rather broken cliff twenty feet high composed of a thick and thin-bedded, coralline, dolomitic limestone cut by a number of jointage planes generally at a high angle to the horizon. The rock appears to be brought up by a light anticline and in places is composed largely of *Cyathophyllum profundum*. With this are associated *Sphærospongia tessellata*, *Pachypora cervicornis*, *Alveolites vallorum*, *Actinostroma Tyrrellii*, *Fenestella vera*, *Polypora Manitobensis*, *Atrypa* Island north of Salt Point

reticularis, *A. aspera*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Actinopteria Boydii*, *Eunema brevispira*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Naticopsis inornata*, *Macrochilina subcostata*, and *Proetus mundulus*.

This evidently represents a portion of the Winnipegosan formation, and probably is at the base of, or just below the bottom of the Stringocephalus zone.

Salt Point.

Returning to the north shore of Salt Point Peninsula and proceeding westward, the first exposure is a cliff thirty feet in height, which consists of white dolomite dipping a little west of south at an angle of 5°. At the water's edge it consists of a tough, white, yellow-weathering, thick-bedded dolomite, in which are many pores and vesicles surrounded by light brownish stains. The surface of the individual beds is very irregular, and in them *Actinostroma Tyrrellii* and *A. fenestratum* are very abundant, along with many other fossils. Overlying the beds above described there are fourteen feet of very similar dolomites, about the middle of which is a band containing a large number of *Kefersteinia subovata*. Besides the above, these rocks contain the following fossils, characteristic of the Stringocephalus zone of the Winnipegosan formation, viz.: *Sphærospongia tessellata*, *Columnaria disjuncta*, *Pachypora cervicornis*, *Alveolites vallorum*, *Actinostroma Tyrrellii*, *A. fenestratum*, *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Gosseletia* sp., *Myalina inflata*, *Modiomorpha compressa*, *M. parvula*, *Goniophora perangulata*, *Nucula Manitobensis*, *Kefersteinia subovata*, *Paracyclas antiqua*, *P. elliptica*, *Conocardium Ohioense*, *Cardiopsis tenuicostata*, *Cypricardella bellistriata*, *Dentalium antiquum* (?), *Pleurotomaria goniostoma*, *P. infranodosa*, *Raphistoma Tyrrellii*, *Murchisonia turbinata*, *M. Dowlingii*, *Eunema speciosum*, *E. brevispira*, *E. subspinosum*, *E. clathratulum*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Pseudophorus tectiformis*, *Naticopsis inornata*, *Macrochilina subcostata*, *M. pulchella*, *Hyolithes alatus*, *Orthoceras Tyrrellii*, *Tetragonoceras gracile*, and *Proetus mundulus*. Above these fossiliferous beds the strata become thinner and much more compact to the top, where, for three feet, they are very resonant and appear to be destitute of fossils.

Half a mile farther west, is a bare cliff fourteen feet in height, consisting of a white or cream-coloured, tough, uncrystalline dolomite with a great number of small vesicular cavities, and containing very many beautifully clear crystals of calcite. It also contains many concretions, which in places are very small, and give the rock quite a pisolitic

appearance. This is overlaid by a bed of hard argillaceous limestone. These beds dip with considerable regularity S. 60° W. at an angle of 3°.

Hill west of Steep Rock River.

Behind the point formed by this projecting cliff, a hill rises to a height of seventy feet above the lake, and in a bay to the west, where this higher hill approaches close to the shore, the top of the porous dolomite outcrops on the beach. The section shown on the face of this hill is as follows in descending order :—

	ft.	in.
Light gray thick-bedded argillaceous limestone, holding *Atrypa reticularis*, *A. aspera*, and *Paracyclas elliptica* in great abundance, associated with other species common to the Manitoban formation....	12	0
A very compact, fine-grained, hard, brittle buff-coloured limestone.....	1	6
A light bluish-gray, soft, fine-grained calcareous argillite, breaking down into a gray shale.....	3	0
Brownish-gray, hard, finely crystalline argillaceous limestone, through which run veins of crystalline calcite	4	0
Covered.....	8	0
Similar hard argillaceous limestone.....	3	0
Covered.....	36	0
Hard argillite.....	2	
Porous white dolomite		

A mile and a half further west a cliff rises to a height of twenty-four feet above the water, composed of tough, white, vesicular dolomite containing *Stringocephalus Burtini* and other associated fossils ; and just at the point in which this cliff terminates, a grassy hill rises in a steep slope to a height of forty feet above the lake, and from the top, and sides of this hill flow several brine springs, aggregating in all about twenty-five gallons a minute.

At a salient point still further west, and just opposite the mouth of Steep Rock River, is a cliff of similar tough, white, vesicular dolomite, the little cavities being arranged in horizontal layers and containing a few fossils, such as *Pentamerus comis*, &c.

This cliff is twenty-four feet in height and is overlaid by a coarse saccharine dolomite, while at the foot of the cliff the rock contains *Stringocephalus Burtini* and a large number of fossils generally associated with it.

About the middle of the exposure, a slight anticline brings a light brown argillaceous and slightly crystalline dolomitic limestone just above the surface of the water. It breaks readily with a very uneven, jagged fracture, and contains a few fossils, among which are *Atrypa reticularis* and *Spirifera fimbriata*.

Steep Rock River.

Crossing the little bay to the west, and ascending Steep Rock River for about half a mile from its mouth, a thin and evenly bedded, light brown, argillaceous limestone of the lower portion of the Manitoban formation outcrops in the bottom of the brook and for a few feet up the side of this bank with a light north-westerly dip.

Portage.

Leaving the river at this point a portage strikes off towards the south-west and passing through a poplar forest for a mile and a quarter again reaches the river in a wide marsh. Towards its western end it passes over a rocky hill that rises 100 feet above the lake, on the sides of which are several low exposures of a coarse-grained, crystalline, mottled white and brown limestone. No fossils were found in it, but it doubtless belongs to the Manitoban formation. The limestone lies in thick horizontal beds which are cut by a number of veins of crystalline calcite, and has much the appearance of some of the bands of limestone below the Atrypa band. It is possible that it has here replaced the shale to a considerable extent.

Hill north of Steep Rock River.

North of the mouth of Steep Rock River a hill rises to a height of eighty feet, with a smoothly rounded top composed of thin-bedded, horizontal, light gray Manitoban limestone, holding *A. reticularis*, &c., while twenty feet below it a spring of brine flows from the side hill and forms a barren, sterile band to the bottom of the slope. Irregular fragments of Winnipegosan dolomite are lying about, evidently derived from the immediate vicinity.

Also three-quarters of a mile north of the mouth of Steep Rock River a hill fifty-five feet in height forms a salient point projecting into the lake. On its summit are ten feet of horizontal, white, or light yellowish-gray limestone, containing a number of typical Manitoban fossils, including *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Hyolithes alatus*, &c. This is underlaid by a light gray or greenish-gray, calcareous argillite which appears to have a thickness of twelve feet or more, and below this the hill is covered to the bottom. At the north end of the hill these rocks have a dip of 20° S. 10° W. At the edge of the water is an irregularly bedded, rather coarse-grained, saccharine limestone, dipping at about 5° from N.E. to E. In places it is pure white and in other places it is of a dark brownish colour, and through it rise a number of springs of brine.

Half a mile further north a similar hill rises to a height of thirty-five feet above the lake, on the summit of which are twelve feet of typical light greenish-gray Manitoban limestone in beds of varying thickness and containing a large number of characteristic fossils. Below it is a calcareous argillite in thin beds.

Leaving the bay into which Steep Rock River empties, and coasting northward beside a long gravel spit, a hill is reached rising to a height of forty feet above the water, its lakeward face being now for the most part overgrown with bushes, and separated from the pebbly beach by a narrow belt of trees. The rock throughout is a light gray, thick-bedded, friable limestone which in places is oolitic and contains many comminuted fragments of fossils, but the only fossils that could be recognized were *Atrypa reticularis*, *Athyris vittata* and *Cypricardinia planulata*. The rock is undoubtedly the same as the upper beds at Point Wilkins, described below.

Point Wilkins.

Two miles further to the north the shore turns abruptly westward, and at the salient angle thus formed, Point Wilkins rises as a vertical cliff to a height of eighty-three feet above the lake, being the highest and most conspicuous promontory on its shore.

It consists of horizontal strata with the following characters, considered in descending order :—

Forty feet of light gray, very compact, fine-grained, thick-bedded, and in places oolitic limestone which breaks readily into polygonal fragments when struck with a hammer. Very few species of fossils were found in these beds, the most common being *Athyris vittata*, and with it are associated a few specimens of *Atrypa reticularis*.

Thirty-three feet of a light gray argillaceous limestone, running down into a hard, compact, sonorous limestone, interbedded with clay shale. This limestone contains, in places, beautifully preserved cubical crystals of pyrite, which disappear on weathering, leaving the surface pitted with small cavities. The argillaceous limestone and the shaly bands contain many beautifully preserved fossils, among which are *Atrypa reticularis*, *Cyrtina Hamiltonensis*, *Paracyclas elliptica*, *Euomphalus subtrigonalis*, *Gomphoceras Manitobense*, and *Ptyctodus calceolus*.

Ten feet of red calcareous argillite without fossils.

These beds represent the upper portions of the Manitoban formation as seen in this district, and although they were not seen in direct contact with the lower portion of the terrane, the red argillite at the base of the section probably lies not far above the limestone seen on the tops of the hills a little distance further south.

The highest part of the promontory is at its north-eastern extremity, from which the summit declines with a slope about a mile in length both to the south and west. The stratification is in general nearly horizontal, and the slope of the surface is formed by the unequal erosion of the beds.

Fissure breccias.

The strata, however, have been cut by vertical fissures in a number of places, and into these fissures the overlying and surrounding rock

has fallen in a confused and irregular mass. One of the most interesting examples of these broken strata occurs three-quarters of a mile south of the point, where the cliff is but eighteen feet in height and hidden behind a row of birch and poplar. For a distance of thirty-two paces along the shore the rock is very much disturbed, and projects thirty feet beyond the rest of the cliff, which consists on both sides of the lower argillaceous limestone lying quite horizontally. In the disturbed portion, however, the rock consists to a considerable extent of the upper limestone holding *Athyris vittata*, in fragments lying in every conceivable position. With this limestone is associated a hard, light blue sandstone composed of fine, more or less rounded grains of white quartz, of about equal size, with occasionally an included nodule of iron pyrites. This sandstone often forms the matrix of a breccia, in which are included the angular pebbles of brittle limestone.

This brecciated mass has undoubtedly been formed by the falling in of the overlying rock to fill a cave or fissure, and the presence of the Athyris limestone shows that this caving in took place before the surface was denuded down to its present level, since the cliff, to its summit, is now composed of the underlying argillaceous limestone, and the presence of the sandstone shows that this limestone was overlaid by a white or light blue sand, which would appear to have been the Dakota sandstone of the base of the Cretaceous, and which was sufficiently soft and incoherent to run down and fill the interstices between the fragments of limestone. This sand has since been converted into a hard sandstone by the infiltration of a calcareous cement.

Dakota sandstone.

About two hundred paces further north the rock in the cliff is again disturbed in a somewhat similar manner, but here there is no sandstone mixed with the limestone.

Buttress of broken limestone.

Half a mile still further north a mass of slidden limestone is standing like a buttress against the face of the cliff, which is here about seventy feet high. This cliff is depicted on page 67 of Dr. Spencer's Report. The beds, especially the upper ones, are but very little disturbed, and practically horizontal, while at the bottom are ten feet of evenly stratified red argillite. All are hidden for a short distance by the mass of limestone fallen from above. This has evidently been formed by the filling in of a cave from above, or of a fissure running parallel to the present face of the cliff, and on account of the inclined position of the rock, the waves of the lake, both at its present and during its higher stages, have not been able to wear it back as rapidly as the adjoining horizontal beds of the cliff, and thus it stands out as a salient feature on the face of the escarpment.

In other places in the same promontory the beds are similarly disturbed, but the instances already described are the most remarkable.

Mouth of Red Deer River.

From Point Wilkins no rock in place was seen on the shore for several miles, until a little peninsula was reached just south of the mouth of Red Deer River, where the beach is composed of dolomite dipping N. 85° W. at an angle of 10°. At the back of the beach, and at the edge of the woods of elm and willow, is a little cliff, a foot or so in height, of hard white vesicular Winnipegosan dolomite, and piled up in front of it, and hiding the cliff in many places, are fragments of the same rock containing *Sphærospongia tessellata, Pachypora cervicornis, Atrypa reticularis, Rhynchonella pugnus, Pentamerus comis, Stringocephalus Burtini, Myalina inflata, Kefersteinia subovata, Mecynodon* like *Eifeliensis, Cardiopsis tenuicostata, Cypricardinia planulata, Orthonota corrugata, Palæacmæa cingulata, Pleurotomaria goniostoma, P. infranodosa, P. Spenceri, Eunema brevispira, E. subspinosum, E. clathratulum, Astralites fimbriatus, Omphalocirrus Manitobensis, Macrochilina subcostata, Orthoceras Tyrrellii, Cyrtoceras occidentale,* and *Gyroceras filitextum.*

North of Red Deer River.

Two miles and a half north-east of the mouth of Red Deer River a slight and rather irregular anticline brings to the surface twenty feet of a thick-bedded, porous, yellow-weathering dolomite of the Winnipegosan series, containing a few very characteristic fossils, such as *Sphærospongia tessellata, Columnaria disjuncta, Amplexus* or *Diphyphyllum, Pachypora cervicornis, Alveolites vallorum, Discina* sp., *Orthis Manitobensis, Spirifera fimbriata, Atrypa reticularis, Pentamerus comis, Stringocephalus Burtini, Actinopteria Boydii, Myalina trigonalis, Modiomorphia parvula, Paracyclas antiqua, Pleurotomaria infranodosa, P. Spenceri, Eunema subspinosum, Straparollina obtusa, Naticopsis inornata, Gyroceras filitextum.*

Two miles further north a prominent point on the shore is formed of similar dolomite, also brought up by an anticline striking north and south. At the east end of the cliff the dip is eastward with an angle of 20°, while at the west end it is westward at a low angle. The rock contains *Stringocephalus Burtini* and many other fossils, the same as those found at the last point, besides which were *Polypora Manitobensis, Spirifera Richardsonii, Atrypa aspera, Spatella subelliptica, Dentalium antiquum,* and *Murchisonia Dowlingii.*

A mile and three-quarters west of this point and close to the shore, a hill of similar dolomite containing *Stringocephalus Burtini,* &c., rises to a height of twenty feet above the lake, and a mile to the north-west is another hill of very similar vesicular dolomite, which, however, did not appear to contain any fossils. Ten feet in all of

this dolomite was seen, and in a bed eight feet below the top are many little crystalline masses of pyrite, some of which have been altered into hematite. A beautiful cast of the exterior of a large salt crystal was also seen.

Below this bed of dolomite a gently sloping hill fifteen feet in height reaches to the lake, and over it are trickling several little rills of brine.

Macoun Point.

The only other exposure of rock in place, seen on the west shore of Dawson Bay is at Macoun Point, which is marked by a beautiful grove of tall spreading elms. Around the grove is a beach of rounded limestone gravel, and in front of, and a little below the gravel is a line of transported boulders of gneiss and limestone. From this line of boulders the shore extends with a gently declining slope to the edge of the water and is strewn with angular fragments of porous dolomite which have been shoved up by the ice from a bed with a very irregular surface, that makes its appearance in extreme low water in a few places. It consists of a thick-bedded, light brownish-gray, saccharine dolomite, so porous as to feel very light. It does not appear to contain any fossils, but closely resembles in general character the dolomite from Devils Point. It would seem to be an upward continuation of the Birch Island dolomite, probably immediately underlying the Stringocephalus zone.

Rowan Island.

Turning now to Rowan Island, which lies two miles and a half off the shore, in the north-western portion of Dawson Bay, its western extremity is found to be composed of a rough porous dolomite precisely similar to that at Macoun Point, and like it quite unfossiliferous.

Near the south point of the island this dolomite again composes the shore, while just back from the margin of the lake, a hill rises to the height of twenty feet and is composed of a white, thick-bedded, tough, vesicular dolomite, practically horizontal, and thus immediately overlying the hard porous dolomite. It would appear to represent the base of the Stringocephalus zone and contains a number of its typical fossils, such as *Sphærospongia tessellata, Actinocystis variabilis, Actinostroma Tyrrellii, A. fenestratum, Cystodictya Hamiltonensis, Fenestella dispanda, Spirifera fimbriata, Atrypa reticularis, Pentamerus comis, Stringocephalus Burtini, Goniophora perangulata, Bellerophon Pelops, Porcellia Manitobensis, Omphalocirrus Manitobensis, Loxonema altivolvis, L. priscum, L. cingulatum, Bronteus Manitobensis,* and *Lichas (Terataspis)* sp.

For the rest the island appears to be composed of these two kinds of dolomite, though at the north end, where low hills occur, their faces are so thickly piled with boulders that the rock itself was not exposed.

Red Deer River.

Leaving the shore of Lake Winnipegosis, and ascending the Red Deer River, its banks are low and alluvial for the first two miles from the lake, at the end of which distance a bare stony hill rises to about twelve feet above the river. Springs of brine issue from the top of the knoll and flow down its sides, discharging in all from one to two gallons a minute. Close to the river is a sloping exposure of rather thin-bedded, light gray, Manitoban limestone breaking into very irregular fragments and holding great numbers of *Atrypa reticularis*, with *Paracyclas elliptica*, *Cyrtina Hamiltonensis* and many other fossils. The beds are dipping east at an angle of 15°, and not more than four or five feet in all are exposed.

A short distance further up the river, on the same side, is a hill consisting of eleven feet of limestone overlaid by six feet of unstratified till. The rock is gray, yellow weathering limestone of the Manitoban series, and dips N. 60° E. at an angle of 16°. The upper five feet is a whitish limestone breaking readily into fragments and containing a number of fossils; while below it is a thicker-bedded, but not very compact, argillaceous limestone, containing but few fossils.

Cliff of argillite and limestone.

A little further up the river, and about half a mile above the lower salt spring, a cliff of limestone rises to the height of twelve feet above the water, overlaid by about ten feet of till. The cliff is about 300 feet long, and the beds dip S. 50° W. at an angle of 5°.

The following section is here shown :—

	ft.	in.
Light blue or blue-gray clay shale or calcareous argillite, the bottom beds of which contain many specimens of *Chonetes Logani*, var. *Aurora*, while the top beds are of a slightly brownish colour.....	8	0
Thin and thick-bedded light blue-gray argillaceous limestone. These beds together with the base of the overlying shales are very fossiliferous, containing *Atrypa reticularis*, *Atrypa aspera*, *Strophodonta arcuata*, *Productella subaculeata*, *Spirifera fimbriata*, *Spirifera Richardsonii*, *Cyrtina Hamiltonensis*, *Paracyclas elliptica*, *Paracyclas antiqua*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Porcellia Manitobensis* *Omphalocirrus Manitobensis*, *Hyolithes alatus*, *Proetus mundulus*, *Amplexus* sp., *Cyathophyllum vermiculare*, *Cyathophyllum petraoides*, *Alveolites* like *cryptodens*, *Actinoceras Hindii*.....	6	0
Thick and somewhat obscurely bedded light gray limestone, breaking on weathered surfaces into irregular fragments. It contains some of the same fossils as the beds above and appears to represent the beds in which *Atrypa reticularis* is most abundant. At		

Red Deer River—*Con.*

its top a little brine is trickling out of the rock, and just east of the exposure is a small area in which springs of brine are flowing over the surface..... 8 0

Light gray thin and evenly bedded limestone, very compact, and resounding when struck with the hammer. It contains very few fossils. To the edge of the water..... 2 0

Three-quarters of a mile further up the river, on the south side, a low anticline striking N. 50° W. brings up six feet of the light blue-gray argillaceous limestone overlaid by a foot of light blue clay shale. A few fossils were found, the same as some of those in the above list.

Half a mile higher up the stream a low anticline brings seven feet of the light gray limestone to the surface, broken in several places by little faults. It also contains a number of fossils, the same as those already recorded from the Manitoban series on this river.

Upper Salt Springs.

This last exposure is at a prominent bend in the river and a mile and a half above it a rounded hill rises on the north bank to a height of twenty feet, on the south side of which are several small brine springs where the Indians occasionally procure a small supply of salt by boiling down the water. The hill consists, to within four feet of the water at all events, of light gray limestone, the sloping face of which breaks off in irregular fragments. This locality was visited by Prof. Macoun* in 1881 and some fossils were collected from it, among which *Orthis striatula* (*O. Iowensis*) is especially noticeable as not having been obtained by the writer.

Fossils are, however, very abundant, and are generally very well weathered out by the action of the salt water. The following species were collected, and may be considered with the preceding list as a typical series for this northern portion of the Manitoban formation: *Cyathophyllum vermiculare*, var. *præcursor*, *C. Waskasense*, *C. petraoides*, *Alveolites* like *cryptodens*, *A. vallorum ? Strophodonta arcuata*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *A. aspera*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Loxonema altivolvis*, *Proetus mundulus*.

Pelican Rapids.

For the rest of the distance to Red Deer Lake the banks are generally composed of till or alluvium, but at the head of Pelican rapids a band of light gray limestone of the Manitoban series crosses the river. Where seen it was dipping southward at an angle of 12° and contained a few fossils, such as *Atrypa reticularis*, *Omphalocirrus Manitobensis*, *Proetus mundulus*, &c.

Red Deer Lake.

Red Deer Lake lies in a very shallow basin and its shores are generally low and alluvial or composed of sand and boulders. In one place on

*Ann. Rep. Dept. of Interior, 1881, pt. 1, p. 75.

J. B. Tyrrell, Photo., Aug. 22, 1889.

CLIFF OF UPPER DEVONIAN LIMESTONE.

ROSE ISLAND, SWAN LAKE, MANITOBA. LAT. N. 52° 36′, LONG. W. 100° 46′.

the south shore, however, peeping out from under the boulders, and at an elevation of from two to three feet above the water, is an exposure, showing in all a foot of a light gray, white weathering, thin-bedded limestone, dipping east at an angle of 5°, and at a hundred yards farther east there is exposed for fifty paces along the shore a horizontally bedded, light gray, slightly magnesian limestone, often red from the presence of iron. In places it is evenly bedded, while in other places it is a breccia with very irregular pebbles.

In the entire absence of fossils it is impossible to determine the exact position of these beds, but it is reasonable to infer that they form part of the upper brecciated portion of the Manitoban series, which is well shown on several of the islands in Swan Lake.

Shoal River. Returning to Lake Winnipegosis, and ascending Shoal River to the north end of Swan Lake, no rock is seen in place on or near the banks of the stream. Occasional areas are rendered wet and barren by flows of brine from salt springs, indicating the probable occurrence of the basal shales of the Manitoban series, under the covering of drift.

Swan Lake. The shores of Swan Lake are also low, and the points are often piled high with travelled boulders. But many of the islands consist of low bosses of limestone standing a few feet above the level of the water.

Rose Island. Rose Island lies towards the northern end of the lake, and consists almost entirely of beautifully glaciated limestone which at the western end rises to a height of ten feet above the water, showing at the same place a dip of 8° to the south. The rock is the fine-grained compact limestone of the upper portion of the Manitoban series, and contains a few *Athyris vittata* and other characteristic fossils. In places it is brecciated, with a matrix of more or less soft argillite, but it is not improbable that the broken character is due to the occurrence of fissures or slight faults.

The three adjoining islands were also found to consist of the same limestone under precisely similar conditions.

Swan River delta. Most of the remaining shores and islands of the lake are low, or covered with boulders, but on the eastern side of the delta of Swan River there are two rocky prominences. The northern one, N. lat. 52° 27′ 45″, long. 100° 42′ W. consists of a low exposure two feet above the water (August 31st, 1889), of a light gray stratified slightly argillaceous limestone belonging to the lower portion of the Manitoban series. On the shore were also lying many large slabs of somewhat similar limestone which had been shoved up by the ice from a thicker-bedded layer below the surface of the water. The rock con-

tains many large and well-preserved specimens of *Atrypa reticularis*, with some large *A. aspera*, besides *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Gyroceras submamillatum* and *Proetus* sp. The beds here have a light dip of 1°–2° S. 60° E.

Rock cliff.

Two miles further south, the other rocky point consists of a little cliff eight feet in height. The rock is a thick-bedded gray limestone, breaking readily into small polygonal fragments, and is generally very similar to that composing Rose Island. It appears to be raised in a low anticline, striking south-east and north-west. At the north-eastern end of a small island off this point there is a low exposure of similar limestone, but in neither places were fossils characteristic of any particular horizon to be found.

A mile north-westward from the last point, and at the eastern end of a small lake, is a stony area in which are several little springs of brine, one of which is flowing about two gallons a minute and all the rest are together flowing about twice as much. The exact horizon in the Devonian from which the brine flows was undeterminable. For many years a local supply of salt has been obtained by the half-breeds from those brine springs, and their rusted iron evaporating-pans can be seen lying here and there on the ground.

Lowest trail crossing.

Two miles and a half west of the rocky cliff on the point, is the lowest trail-crossing of the Swan River, on the south side of which is a hill rising to a height of thirty feet above the river. On the north side of this hill is a cliff six feet high showing at the bottom three feet of a horizontally, thinly and evenly-bedded light reddish limestone which appears to be unfossiliferous, while above it is a band five feet thick of a cream-coloured limestone, often saccharine and porous, with many crystals of calcite. This upper band contains a few fossils, such as *Cyrtina Hamiltonensis*, *Raphistoma Tyrrellii*, &c., and the whole probably represents a horizon in the Manitoban series just below the base of the Point Wilkins beds.

No Palæozoic rocks in place were found higher up the Swan River than in this hill at the crossing.

LAKE MANITOBA.

Low shores.

The shores south of Manitoba House were not closely examined, but they are generally low, with a ridge of sand and gravel running along at, or a little back from, the edge of the water. The water is shallow, and the gently declining lake bottom is studded with large gneissoid boulders, which are especially abundant off the more prominent points. No cliffs of the older rocks are apparent along the western shore of this portion of the lake.

North of Manitoba House the shore maintains much the same character, but boulders are stacked up somewhat more thickly on the points. On one of these points, a little north of the entrance to Ebb and Flow Lake, a boulder of Huronian conglomerate with pebbles of gneiss in a fine green matrix was lying in a pile of boulders of gneiss.

On both sides of this point extend ridges of rather angular pebbles of limestone.

Sifton Narrows.

On the east side of the lake, at Sifton Narrows, where the old location of the Canadian Pacific Railway can be plainly seen as a wide and well-cut-out line through the surrounding poplar forest, is a low exposure of porous Devonian limestone close to the edge of the water.

Old quarry.

Following the projected railway line eastward from the lake, a clearing is reached in the woods where a small quarry has been opened. The rock is a cream-coloured, harsh, semi-crystalline, porous, and very light dolomitic limestone, in which large open vesicles are rarely present. It effervesces feebly in weak hydrochloric acid, but dissolves readily in the acid when warmed, with a slight white residue. The bedding is thick and practically horizontal. 290 paces further eastward along the old line more extensive quarrying operations have been carried on. The rock is a magnesian limestone similar to the last, but here it is dipping westward at an angle of 19°, and is cut by two sets of more or less irregular jointage planes that dip at angles of 80° to the bedding. The directions of these two sets of planes are north and south, and N. 80° W. and S. 80° E. The rock weathers very rapidly, softening on exposure to the air.

Fossils.

It is a very poor medium for the preservation of fossils, but numerous fragments occur in this and the previous exposures, among which are large and small stems of Crinoids, *Cyathophyllum Anna*, *Cyathophyllum profundum*, *Pachypora cervicornis*, and *Atrypa reticularis*.

In the last-mentioned quarry about ten feet in all of the limestone is exposed, while the other two exposures represent the same or slightly higher beds near the summit of the Winnipegosan formation.

Manitoba Island.

A mile and a half north of the crossing of the old Canadian Pacific Railway, at the north end of Manitoba Island, is a cliff 200 paces in length and twelve feet high, composed of horizontal strata of hard, compact, brittle, thin-bedded limestone, very irregularly jointed and fractured. The general colour is cream, but in some places this runs into a bright buff or dull pink. A rather softer buff-coloured band runs along the face of the cliff five feet down from the top. Some of the more compact layers contain little masses and vugs of crystalline calcite, and occasional little pits are seen from which crystals of pyrite have weathered out.

Manitoba Island—*Con.*

The rock breaks into very irregular flattened fragments. From the foot of the cliff a beach fifty feet wide of these flattened pebbles, which ring like a bell when struck with a hammer, with occasional boulders of gneiss, extends to the edge of the water. When the wind blows from the north and the waves roll on this shingle beach, carrying with them, both advancing and retiring, these resonant pebbles and dashing them against one another, a roaring noise is made which Indian superstition has attributed to the Manito beating a drum, or otherwise similarly disporting himself. Thus this part of the lake was called "Manito-bà," or the "Narrows of the Spirit," a name that was afterwards applied to the whole lake and then to the province in which the lake is situated.

The rock effervesces strongly in weak hydrochloric acid and dissolves quickly, leaving a flocculent pink residue of argillaceous material.

The beach at the foot of the cliff extends westward into a spit of coarse gravel, and in the pebbles that had evidently been derived from the cliff, a number of fossils were found, among which are the following: *Chonetes Manitobensis*, *Productella subaculeata*, *Atrypa reticularis*, *A. aspera*, *Nucula lirata*, *Nuculites* sp., *Paracyclas elliptica*, *Bellerophon* sp., *Orthoceras* sp., a tooth of a species of *Rhynchodus*, and a scale of a species of *Onychodus*.

Fossils.

On the east and west sides of the island low exposures of limestone are also seen, apparently horizontal, but it is generally a little softer and more yellowish-brown and argillaceous than at the cliff, and is probably a few feet lower.

Limestone on west side of strait.

On the opposite side of the strait, bearing south from the north-west end of Manitoba Island, is an outcrop 150 paces in length along the shore, of similar brittle salmon-coloured limestone. It is lying in well-defined beds of from two to six inches in thickness, and besides being broken by numerous small cracks, is cut by several series of jointage planes sloping at considerable angles from the vertical, and cracks and holes in the rock are filled with crystals and crystalline veins of calcite. The bedding appears on the whole to be about horizontal, though at the eastern end of the exposure the rocks rise in a light anticline striking N. 45° E., and dipping away on both sides at angles up to 2°. A little further west the beds all dip in towards a centre at the edge of the bushes. Nothing but obscure fragments of fossils could be found.

Base of Manitoban formation.

This limestone occupies a position at the base of the Manitoban formation, representing the southern continuation of the shales seen at South Manitou Island, and near the mouth of Bell River.

The exposed surface along the shore is smooth but lightly undulating, being modified by water erosion; and at several places back from the shore, when it was stripped of its covering of clay, it was found to present the same character. The covering, however, generally consisted of broken fragments of the rock itself, probably shoved over it by the ice.

Point Richard

Proceeding northward along the east side of the lake, the next exposure of Devonian rock is seen at a point on the west side of Point Richard, where a cliff rises abruptly out of moderately deep water to a height of ten feet, having been brought up by a low anticline striking N. 15° W. and S. 15° E. It is difficult to measure exactly the thickness of beds here exposed, as the bedding is heavy and indistinct, and it is only possible to examine it thoroughly from a boat in calm water, while during the day on which it was visited by the writer, a strong north wind was blowing, causing a heavy sea to beat against the face of the cliff. The section as measured, however, shows thirty feet of cream-coloured, hard, dolomitic limestone, like that seen further north at Monroe Point, full of small cavities left by the decay of numerous minute fossils, and weathering with a very irregular knobby surface. Five feet from the bottom of the section a few fossils were collected, consisting of small Crinoid stems, *Loxonema cingulatum*, and several other small gasteropods. The exposure represents a horizon about the summit of the Winnipegosan formation.

Off Point Richard lie two small islands consisting in the centre of boulders of gneiss and cream-coloured limestone, around which is a beach of gravel.

South of these islands is a deep bay with low shores fringed by a shelving beach of glistening shingle.

Reed Island.

Reed Island was not examined, but it appeared to be low, without rock exposures, and surrounded by a beach of gravel or boulders.

The shore directly east of Point Richard is low, and broken only by prominent points surrounded by sloping walls of large gneissoid boulders, piled about six feet in height, between which are circling bays cut off from the low land behind by gravel beaches, or running back into deep marshes.

The shore all the way northward to Elm Point maintains precisely the same character.

Elm Point.

Elm Point itself is, however, a spit of limestone gravel without boulders projecting southward into deep water, formed by the action of the shore current moving southward and carrying with it and assorting the pebbles derived from the wear of the shore to the north.

For a short distance north of Elm Point the shore is somewhat more regular than before, with fewer boulders collected on the points. In one place the land behind the beach is a few feet higher than the lake, but boulders are shoved up against it so thickly that no section can be seen. The land, however, in all probability here consists of till, and the action of the waves has carried away the finer material, while the shoving of the ice in spring has constantly tended to pile the boulders in a compact wall along the beach.

Steep Rock Point.

Three miles and a half north of Elm Point Devonian limestone of the Manitoban series begins to make its appearance on the shore, and thence northward for two miles there is an almost continuous exposure of these rocks rising in a low anticline to a greatest height of twenty feet nine inches above the level of the water of July, 1888, while close to the foot of the highest part of the cliff the water is seventeen feet deep, giving the cliff a total height of more than thirty-seven feet.

Undermined cliffs.

The rock is white or light gray limestone, moderately thin-bedded and breaking very irregularly into angular fragments. About twenty-five feet in all are exposed and of these the lower beds are the most friable and easily worn away by the water, forming an irregular overhanging cliff, through narrow parts of which the waves have in several instances cut wide apertures, while in other places, planes of jointage have carried back the erosive agents to wear out narrow bays and caverns, the floors of which are formed of rounded limestone pebbles broken from the cliff itself.

The strata, which are just above the basal argillites or argillaceous limestones of the Manitoban formation, are not at all rich in fossils, but nevertheless the following species have been collected, viz. :—*Favosites Gothlandica*, Crinoid stems, *Monotrypa* sp., *Atrypa reticularis*, *Atrypa aspera*, *Pentamerus comis*, *Gyroceras submamillatum*, *Bellerophon Pelops*, *Euomphalus Manitobensis* and remains of fishes.

Glacial striæ.

The surface of the rock in a number of places shows well-marked glacial grooves and striæ bearing S. 13° E., and in one place, at the north-west extremity of the point, the striæ are bearing S. 2° W., while at another place on the north-east side of the point they are bearing S. 1°—8° E. At this latter place they are on a sloping beach close to the edge of the water.

The surface of the limestone is generally covered with two or more feet of clay, filled with angular fragments of the rock itself derived from close at hand, and this is often overlaid by rounded limestone gravel, while along the shore on the side of the point, boulders of gneiss are thickly scattered.

From Steep Rock Point to the head of Fairford River the shore is low and consists of a gravel ridge, on the edge of a marsh that stretches back into the interior.

Rock at head of Fairford River.

At the discharge of Lake Manitoba into the Fairford River, a band of white limestone, probably of Silurian age, crops out on the south bank close to the edge of the water, and extends northward beneath the bed of the stream. It is a white, hard, thin-bedded, and semi-crystalline limestone, and eighteen inches in all is exposed. No fossils could be found. Its surface is polished and striated, the striæ running S. 13° E.

Glacial striæ.

A mile to the east of this is a ridge six feet in height running S. 13° E., and apparently composed of the same rock, while in the vicinity of the Fairford Mission Church, and for a mile or more to the east of it, similar rock immediately underlies the surface, and occasionally rises into view in little bare knolls.

Vertical cave.

A mile and a half a little north of east from the Mission and just south of a road to Lake St. Martin, the rock comes to the surface and in it is a hole, five feet in diameter, running straight down for fourteen feet, and expanding somewhat at the bottom. I was told that the Indians of the vicinity ascribe the formation of this hole to a great snake that lived in former times. Even now they refuse to go down into it. It gives a section from top to bottom of hard compact white limestone, in places rather thin-bedded.

The cave has been formed by water charged with carbonic acid trickling through fissures in the limestone and dissolving out its more soluble portions. When examined in July, 1888, the bottom was covered with ice.

Silurian.

No fossils were found anywhere throughout this band of limestone, but it would seem evident that it is a continuation of the Silurian magnesian limestone that occupies the east side of Lake Winnipegosis, north of Birch Island.

Davis Point.

North-west of the head of Fairford River the shore of the lake is generally low, and it is not till the vicinity of Davis Point is reached that the Silurian again makes its appearance. At the southern end of this low exposure, a thin and even-bedded dolomitic limestone crops out of the bank near the water's edge, and many slabs of the same rock are scattered over the shore. No fossils were found in it, but it is doubtless the same band as is exposed at Fairford.

At the north end of the exposure, and apparently overlying the last-mentioned rock, is a layer of very thick-bedded limestone, also slightly dolomitic. It is yellow, hard and tough, but not compact like the

last, being largely composed of the debris of Stromatoporoids and corals. It weathers white, with a very rough surface.

The following fossils were collected from this latter bed: *Clathrodictyon ostiolatum*, *Clathrodictyon vesiculosum*, *Pycnostylus Guelphensis*, *Zaphrentis*, sp., and *Favosites Gothlandica*.

The north shore of Portage Bay is low, without rock exposures, with long points of boulders running out in the direction of general glacial striation. The islands off the shore are also chiefly composed of gneissoid boulders, and from the highest points there are low ridges extending S. 8° E. in the same direction as the points.

Paonan Point. The shores of Paonan Point, as far as they were examined, were also found to present in most places a boulder wall to the lake, while in the interior the land was low and marshy. Cherry Island, off the southern extremity of this point, is also surrounded by boulders on its southern side, while its northern side is a beach of gravel and sand.

North shore of lake. West of the portage at the north end of Paonan peninsula, to the mouth of Waterhen River, no rock is seen anywhere on the north side of the lake, but the shore is everywhere low and the points and islands are surrounded by boulders, often piled up to a height of six to eight feet. Off the points, boulder reefs frequently extend into the lake for a considerable distance, while the deep bays lying between the points run back to extensive marshes. The boulders are chiefly of gneiss, mica schists and other Archæan rocks, while the pebbles on other parts of the shore are mostly of white limestone. Some of these hold impressions of salt crystals, and doubtless have been transported by the glacier from the Silurian limestone to the north.

Returning to Sifton Narrows, and thence proceeding northward up the west side of Lake Manitoba, the country is found to be very similar to that on the east side of the lake. The shore, however, is not so thickly strewn with boulders, which are generally confined to the more prominent points and to little rocky islands, while the beach in most places is composed of a ridge of finer or coarser limestone gravel extending along the face of a marsh which stretches back to a poplar forest. No rock in place is seen till Big Sandy Point is reached, one of the best known harbours on the lake. It is a spit of small pebbles of limestone and gneiss rising six feet above the water, which is six to eight feet deep close to the shore.

Big Sandy Point.

North of the harbour is a rocky hill, the face of which forms a cliff ten feet high overlooking the lake. It is composed of a harsh semi-crystalline very light brown magnesian limestone, which weathers to a somewhat darker shade of brown. It is rather thick-bedded and approximately horizontal, though the beds appear to have an undulat-

ing dip. Fossils were poorly preserved, but the following were recognized :—*Pachypora cervicornis*, Crinoidal columns, *Atrypa reticularis*, *A. aspera*, and *Pentamerus comis*.

Munroe Point.

The shore onwards past Crane River narrows is piled high with boulders, and the next Devonian exposure seen was at Monroe Point, on the west side of the mouth of Crane River. There are here three minor points, at which are little cliffs, showing respectively nine, nine, and six feet of a tough white compact or vesicular and entirely uncrystalline dolomitic limestone. In some of the compact bands, where no vesicles are present, a smooth, newly fractured or polished surface of the rock shows a kind of oolitic structure, the round or irregularly shaped oolitic grains being more opaque than the surrounding matrix. The bedding is heavy and horizontal, but at the south-easterly point there are several series of jointage planes, along which there would seem to be slight faults, with throws of a foot or two.

A large number of fossils were collected here, of which the following were broken out of the face of the cliff itself :—*Pachypora cervicornis*, *Favosites Gothlandica*, Crinoidal columns, *Cystodictya Hamiltonensis*, *Polypora Manitobensis*, *Atrypa reticularis*, *A. aspera*, *Strophalosia productoides*, *Spirifera fimbriata*, *Conocardium Ohioense*, *Euomphalus annulatus*, *Loxonema priscum*, *Loxonema cingulatum*, *Bellerophon Pelops*, *Orthoceras* sp., *Bronteus Manitobensis*.

The following species were collected from the rock debris at the bottom of the cliff, and apparently have been derived from it :—*Sphærospongia tessellata*, *Pentamerus comis*, *Terebratula Sullivanti* *Dentalium antiquum ?*, *Naticopsis Manitobensis*, with several other small species of gasteropods.

The surface of the rock on the top of the cliff was in one place found to be smooth and glaciated, but the striæ had been entirely weathered out.

Pentamerus Point.

Three miles and a half north of Monroe Point, Pentamerus Point projects into the lake and is strewn with large irregular masses of dolomite. Off the point, a foot below the surface of the water, the bottom is found to be composed of bed rock, and the masses lying on the point have been broken from this ledge by the action of the frost and shoved up on the shore by the ice. The rock is a hard, white, vesicular dolomite, similar to that seen outcropping at Monroe Point, and, like it, containing a large number of fossils, of which the following are the most typical :—*Sphærospongia tessellata*, *Actinostroma fenestratum*, *Calumnaria disjuncta*, *Favosites Gothlandica*, *Pachypora cervicornis*, a Polyzoon, Crinoidal columns, *Atrypa reticularis*, *A. reticu-*

laris, var. *aspera*, *Spirifera fimbriata*, *Pentamerus comis*, *Rhynchonella pugnus*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Actinopteria Boydii*, *Myalina inflata*, *Spathella subelliptica*, *Glossites Manitobensis*, *Dentalium antiquum*, *Pleurotomaria infranodosa*, *Pleurotomaria* (sp. reversed), *Porcellia Manitobensis*, *Eunema clathratulum*, *Astralites fimbriatus*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Platyostoma tumidum*, *Naticopsis Manitobensis*, *Loxonema priscum*, *Pleurotomaria Spenceri*, *Gyroceras filitextum*, *Orthoceras Tyrrellii*, and *Bronteus Manitobensis*.

Horizon. These two localities are quite typical of the Winnipegosan formation.

Five miles a little west of north from Pentamerus Point, a prominent point stretches out into the lake to the west of the harbour of Little Sandy Point, and is underlaid by a rather thin-bedded bluish-gray limestone, rising with a gentle slope out of the water. Its surface is Glacial striæ. well glaciated, showing grooves bearing S. 12° W., crossed by fine striæ bearing S. 8° E. The rock holds a few fossils, the same as those just to be recorded from Onion Point.

A slight exposure of similar limestone forms a little cliff at Flat Onion Point. Rock Point, but the main exposure is at Onion Point, a mile and a half still further west. Here a vertical cliff, eight feet high, faces the lake, and extends 150 yards along the shore. It is composed of white or light gray limestone, very evenly bedded, and the beds appear on the face of the cliff to be from two to three feet in thickness, but they readily break into thinner layers, and have also an irregular cross-fracture which would make it difficult to quarry pieces of any considerable or regular size.

Anticline. The rock is brought up by a low anticline striking N.W., and towards the north-east it dips at an angle of 2° to the edge of, and beneath the water, while to the south-west it breaks off abruptly above a tail heap of large boulders. The total thickness of rock seen is nine feet six inches.

Fossils Fossils were very plentiful, but, unlike those at Monroe and Pentamerus points, they belong to comparatively few species. *Atrypa reticularis*, *A. reticularis*, var. *aspera* and small Crinoidal columns are particularly abundant, while *Paracyclas elliptica*, *Euomphalus Manitobensis* and *Raphistoma Tyrrellii*, are found in considerable numbers. With them the following species also occur :—*Pachypora cervicornis*, *Cyathophyllum petraioides*, *Cyrtina Hamiltonensis*, *Productella subaculeata*, *Kefersteinia subovata?*, *Bellerophon Pelops*, *Loxonema altivolvis*, *Euomphalus circularis*, var. *subtrigonalis*, *Orthoceras Hindii*, and *Hyolithes alatus*.

This locality is typical of a zone near the base of the Manitoban formation.

SYSTEMATIC GEOLOGY.

TABLE OF FORMATIONS.

	Feet.
RECENT.	
Present lake beaches. Delta deposits in Dauplin, Swan and Red Deer Lakes, &c.	
POST TERTIARY.	
Champlain.	
Terraces in the valleys of Shell and Assiniboine rivers and their tributaries. Beaches and deltas of Lake Agassiz on the slope of the Manitoba escarpment, at least as far northward as Red Deer River.	
Glacial.	
Till on the general surface. Moraines on and in front of the Riding, Duck and Porcupine mountains; north of Lake Winnipegosis, &c. Drumlins in the lakes, and in the Assiniboine valley. Kames in the Valley river valley, &c.	
Inter or *Preglacial.*	
Clays and sands on Rolling River and at Churchbridge.	
CRETACEOUS.	
Pierre.	
Odanah Series.	
Light gray hard fissile shales very poor in fossils, occurring on the upper portion of Riding Mountain and southward to the International Boundary line.	400
Millwood Series.	
Dark gray soft shale.	664
Niobrara.	
Light gray mottled calcareous clay shale with bands of chalky limestone, everywhere containing a large number of foraminifera.	130–540
Benton.	
Dark gray very soft non-calcareous clay shale, poor in fossils, and weathering into gentle slopes.	160
Dakota.	
A rather soft white or light gray sandstone often calcareous.	13–200
DEVONIAN.	
Upper Devonian or *Manitoban.*	
Light gray hard brittle limestone containing *Athyris vittata*, &c., underlaid by red argillites, outcropping at Rose Island and vicinity in Swan Lake, and at Point Wilkins.	100
Light gray hard limestone seen at Onion Point, Snake Island, Beardy Island, &c.	40
Red and gray shale seen near the mouth of Bell River, south of Weston Point, &c.	70

Middle Devonian or *Winnipegosan.*

	Feet.
Whitish or light yellow, hard, tough, generally compact, dolomite containing *Stringocephalus Burtini* and numerous other fossils. It outcrops chiefly on the islands and shores of Dawson Bay, and southward to Point Richard on Lake Manitoba.	100
Porous spongy yellow dolomites of Pemmican Island, Devil's Point, Macoun Point, &c.	100

Lower Devonian.

These beds have not been clearly defined, but they appear to be composed of red and other shales.	100

SILURIAN.

Niagara.

Compact, thin bedded dolomites, found chiefly on the west side of Lake Winnipegosis.	
Compact and porous dolomites containing a considerable number of fossils, seen on Cross Lake and vicinity.	
Hard, tough, light yellowish dolomitic limestone, seen on the Saskatchewan River at Grand rapids.	
Soft white or light yellow chalky or argillaceus limestone, with a number of fossils. Near the bottom is a hard band containing large numbers of *Pentamerus decussatus.*	200

SILURIAN.

Area.

The Silurian occupies the whole of the north-eastern portion of the area described in the present report, where it is represented by a series, a few hundred feet in thickness, of light gray limestones and dolomites.

Lower Niagara limestone.

The lower portion of the system is best shown in the gorge at the Grand Rapids, near the mouth of the Saskatchewan River, where it outcrops in a horizontal attitude a few miles south of an exposure of Trenton limestone on the west side of Lake Winnipeg.

The following descending section is here shown :—

	ft.
1. White thin-bedded limestone	15
2. Covered	6
3. Soft yellow limestone	8
4. Gap in section	10?
5. Hard yellow magnesian limestone	4
6. Moderately thin-bedded white limestone	8
7. Hard compact buff limestone	1
8. Brecciated limestone	2
	54

The three lower bands are, as far as is at present known, quite unfossiliferous, while No. 5 contains a great number of a beautifully preserved *Pentamerus*, recently described by Mr. Whiteaves as *P. decussatus.* With it are found *Favosites Niagarensis, Alveolites* sp., *Lyellia* sp., *Halysites catenulatus, Orthis* sp., and *Euomphalus* sp.

Above No. 5 is a gap in the section where the beds have been worn away, being in all probability too soft to resist erosion to the same extent as the surrounding beds.

In band No. 3 fossils were not plentiful, but *Strophomena acanthoptera* and *Leperditia Hisingeri*, var. *fabulina* were collected. This band is generally porous and contains a large number of impressions of salt crystals. In places the bedding is moderately even and horizontal, but generally it is hardly discernible, and the rock breaks into very irregular lumpy pieces. Lying on the bank, and having been apparently derived from this band, are some nodules of marcasite, and red masses of ironstone.

No. 1 is a thin-bedded, white, horizontal, chalky limestone, in places argillaceous, very light, and breaking regularly when struck with the hammer. It has a more or less granular structure, and in places was strongly ripple-marked. A thin band a few feet below the top, contains a considerable number of fossils, among which are the following: *Favosites Niagarensis*, *Leptocœlia* sp., *Rhynchonella* sp., *Pterinea aviculoidea ?*, *Pleurotomaria occidens*, *Orthoceras* sp., *Gomphoceras parvulum*, *Leperditia Hisingeri*, var. *egena*, *Leperditia cœca*, and *Isochilina grandis*, var. *latimarginata*.

This series is sharply delimited above, and probably also below, though its exact contact with lower beds has not been observed. It appears to occupy a position at the base of the Silurian (as distinguished from the Cambro-Silurian) system and probably represents the lower part of the Niagara of Wisconsin, &c.

Upper Niagara limestone.

Overlying the lower Niagara limestones is a considerable thickness, possibly a few hundred feet, of dolomites and dolomitic limestones of Upper Niagara age.

Grand Rapids

The base of this series is well shown in the gorge of the Grand Rapids, where it consists of ten feet of a hard, tough, light-yellowish dolomitic limestone, rather indistinctly bedded, but conformable to the underlying series. It is generally clearly fragmental, and in its lower portion contains a large number of salt crystals. Fossils are here moderately plentiful, but difficult to break out. Crinoid stems are very abundant, and with them are *Favosites Gothlandica*, *Zaphrentis* sp., and *Strophomena acanthoptera*.

This crinoid bed grades up into, and is overlaid by, from twenty to thirty feet of hard, brittle, yellow dolomite, generally thinly and evenly bedded. The only fossil here appears to be a large Stromatoporoid.

This compact band is overlaid by a porous yellow dolomite in moderately thin but uneven beds, and contains many impressions of salt crystals.

Cedar and Winnipegosis Lakes.

From Grand Rapids, where the above section was obtained, beds of this series have been traced westward through Cross Lake to the extreme west end of Cedar Lake, and down the east shore of Lake Winnipegosis from its north-east angle to latitude 52° 32′, as well as on the Fairford River and at several points around Lake St. Martin. Throughout this distance all the exposures are low and practically horizontal, and though there is considerable local variation in the character of the rock, it is doubtful whether the variations are sufficiently persistent to enable the geologist to determine with any degree of accuracy the total thickness of the terrane. In many places the beds are hard and almost slate-like, but these merge both vertically and horizontally into others that are much more porous and often contain many impressions of salt crystals. At the north-east angle of Lake Winnipegosis one bed is thick and almost porcellanous in texture, and close by is another heavy bed containing many large and small nodules of gray chert. In the immediate vicinity is a thin-bedded slaty dolomite very much broken by minute fissures, and having its surface often thickly strewn with fossil ostracods. Farther north, at Cross Lake Rapids, similar ostracodous dolomites are associated with more porous and highly fossiliferous beds, corresponding closely with the Niagara limestone of Wisconsin.

Niagara fossils.

The following is a rough provisional list of the fossils found in this formation :—

Stromatopora sp.
Calapœcia sp.
Zaphrentis Racinensis ? Whitfield.
Cyathaxonia Wisconsinensis ? Whitfield.
Omphyma sp.
Favosites Gothlandica, Lamarck.
Favosites Niagarensis, Hall.
Alveolites Niagarensis, Rominger.
Halysites catenulatus, L.
Lyellia papillata ? Rominger.
Orthis sp.
Strophomena acanthoptera, Whiteaves. N. sp.*
Rhynchonella sp.
Rhynchonella altiplicata ? Hall.
Atrypa reticularis, L., (young).
Leptocœlia sp.
Meristella sp.
Pentamerus decussatus, Whiteaves. N. sp.
Trematospira formosa, Hall.
Pterinea aviculoidea ? Hall.

* N. sp. is inserted in these lists after species described in the reports cited on pages 19 and 20 from collections made in the course of the present exploration.

Murchisonia sp.
Pleurotomaria occidens, Hall.
Pleurotomaria Hoyi? Hall.
Pleurotomaria sp.
Polytropis sp.
Euomphalus sp. (very small).
Orthoceras sp.
Orthoceras sp.
Gomphoceras parvulum, Whiteaves. N. sp.
Gyroceras sp.
Dalmanites sp.
Illaenus sp.
Acidaspis perarmata, Whiteaves. N. sp.
Isochilina grandis, var. *latimarginata*, Jones. N. var.
Leperditia Hisingeri, var. *fabulina*, Jones. N. var.
" " " *egena*, Jones. N. var.
" " " *gibbera*, Jones. N. var.
" *cœca*, Jones. N. sp.
" *phaseolus*, Hisinger.
" *Whiteavesii*, Jones. N. sp.
" *marginata*, Schmidt.

Southern extension of the terrane.

In the vicinity of Lake St. Martin thin-bedded dolomites of this formation rest directly on and against rounded bosses of red micaceous granite, and green soda-rich syenite porphyry, which have formed elevated portions of the Archæan floor on which the Palæozoic rocks of Manitoba were deposited. Elsewhere they would appear to rest on undisturbed limestones and shales of Cambro-Silurian age.

Gypsum.

A short distance west of these isolated bosses of Archæan rocks an irregular hilly tract rises above the gently sloping wooded plain. The hills are found for the most part to be composed entirely of massive or crystalline gypsum, while a few consist of light bluish-white anhydrite.

On the eastern shore of Lake Manitoba, a short distance west of this gypsum outcrop, the thin-bedded Upper Niagara dolomites are overlain by a few feet of a thick-bedded massive stromatoporoid magnesian limestone in which the only fossils found were a few corals, but among them *Pycnostylus Guelphensis* could be easily recognized. This limestone forms the upper beds of the Niagara of this region, but it has not been deemed advisable to separate the horizon as Guelph on the evidence of a fossil whose range is so little known, especially as the Leperditia beds below it show so many points of similarity to the Lower Helderberg of Wisconsin.

South of the region of the lakes the Silurian has not yet been outlined, but some fragments of rock collected from the top beds at Stonewall look as if they might belong to this system, and the high ridge between Lakes Manitoba and Winnipeg is not improbably capped by beds of the same age.

DEVONIAN.

Position.

Overlying the Niagara dolomites in the region of Lakes Winnipegosis and Manitoba there is a considerable thickness, probably a hundred feet or more, of strata, of which no natural exposures have yet been recognized. That these strata are softer than the overlying and underlying beds, is testified to both by the absence of any cliffs of hard rock, and by the presence of an extended depression along the strike of the beds, now largely occupied by the above-mentioned lakes. A bed of red clay or shale, just above this gap, is seen on Pemmican Island, &c., and it is not improbable, considering the argillaceous character of many of the overlying limestones, that the whole of the concealed series is composed of argillaceous shales or soft limestones. The absence of sand from the till of that region makes it unlikely that much sandstone is included in the series.

Lower Devonian.

These shales are placed at the local base of the Devonian system, since the above-mentioned red bed lies conformably below Devonian dolomites, and there is little or no evidence at hand to prove the presence or absence of an unconformity at the top of the Silurian. These shales may, therefore, possibly represent the Corniferous in Manitoba, and the Palæozoic strata passed through in the Morden well probably represent the more southern continuation of this formation.

Winnipegosan formation.

The next rock in ascending order is a series of light brown or gray, harsh, porous, and very irregularly weathering, dolomitic limestones, having a probable thickness of a hundred feet or more. This zone or terrane contains a number of typical Devonian fossils, among which the following are some of the most characteristic, viz.: *Atrypa reticularis*, *Pentamerus comis*, *Productella subaculeata*, *Paracyclas elliptica*, *Paracyclas antiqua*, *Bellerophon Pelops*, *Straparollina obtusa*, &c. Nearly all these fossils are also characteristic of the immediately overlying zone.

Hard dolomites.

Stringocephalus zone.

The harsh dolomites are overlaid by a somewhat similar thickness of very thick-bedded white tough dolomites, often containing more porous bands, in which are many well-preserved casts of salt crystals. These compact dolomites have yielded a rich harvest of fossils, among which are many forms, such as *Stringocephalus Burtini*, *Pentamerus*

comis, &c., typical of the Middle Devonian of Europe. The harsh, and the compact dolomites are therefore regarded as the lower and upper portions of the Winnipegosan formation or Middle Devonian. They are best exposed on the islands and shores of Dawson Bay, near the north-west extremity of Lake Winnipegosis, and isolated outcrops are seen on the shores as far south as "Sifton's Narrows," on Lake Manitoba. South of this point no natural exposures of Devonian rocks have yet been recognized in the province of Manitoba.

Manitoban formation.

Above the Winnipegosan dolomites the base of the Manitoban formation or Upper Devonian consists of red and gray calcareous shales, from forty to seventy feet in thickness, containing comparatively few fossils. These shales are, however, almost everywhere marked along their eastern outcrop by brine springs that pour a copious flow of salt water over the surface of the underlying dolomites.

Above the shales is a comparatively thin band of argillaceous and highly fossiliferous light gray limestone, in which *Atrypa reticularis* and *Paracyclas elliptica* are especially abundant.

The highest Palæozoic rocks seen in Manitoba, but possibly still low down in the Upper Devonian, outcrop on some islands in Swan Lake, and in the high promontory of Point Wilkins, on the west side of Dawson Bay. They consist of from sixty to eighty feet of light gray compact brittle limestone not very rich in fossils, but those that are present, viz.: *Atrypa reticularis*, *Cyrtina Hamiltonensis*, *Athyris vittata*, *Paracyclas elliptica*, *Bellerophon Pelops*, &c., are typically Devonian.

Devonian fossils.

The following is a list of the fossils from the Devonian rocks of Manitoba and vicinity, all of which, except *Orthis striatula*, were collected on the recent explorations under the charge of the writer. The letters M. and U. indicate that they were found in either the Middle or Upper Devonian, respectively.

PROTOZOA.

Sphærospongia tessellata, Phillips.	M.
Astræospongia Hamiltonensis, Meek & Worthen.	M.

CŒLENTERATA.

Cyathophyllum vermiculare, var. *præcursor*, Frech.	U.
" *dianthus*, Goldfuss.	U.
" *Waskasense*, Whiteaves. N. sp.	U.
" *petraioides* " N. sp.	U.
" *Anna*, Whitfield.	M.
" *profundum*, Hall.	M.
" *profundum*, Hall, var.	U.
" *Athabascense*, var.	U.

Columnaria disjuncta, Whiteaves. N. sp.	M.
Amplexus sp.	M.
Actinocystis variabilis, Whiteaves. N. sp.	M.
Favosites Gothlandica, Lamarck.	M.
Pachypora cervicornis, DeBlainville.	M.
Pachypora or *Alveolites*.	U.
Alveolites vallorum, Meek.	M. U.
Clathrodictyon (like *C. laxum*, Nicholson.)	U.
Stromatopora sp. (cfr. *L. Bücheliensis*, Bargatzky.)	M.
" sp. (cfr. *L. Hüpschii*, Bargatzky.)	M. U.
Actinostroma expansum, Hall & Whitfield	M.
" *Tyrrellii*, Nicholson. N. sp.	M.
" *fenestratum*, Nicholson.	M.

ECHINODERMATA.

Ctenocrinus sp.	M.

VERMES.

Spirorbis omphalodes, Goldfuss.	M.

POLYZOA.

Leptotrypa quadrangularis, Nicholson.	U.
Pinacotrypa marginalis, Whiteaves. N. sp.	M.
Cystodictya Hamiltonensis, Uhlrich.	M.
Fenestella vera, Uhlrich.	M.
" *dispanda ?* Hall.	M.
Polypora Manitobensis, Whiteaves. N. sp.	M.
Monotrypa sp.	U.

BRACHIOPODA.

Discina sp.	M.
Chonetes Logani, var. *Aurora*, Hall.	U.
" *Manitobensis*, Whiteaves. N. sp.	U.
Strophalosia productoides, var. *membranacea*.	M.
Productella subaculeata, Murchison.	M. U.
Orthis striatula, Schlotheim.	U.
" *Manitobensis*, Whiteaves. N. sp.	M.
Orthothetes Chemungensis, Conrad.	M.
Strophodonta arcuata, Hall.	U.
" *interstrialis*, Phillips.	M.
Spirifera fimbriata, S. A. Miller.	M. U.
" *Richardsonii*, Meek.	M. U.
Cyrtina Hamiltonensis, Hall.	U.
Athyris vittata, Hall.	U.
Atrypa reticularis, L.	M. U.
" " var. *aspera*, Schlotheim.	M. U.

Rhynchonella pugnus, Martin. M.
Pentamerus comis, Owen. M. and base of U.
Stringocephalus Burtini, Defrance. M.
Terebratula Sullivanti, Hall. M.

LAMELLIBRANCHIATA.

Pterinea lobata, Whiteaves. N. sp. M.
Actinopteria Boydii, Conrad. M.
Gosseletia sp. M.
Mytilarca inflata, Whiteaves. N. sp. M.
Myalina trigonalis, " N. sp. M.
Modiomorpha attenuata, Whiteaves. N. sp. M.
" *compressa*, " N. sp. M.
" *tumida*, " N. sp. U.
" *parvula*, " N. sp. M.
Spathella subelliptica, " N. sp. M. U.
Goniophora perangulata, Hall. M.
Macrodon pygmæus, Whiteaves. N. sp. M.
Nucula lirata, Conrad. U.
" *Manitobensis*, Whiteaves. N. sp. M.
Nuculites sp. U.
Kefersteinia subovata, Whiteaves. N. sp. M. U.
Mecynodon Eifeliensis ?, Frech. M.
Anodontopis affinis, Whiteaves. N. sp. M.
Paracyclas antiqua, Goldfuss. M.
" *elliptica*, Hall. U.
" " var. *occidentalis*, Billings. U.
" sp. M.
Conocardium Ohioense, Meek. M.
Cardiopsis tenuicostata, Whiteaves. N. sp. M.
Cypricardella bellistriata, Conrad. M. U.
" *producta*, Whiteaves. N. sp. M.
Cypricardinia planulata, Conrad. M.
Glossites Manitobensis, Whiteaves. N. sp. M.
Orthonota corrugata, Whiteaves. N. sp. M.

GASTEROPODA.

Dentalium antiquum ? Goldfuss. M.
Palæacmæa cingulata, Whiteaves. N. sp. M.
Pleurotomaria goniostoma, Whiteaves. N. sp. M.
" *infranodosa*, " N. sp. M.
Pleurotomaria Spenceri, " N. sp. M.
Raphistoma Tyrrellii, Whiteaves. N. sp. M. U.

Murchisonia turbinata, Schlotheim.	M.
" *Dowlingii*, Whiteaves. N. sp.	M.
Bellerophon Pelops, Hall.	M. U.
Porcellia Manitobensis, Whiteaves. N. sp.	M.
Eunema speciosum, Whiteaves. N. sp.	M.
" *brevispira*, " N. sp.	M.
" *subspinosum*, " N. sp.	M.
" *clathratulum*, " N. sp.	M.
Astralites fimbriatus, " N. sp.	M.
Euomphalus annulatus, Phillips.	M.
" *subtrigonalis*, Whiteaves. N. sp.	U.
Omphalocirrus Manitobensis, " N. sp.	U.
Straparollina obtusa, " N. sp.	M.
Pseudophorus tectiformis, " N. sp.	M.
Platyceras parvulum, " N. sp.	M.
Platyostoma tumidum, " N. sp.	M.
Naticopsis Manitobensis, " N. sp.	M.
" *inornata*, " N. sp.	M.
Loxonema altivolvis, " N. sp.	U.
" *priscum*, Munster.	M.
" *cingulatum*, Whiteaves. N. sp.	M.
" *gracillimum*, " N. sp.	M.
Macrochilina subcostata, Schlotheim.	M.
" *pulchella*, Whiteaves. N. sp.	M.

PTEROPODA.

Hyolithes alatus, Whiteaves. N. sp.	M. U.

CEPHALOPODA.

Orthoceras Hindii, Whiteaves. N. sp.	U.
" *Tyrrellii*, " N. sp.	M.
Gomphoceras Manitobense, Whiteaves. N. sp.	U.
Cyrtoceras occidentale, " N. sp.	M.
Homaloceras planatum, " N. sp.	M.
Tetragonoceras gracile, " N. sp.	M.
Gyroceras Canadense, " N. sp.	M.
" *filicinctum*, " N. sp.	M.
" *submamillatum*, " N. sp.	U.

CRUSTACEA.

Isochilina Dawsoni, Jones. N. sp.	M.
Elpe Tyrrellii, " N. sp.	M.

Leperditia exigua, Jones.	M.
Bronteus Manitobensis, Whiteaves. N. sp.	M.
Lichas sp.	M.
Cyphaspis bellula, Whiteaves. N. sp.	M.
Proetus mundulus, " N. sp.	M. & U.

FISHES.

Ptyctodus calceolus, M. & W.	U.
Rhynchodus sp.	U.
Dinicthys Canadensis, Whiteaves. N. sp.	U.
Aspidicthys notabilis, " N. sp.	U.
Onychodus sp.	U.

Extension of the Devonian.

South of "Sifton Narrows" on Lake Manitoba, no Devonian rocks are known to outcrop within the Province of Manitoba. Northward and north-westward of Lake Winnipegosis the characters of the Palæozoic rocks, other than those on Cedar Lake, have not yet been determined throughout a distance of almost five hundred miles, or till the Clearwater and Athabasca Rivers are reached. Here Devonian rocks, very similar in character to the Upper Devonian of Manitoba, have again been recognized, and traced northward along the Athabasca and Mackenzie rivers to within the Arctic Circle.

CRETACEOUS.

Dakota.

Sandstone.

This formation, resting unconformably on the limestones of the Devonian, is composed of white or reddish sandstones, either cemented by a calcareous matrix or often quite incoherent, being then an even-grained white quartzose sand. It grades up into a light green and rather hard sandstone, commonly interstratified with thin bands of shale.

Fossils.

Very few fossils have been found in this sandstone, and those that have been found are confined to the greenish upper beds. They consist chiefly of carbonized fragments of wood and coniferous leaves, but the following animal remains have also been collected, viz. :—

Lingula subspatulata, Hall and Meek.
Ostrea congesta, Conrad.
Modiola tenuisculpta, Whiteaves. N. sp.
Cycloid scales of fishes.

Outcrops.

The terrane can be seen in several exposures along the foot of the northern portions of the Manitoba escarpment, as on the banks of Red Deer, Armitt, Kematch and Swan rivers, and on Kettle Hill, south of

Swan Lake. Also at Pemmican Island, in Lake Winnipegosis, there are evidences of the presence of this or the overlying terrane.

Thickness.

The exposures were altogether too small and infrequent to allow of any exact determination of its total thickness to be made, but on account of the irregularity of the Palæozoic floor on which it was laid down, this certainly varies greatly, even within short distances. Near the north-west corner of the map it has probably a maximum thickness of two hundred feet, while on the north side of the Riding Mountain, where it was passed through in the Manitoba Oil Company's well on Vermilion River, it has, so far as can be determined from the few specimens at hand, a thickness of nineteen feet.

Extension.

South of this point these sandstones have not been recognized in natural exposures within the province, but they are again reported in the states to the south. Towards the north-west they would appear to be represented by the "Tar Sands" on the Athabasca River, but the formation has not yet been determined to be continuous throughout the intervening area.

Benton.

Dark gray shales.

Overlying the Dakota sandstones, the Benton formation occurs as a band of dark gray, almost black shale, holding a considerable quantity of carbonaceous material. This shale is evenly bedded, and breaks down readily into thin flakes, on which account it generally forms sloping banks. With the dark shales are associated thin beds of white, soft, sweet-tasting magnesian clay.

In the bore on Vermilion River, the Benton appears to be 178 feet thick, and further north, on the face of the Duck and Porcupine mountains, it continues of about the same, or slightly less, thickness. It is easily recognized, even when good naked exposures are absent, by its characteristic property of breaking into more or less minute graphite-like flakes, and not weathering immediately into a soft clay, as usually occurs in the less consolidated beds of the Pierre.

It is generally quite destitute of fossils, but in a few places undeterminable fragments of oysters and Inocerami have been collected from the shale.

Niobrara.

Mottled calcareous shale.

The Niobrara formation conformably overlies, and is an upward extension of, the Benton. The rock, however, instead of being a soft fissile shale, with little or no admixture of calcareous material, is a lighter gray calcareous shale or marl, sometimes varying to a band of moderately hard limestone. This is especially the case at the top of the terrane, where a band of grayish chalky limestone is generally met with. This band is often highly charged with pyrite.

A very characteristic feature of the formation is the presence of a large number of Foraminifera, among which *Globigerina cretacea* is often very conspicuous and in great abundance. From most of he exposures throughout north-western Manitoba, the species of foraminifera have not yet been authoritatively determined, but in specimens from Edwards Creek, and from a depth of 1,115 feet in the deep well at Deloraine, in southern Manitoba, the following species were kindly determined for me by Mr. C. Davies Sherborn, of London, England :— Fossils.

Globigerina cretacea, d'Orbigny.
" *bulloides*, d'Orbigny.
" *linnæana*, d'Orbigny.
Cristellaria rotulata, Lamarck.
Planorbulina ammonoides, Reuss.
Anomalina rotula, d'Orbigny.
Bulimina variabilis, d'Orbigny.
Textularia globulosa, Ehrenberg.
Verneuilina triquetra, d'Orbigny.
Marginulina variabilis, Neugeboren.
Dentalina pauperata, d'Orbigny.

Coccoliths and *Rhabdoliths* are also found in many of the specimens. With these minute forms may also occur in great abundance the fragments of shells of a large *Inoceramus* together with the following species :—

Serpula semicoalita, Whiteaves. N. sp.
Ostrea congesta, Conrad.
Anomia obliqua, Meek & Hayden.
Inoceramus problematicus, Schlotheim.
Belemnitella Manitobensis, Whiteaves. N. sp.
Loricula Canadensis, Whiteaves. N. sp.
Ptychodus parvulus, Whiteaves. N. sp.
Lamna Manitobensis, Whiteaves. N. sp. (loose.)
Enchodus Shumardi, Leidy.
Cladocyclus occidentalis, Leidy.

Very characteristic exposures of this formation may be seen in the valleys of all the streams on the north side of Riding Mountain from the Ochre to the Valley rivers, the highest cliffs being usually in the vicinity of some of the strongest of the old shore lines of Lake Agassiz. North of Valley River no outcrops of Cretaceous rocks were detected on the east face of Duck Mountain until North Pine Creek was reached. Here the foraminiferous Niobrara marls are again well exposed, and on Swan River and its tributaries, and on the streams flowing from the eastern and northern slopes of Porcupine Exposures.

Mountain many excellent sections were discovered, so that these rocks form a clearly marked horizon in the middle of the Cretaceous of Manitoba. They generally weather into steep or vertical cliffs, and consist as a rule of gray calcareous shale, with a mottled appearance caused by the presence of large numbers of Foraminifera.

Thickness.

The terrane varies considerably in thickness. In the Manitoba Oil Company's bore on Vermilion River it appears to have a thickness of 130 feet. On North Pine Creek its total thickness is less than 400 feet, and probably is not more than 200 feet. On Bell River it is probably less than 250 feet. In the Swan River valley, near Thunder Hill, it would seem to have a thickness of 540 feet, but it is quite possible that the upper beds represent a foraminiferous horizon in the overlying Pierre formation.

Extension.

This terrane is known to extend southward through the western portion of the province of Manitoba, having been recognized in the valleys of the Assiniboine and other streams near the face of the Manitoba escarpment, and in the borings from the deep wells at Morden and Deloraine. It is doubtless continuous with the Niobrara shales and limestones, originally described by Messrs. Meek and Hayden, from the banks of the Missouri River in Nebraska. Northwest of the area now described, a fragment of typical Niobrara rock was collected from Carrot River, about west long. 103°, by Mr. A. L. Russell, beyond which it has not been traced, and its exact correlation with the beds on Athabasca River is not yet known.

Pierre.

Grading upwards from the top of the Niobrara formation the Pierre shales occupy the summits of all the higher lands of the Riding, Duck and Porcupine mountains. In the Riding Mountain and further south this formation naturally separates itself into an Upper and a Lower Subdivision, which the writer has elsewhere called the Millwood and the Odanah Series.* It is not improbable that the separation of these two series could also be traced northward through the Duck and Porcupine mountains, but that no sections exposing the Cretaceous were found in any of the higher parts of the country, or above the heights at which the Millwood Series might be expected to be found. This series is composed of dark grey soft clay shales very similar to those already described by Dr. Dawson, Mr. McConnell and the writer from Alberta and Assiniboia, containing crystals of selenite and septarian nodules of ironstone. Further west the Pierre is highly fossiliferous, but in north-western Manitoba fossils are very scarce, and of those recorded in the following

Subdivisions.

Millwood series.

*"The Cretaceous of Manitoba," by J. B. Tyrrell. Am. Jour. Sci., vol. 40, (1890) pp. 227-232.

list the Radiolaria are from a bed of shale on Bell River, and the remainder are from ironstone nodules from the west bank of the Assiniboine Valley at Millwood, a short distance south of the present map. Radiolaria and other fossils.

Caryosphæra æquidistans, Rüst. N. Sp.
Cenellipsis hexagonalis, " "
Prunulum calococcus, " "
Cyrtocalpis crassitestata, " "
Dictyocephalus microstoma, " "
" *macrostoma*, " "
Theocampe sphærocephala, " "
Tricolocapsa salva, "
" *thoracica*, " N. Sp.
" *Dowlingi*, " "
" *Selwyni*, " "
Dictyomitra Canadensis, " "
" *polypora*, Zittel.
" *multicostata*, Zittel.
Stichocapsa Tyrrelli, Rüst. N. Sp.
" *Dawsoni*, " "
Pteria linguiformis, Evans and Shumard.
Inoceramus tenuilineatus, Hall and Meek.
" *Sagensis*, var. *Nebrascensis*, Owen.
Nucula sp.
Lucina occidentalis, Morton.
Entalis paupercula, Meek & Hayden.
Dentalium gracile ? "
Baculites compressus, Say.
Scaphites nodosus, var. *quadrangularis*, Owen.
Hylobiites cretaceus, Scudder. N. Sp.
Fragments of fishes.

These shales everywhere form the banks of the Assiniboine valley from Fort Pelly southward, the river flowing on the strike of the terrane. They are also shown in high cliffs on the banks of Ochre and Vermilion rivers and Edwards Creek on the north face of Riding Mountain, the exposure on the latter stream showing the total thickness of the series. Further northward, on the eastern face of the escarpment, the Lower Pierre was recognized on North Pine and Bell rivers, in both of which places it was highly siliceous and contained large numbers of Radiolaria of the above-named species. For the rest the higher slopes are covered with drift. Outcrops.

These Millwood shales extend southward to the International Boundary, being seen at the foot of the bank at Minnedosa; in the valley of Extension.

Horse Creek west of Morden, and in many other places. Towards the north-west they have not yet been followed, but they are not improbably continuous with the similar dark shales on the Saskatchewan, and under large areas of the great plains.

Odanah series. The Millwood shales are overlaid by a considerable thickness of Upper Pierre light gray hard clay shales which are locally known as slate, and which, from their typical development at Odanah, near Minnedosa, on the Little Saskatchewan River, have been called by the writer the *Odanah Series*. Throughout the series are many beds of septarian ironstone nodules, but very few of these are compact like those in the Millwood series, and they are generally cut by many veins of crystalline calcite. No fossils were found by the writer in these shales, but Professor H. Y. Hind, in 1858, collected some fossils from beds of this series, near the mouth of Two Creeks, in township 13, range 27, which clearly show that these shales belong to the marine Cretaceous Pierre formation.*

The following is a list of these fossils :—

Anomia Flemingi, Meek.
Inoceramus Canadensis, Meek.
Yoldia Hindi, Meek.
Lunatia obliquata, Hall and Meek.
Cinulea concinna, Hall and Meek.
Ammonites, sp undet.

Character. The cliffs of this terrane generally weather with a more or less sloping surface, but in railway cuttings, or by some streams, where erosion is very rapid, they rise almost vertically, presenting a general lead-gray appearance. The beds are also much fissured, and iron stains are everywhere seen along the lines of fissure. On a fresh surface the shale can be readily cut, but it quickly hardens on exposure to the atmosphere, and the streams cutting through it have their banks strewn with lenticular pebbles derived from it. In some places, as in the valley of the Little Saskatchewan River near Minnedosa, alluvial beds of these pebbles are being used as ballast for the railway.

Outcrops. The Odanah series is well shown in the upper part of the valley of Edwards Creek, where it conformably overlies the Millwood shales. Slight exposures are also seen on the upper parts of Vermilion River, and the bed of Ochre River is thickly strewn with pebbles derived from

*In a paper on "The Cretaceous of Manitoba" in Am. Jour. Sci., vol. 40, 1890, p. 230, the writer states that the above-named fossils are probably from the Millwood series, but since that paper was written he has carefully examined the banks of the Assiniboine near where these fossils were collected, and has also examined the fossils themselves in the Museum of the Geological Survey of Canada. He is therefore now able to say definitely that the character of the rock in which they are imbedded proves them to be from the Odanah series or Upper Pierre.

it. Pebbles of this shale are first washed into the Assiniboine valley near the mouth of Skunk Creek, and a well at Barnardo's farm near Russell is stated to have been sunk 170 feet through these shales to the underlying series.

Extension.

Fifty miles down the Assiniboine valley below the southern edge of the present map, these shales become conspicuous along its sides, and for thirty-five miles, or to opposite Griswold, the banks are more or less formed of them, and barren rounded knolls, too sterile to grow more than a few small cactus plants (*Opuntia Missouriensis*), rise from the low lands at the bottom of the banks. The valley here has a certain resemblance to the "Bad Lands" of the States to the south-west. This shale is also seen in the higher railway cuttings to the west of Minnedosa. Further south a beautiful section of these shales may be seen in the Pembina valley near La Rivière, on the Pembina Mountain branch of the Canadian Pacific Railway.

Thickness.

The total thickness of the Pierre in north-western Manitoba is 800 feet or more. The Millwood series, as seen in the valleys on the northern face of Riding Mountain, has a thickness of between 450 and 500 feet, while about 300 feet of the overlying Odanah series is there also seen, reaching to near the summit of the mountains, and being immediately overlain by the drift deposits. The top of the Odanah series is not seen.

At the village of Deloraine, in south-western Manitoba, and close to the northern face of Turtle Mountain, the tank well on the Pembina Mountain branch of the Canadian Pacific Railway strikes the Odanah shales at a depth of about ninety feet, and a deep well close by it does not strike the Niobrara until a depth of 1,050 feet is reached, giving a thickness for the Pierre of 960 feet. At the foot of Turtle Mountain, a horizontal band of hard gray calcareous sandstone crops out, and assuming this to represent the base of the Laramie, though no fossils have yet been recognized from it, the whole thickness of the Pierre would be given as a little more than 1,050 feet. Considering the Millwood series as having a thickness of 650 feet, a thickness of about 400 feet would remain for the Odanah series.

PLEISTOCENE.

Post-Cretaceous erosion.

At the close of the Cretaceous epoch, north-western Manitoba rose above the sea which had covered it since Dakota times, and which had left it mantled with a great series of sands and clays. A period of denudation then set it and continued throughout the whole of the Tertiary epoch. During this time the high table land of the Duck and Riding mountains was cut through by the valleys of the

Red Deer, Swan and Valley rivers, and the great valley of the Winnipeg basin, extending from the Manitoba escarpment to the Archæan nucleus, was formed by a river which may have been similar in size and character to the Mississippi of to-day. From this valley the Cretaceous rocks were almost entirely denuded down to the underlying floor of Palæozoic limestones. The trend of the afferent valleys, and the positions of the points of Cretaceous rocks on the edge of the escarpment, would appear to indicate that the main stream flowed north-westward.

Such was the shape of the country at the beginning of the Glacial period, when a great snow-field appears to have formed on the country around and to the north and east of Reindeer Lake, and the ice appears to have flowed in great glaciers westward through the basin of Lake Athabasca, southward across the plains, and south-eastward up the valley of the ancient river of the Winnipeg basin.

Glacial striæ.

Among the evidences of the course followed by this glacier, or these glaciers, across the region under consideration, the following list of glacial striæ is particularly important. Most of these are strongly marked on the highest parts of level polished surfaces of Palæozoic limestone, and the direction of glacial movement is often shown by curved chatter-marks and cross fractures, &c.

Fairford	S. 33° E.
Flat Rock Bay, Lake Manitoba	S. 10 E.
Steep Rock Point, Lake Manitoba	S. and S. 13 E.
Little Sandy Point, Lake Manitoba	S. 10 E. and S. 10 W.
Onion Point, Lake Manitoba	S.
Granite Island, Lake St. Martin	S. 33 E.
South end Lake Winnipegosis, near Meadow Portage	S. 63 E.
South end Lake Winnipegosis, near Mossy River	S.
Charlie Island, north end, Lake Winnipegosis	S. 2 E.
Charlie Island, east side, Lake Winnipegosis	S. 8-13 E.
Charlie Island, (obscure,) Lake Winnipegosis	S. 37 W.
Weston Point Island, Lake Winnipegosis	S. 2 E.
South Manitou Island, Lake Winnipegosis	S. 12 W.
Lat. 52° 45′, E. side Lake Winnipegosis	S. 9 W.
Long Point, Lake Winnipegosis, several places	S. 22 W.
Long Point, Lake Winnipegosis, one place	S. 8 E.
Ami Island, Lake Winnipegosis	S. 23 W.
S.W. side Cameron Bay, Lake Winnipegosis	S. 43 W.
Rowan Island, Dawson Bay, Lake Winnipegosis	S. 42 W.
Beardy Island, Dawson Bay	S. 58 W.

Rose Island, Swan Lake	S. 48-53 W.
McKay Island, Swan Lake and islands to the south	S. 53 W.
Red Deer River, ½ mile below Upper Salt Spring	S. 78 W.
Red Deer River, Upper Salt Spring	S. 68 W.
Red Deer River, Pelican Rapids	S. 78 W.
Saskatchewan River, Grand Rapids, bottom	S. 2 W.
Saskatchewan River, Grand Rapids, middle	S. 62 W.
Saskatchewan River, Grand Rapids, middle (second set.)	S. 92 W.
Saskatchewan River, below Roche-rouge	S. 12 W.
Saskatchewan River, Roche-rouge	S. 12 W.
Cedar Lake, south-east shore	S. 19 W.
Cedar Lake, Island east of Rabbit Point	S. 18 W.
Cedar Lake, mouth of Saskatchewan River	S. 39 W.
Cedar Lake, mouth of Saskatchewan River, one groove	S. 65 E.
Assiniboine River, Sec. 16, Tp. 25, R. 29, on boulders in boulder pavement	S. 73 E.

The surface is very generally covered with till, which on the lacustral plain, over the hard Palæozoic limestones, does not appear to be anywhere of great depth; but on the summit of the Cretaceous plateau to the west, where the rocks consist entirely of soft shales, the till would seem to be very much deeper. In most places it immediately overlies the Cretaceous shales, but in some excellent exposures on Rolling River it is seen to be underlaid by seventy feet or more of stratified sands and clays which are probably of Interglacial age. The clays contain the following species of plants and freshwater shells :— Interglacial beds.

Diatomaceæ.

Navicula lata.
Encyonema prostratum.
Denticula lauta.
Licmophora ?
Cocconeis.

Phanerogamæ.

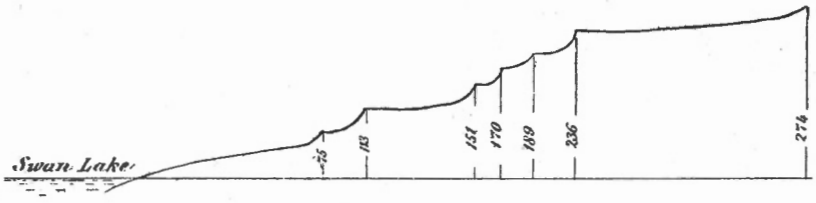
Taxus baccata. L.
Seeds of a Conifer.
Elodea Canadensis (?) Michx.
Vallisneria (?)

Mollusca.

Lymnæa catascopium ? Say. Variety with very short spire.
Valvata tricarinata, Say., and a keelless variety.
Amnicola porata ? Say.
Planorbis bicarinatus, Say.
" *parvus ?* Say.
Pisidium abditum, Haldeman.
Sphærium striatinum, Lamarck.

Lake shores.

On the summit of the Cretaceous plateau the till is covered in a number of places by lake deposits, and east of the escarpment the ancient beaches of Lake Agassiz form long lines of parallel gravel ridges. In some places the ancient lake shores are represented by terraces, cut in the glacial or Cretaceous deposits. An interesting series of these terraces may be seen on the north side of Kettle Hill, south of Swan Lake, as shown in the following figure :—



Section of Kettle Hill South of Swan Lake.
Horizontal Scale. 3000 ft. to an inch
Vertical Scale. 300 ft. to an inch.

A small amount of lacustral sand and clay is occasionally present on the surface, but as a rule, throughout the greater portion of this district, the old lake floor is composed of till.

Moraines.

Moraines are also present at the Mossy Portage and on and around the "mountains," and will be found more particularly described in the descriptive portion of this report.

The glacial and post-glacial deposits of this region will, however, be more fully discussed in the forthcoming report on Lake Winnipeg.

ECONOMIC GEOLOGY.

Salt.—The presence of brine springs is a well-marked feature of the Devonian area west of Lakes Winnipegosis and Manitoba; but while the most copious supply of brine flows from the Devonian rocks, chiefly marking the base of the Upper Devonian, salt is not absent from the beds of Silurian age, and many slabs of this rock were found showing beautiful moulds of typical crystals of Chloride of Sodium. A few small springs of clear salty water were found flowing from the Silurian area on the west side of Winnipegosis. Careful search was made everywhere for indications of the presence of beds of pure salt, but none were found, and instead, impressions of salt crystals were common in all the more porous dolomites. It is probable, therefore, that the salt occurs entirely in more or less isolated crystals scattered throughout the rock, but in some cases these are so numerous that at least a third of the whole mass has been salt. Brine springs.

The following are some of the principal places where brine springs have been observed :— Localities.

1. Salt Creek, west of Lake Dauphin.
2. Banks of Mossy River.
3. Salt Point, south end Lake Winnipegosis.
4. Monkman's Salt Springs, Red Deer Peninsula.
5. Pine Creek.
6. Pelican Bay, mouth of Pelican Creek.
7. " " west side.
8. Mouth of Bell River.
9. Salt Point.
10. Salt Point Peninsula, wide salt area near its base.
11. Salt Point Peninsula, north side of its base.
12. Mouth of Steep Rock River.
13. Lower Red Deer River, many places.
14. Banks of Shoal River.
15. Mouth of Swan River.

At many other places near the line of the base of the Upper Devonian, small saline areas occur, where the brine oozes up through the overlying drift. The characters of these saline areas are very similar throughout, and the descriptions already given of those on Pelican Bay and other places might suffice for all. They are generally barren tracts several acres in extent, surrounded by a fringe of the red salt plant (*Salicornia herbacea*). Here and there springs bubble up and often build rounded mounds of reddish scinter, several feet in height, in the centre of the tops of which, over the springs, are little basins of clear brine. Down the sides of these mounds the water trickles Character of saline areas.

to the arid flats, where it evaporates in the dry seasons. In other places the pool of salt water is in the middle of a little tract of soft mud, over which may be a sod of coarse grass. In the pool bubbles of gas are constantly rising. This gas was found to be uninflammable, and was probably to a large extent composed of air.

Some of the springs mentioned above were used for the manufacture of salt in the early days of the Red River Settlement, and even yet the Indians occasionally boil down a little salt from them.

Monkman's Salt Works in 1858.

The following excellent description of Monkman's Salt Works, as they existed in 1858, is given by Prof. H. Y. Hind :—*

"The soil at the Salt Springs is a very retentive yellowish white clay, containing small limestone boulders and pebbles, with boulders of the unfossiliferous rocks. The wells, for obtaining a supply of brine, are sunk wherever a small bubbling spring is observed to issue from this retentive clay. The springs are constantly changing their position, and as the wells become exhausted from time to time, a fresh excavation is made where a new spring is observed to issue. No doubt boring, or deeper wells, would prevent these changes, and not only secure a larger flow of brine, but ensure it permanency. The wells at present are 25 in number; but some of them appear to have been lately abandoned, and others have long since ceased to yield brine. They are situated 400 yards from the lake shore, and were first worked 40 years since, by James Monkman. This enterprising individual struggled for many years against the importation of English salt, which was sold in the settlements at a cheaper rate than he could afford to manufacture salt on Lake Winnipegosis. He has made salt at Swan River and Duck River. The manufacture is now carried on with profit for the Hudson's Bay Company, at Swan River, and at Winnipegosis Lake by Monkman's sons.

"At the 'Works' there are two small log-houses and three evaporating furnaces. The kettles, of English construction, are well made rectangular vessels of iron, five feet long, two feet broad and one foot deep. They are laid upon two rough stone walls, about twenty inches apart, which form the furnace. At one extremity is a low chimney. The whole construction is of the rudest description; and at the close of the season the kettles are removed, turned over, and the furnace permitted to go to ruin, to be rebuilt in the following spring.

"The process of making salt is as follows: When a spring is found, a well, five feet broad and five feet deep, is excavated, and near to it an evaporating furnace erected. The brine from the wells is ladled into the kettles, and the salt scooped out as it forms, and allowed to remain

*Op. cit., pp. 94 and 95.

for a short time to drain before it is packed in birch bark roggins for transportation to Red River, where it commands twelve shillings sterling a bushel, or one hundred weight of flour, or a corresponding quantity of fish, pemican or buffalo meat, according to circumstances.

"The brine is very strong. From one kettle two bushels of salt can be made in one day in dry weather. There are nine kettles at the 'Works,' seven being in constant use during the summer season. The half-breeds engaged in the manufacture complained of the want of fuel—in other words, of the labour and trouble of cutting down the spruce and poplar near at hand, and the difficulty of hauling it to the furnaces. An objection of no moment, but characteristic of some of the people, who are generally unaccustomed to long-continued manual labour. Unfortunately, I had no instrument with me for ascertaining the specific gravity of the brine, and a supply which I took to Red River for that purpose, as well as with a view to its analysis, still remains in the settlements. It will be seen that the processes employed in the manufacture of salt are of the rudest description, so that without any outlay beyond a few days' labour, the quantity might be largely increased. I spoke to John Monkman, who now makes salt here, of pumps and solar evaporation. Of a pump he knew absolutely nothing. He had heard that such an apparatus had been contrived, but had never seen one. He readily comprehended the advantage to be derived from pumping the water into shallow troughs, dug in the retentive clay near the springs, and strengthening the brine by solar evaporation."

Importance of the salt industry to Manitoba.

At the present time the cost of carriage of salt from Ontario renders it very expensive in Manitoba, and the large development of the fishing industry on Lake Winnipeg, and its probable extension to the other lakes of the North-West, renders the question of obtaining an abundant local supply at a reasonable cost one of great importance.

As is shown below the natural brines of Manitoba are not very strong but the supply is large, and the dry climate would be very favourable to their concentration by solar evaporation, which at the same time would remove some of their impurities, and the forests in the immediate vicinity of the springs would furnish an abundant supply of fuel for boiling down the concentrated brine.

Analyses of brines.

Brines were collected from most of the important springs throughout this portion of the country, and have been analysed by Mr. G. C. Hoffmann, of this Survey.* The following table gives in synoptical form the result of his examination :—

*Geol. Sur. Can., Ann. Rep. Vol. V., 1889-90-91, pp. 26 R.—37 R.

ANALYSES OF BRINES FROM MANITOBA.

THE following Table shows the number of grains per Imperial gallon of each of the chief constituents entering into the composition of these Brines.

Constituents.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Chloride of sodium	3426·61	2777·44	3402·38	3716·73	3884·57	3673·23	6024·98	3233·15	3709·59	1873·78	1347·08	3099·41
do potassium	163·86	114·59	209·39	180·21	137·90	145·16	86·17	138·81	179·86	150·16	48·72	23·11
do calcium	.....	28·45	.....	.....	.....	7·87	.....	10·43	.....	15 67	.....	44·05
do magnesium	77·17	101·16	101·75	85·69	47·43	94·66	125·46	78·03	81·46	79·84	58·53	142·22
Sulphate of lime	285·83	233·72	296·23	304·96	272·81	300·30	425·25	281·90	308 38	205·53	204·83	252·71
do magnesia	3·42	.....	1·24	6·49	57·30	.....	19·42	.....	10·98	.....	10·95	.....
Total	3956·89	3255·37	4010·99	4294·08	4400·01	4221·22	6681·28	3742·32	4290·27	2324·98	1670·11	3561·50
Specific gravity	1·039	1·032	1·039	1·041	1·044	1·041	1·063	1·035	1·039	1·022	1·016	1·035

1. Spring on the south bank of Red Deer River, four miles from Lake Winnipegosis. N. lat. 52° 52′ 30″; W. long. 101° 5′. Flow, 10 gallons a minute. Collected, 9th September, 1889.

2. Lower Salt Spring, on the north side of Red Deer River, a mile and three-quarters above its discharge into Lake Winnipegosis. N. lat. 52° 53′ 20″; W. long. 101° 2′ 15″. Flow, 2 gallons a minute. Collected, 13th August, 1889.

3. Spring near the west shore of Dawson Bay, Lake Winnipegosis, three-quarters of a mile north of the mouth of Steep Rock River. N. lat. 52° 48′ 30″; W. long. 100° 57′. Flow, 4 gallons a minute. Collected, 6th August, 1889.

4. Spring on a hillside near the shore of Dawson Bay, Lake Winnipegosis, at a point two miles east of the mouth of Steep Rock River. N. lat. 52° 48′ 30″; W. long. 100° 57′. Flow, 25 gallons a minute. Collected, 8th August, 1889.

5. Salt Point, on the south-west shore of Dawson Bay, Lake Winnipegosis. N. lat. 52° 48′; W. long. 100° 48′. Flow, 1½ gallons a minute. Collected, 3rd August, 1889.

6. Spring on the west side of Dawson Bay, Lake Winnipegosis, three miles and a-half north of the mouth of Bell River, and a mile back from the lake shore. N. lat. 52° 48′; W. long. 100° 51′ 20″. Flow, 20 gallons a minute. Collected, 2nd August, 1889.

7. Brook flowing into the west side of Dawson Bay, Lake Winnipegosis. N. lat. 52° 47′ 40″; W. long. 100° 51′. Flow, 60 gallons a minute. Collected, 1st August, 1889.

8. Spring half a mile back from the west shore of Swan Lake, between it and the lower portion of Swan River. N. lat. 52° 26′ 35″; W. long. 100° 42′ 45″. Flow, 5 gallons a minute. Collected, 31st August, 1889.

9. Spring on the shore of Pelican Bay, Lake Winnipegosis, just east of the mouth of Pelican Creek. N. lat. 52° 38′ 30″; W. long. 100° 21′. Flow, 25 gallons a minute. Collected, 21st July, 1889.

10. Spring on the west side of Pine Creek, near its discharge into Lake Winnipegosis. N. lat. 52° 1′; W. long. 100° 8′. Collected, 6th July, 1889.

11. Monkman's Salt Springs, on the west shore of Lake Winnipegosis. N. lat. 51° 45′; W. long. 99° 56′ 40″. Collected, 1st July, 1889.

12. Monkman's Salt Springs. An old well a few yards from the spring from which No. 11 was obtained. Collected, 1st July, 1889.

Speaking of these brines, and of the various methods pursued in the manufacture of salt, Mr. Hoffmann says :—*

"The proportion of foreign saline matters in these brines is not excessive, and if certain purifying processes are had recourse to, there is no reason—local conditions being favourable—why they should not be utilized in the manufacture of salt.

Outlines of methods pursued in the preparation of salt from its solutions.

"The following brief outline of the methods pursued in the preparation of salt from its solutions, will serve to convey some idea of the expedients resorted to for the economical treatment of the weaker salt waters. The processes may be arranged under the following headings : 1. Those in which evaporation is entirely effected by artificial heat : 2. Those dependent upon natural evaporation—either wholly or in part : 3. That in which concentration is effected by congelation—with subsequent recourse to artificial heat.

"1. By artificial evaporation.

Artificial evaporation.

"The manufacture of salt from its solutions by evaporation with artificial heat, is conducted either in large shallow iron pans—as in Cheshire, Worcestershire, and Staffordshire—or in kettles—as at the Onondaga salines and elsewhere. The heating being in both instances effected by fires placed beneath.

Natural evaporation.

"2. By natural evaporation—either wholly or in part.

"(*a*) By the influence of the sun, aided by that of the air—solar evaporation. This method is resorted to in the preparation of salt from sea water, on the shores of the Mediterranean, some parts of the English and Scottish coasts, and in some localities on the Atlantic and Pacific coasts of the United States. The evaporation is carried on in a series of shallow ponds or basins in which the water is spread over a very large surface. These reservoirs, which are excavated on the sea shore, are generally puddled with clay, but on the Bay of San Francisco the better grade of salt is prepared in ponds which are provided with wooden floors, or wholly inclosed with boards, and when a specially pure salt is required, the cleanest of the brine is transferred to, and the evaporation completed in, wooden tanks. When solar evaporation is pursued in the manufacture of salt from natural brines, the process is conducted in a series of shallow wooden vats, arranged in tiers, provided with movable covers running upon rollers for use during rainy weather. The brine is let into the upper tier of vats and from thence is allowed, at different stages of alteration, to pass on until it ultimately arrives—having in the interval deposited and suspended nearly all the less soluble impurities, and lost a large proportion of its water by evaporation—as a clear saturated brine, in the lower tier of vats where the formation of salt goes on.

*Geo. Survey Can., Ann. Rep., Vol. V., pt. R., pp. 36 and 37.

Natural evaporation—*Con.*

"(*b*) By exposure to a current of air—the 'graduation' process. A method employed, among other places, at Montiers in France, and at Nauheim, Dürrenberg, Rodenberg, and Schönebeck, in Germany, in the preparation of salt from weak brines. The process is carried on in what are termed 'graduation-houses.' These are large wooden structures covered over at the top to exclude rain, but left open at the sides to allow of free circulation of air through the building. The interior arrangement may, in a general way, be described as consisting of a large shallow wooden cistern, for the reception of the brine, over which are arranged bundles of brushwood or thorns built up in the form of a wall between wooden supports, and over this a reservoir for the weak brine. The saline water is pumped into the upper reservoir and thence allowed to trickle down over the surface or through the interstices of the thorns, thereby exposing it, diffused over a very large surface, to the influence of the air and effecting its concentration. The operation is repeated as often as may be found necessary for the conversion of the weak into a strong brine.

"The success of these two processes, solar evaporation and 'graduation,' being altogether dependent upon the state of the atmosphere, their use is consequently limited to the more favourable time of the year.

Congelation.

"3. By congelation.

"In some parts of Northern Europe the separation of salt from sea water is, in part, effected by the agency of frost—salt water when partially frozen separating into ice, retaining very little salt, and a proportionately stronger saline liquor. So that by submitting sea water, contained in reservoirs, to repeated partial congelations and removing the ice as it forms, each successive mother liquor becomes more and more impregnated with salt, until at length the solution attains the strength of a saturated brine.

"The process dependent upon evaporation with artificial heat is usually only resorted to in the treatment of strong brines, but where cheap fuel can be obtained the same plan is pursued with the waters of the weaker springs, and sometimes, though rarely, even with sea water. When fuel is scarce the more diluted saline waters cannot be profitably worked in this way, and these can, therefore, only be utilized by resorting to one of the processes of natural evaporation—solar evaporation or that by 'graduation.' The salt may, by either of these methods, be prepared without the aid of artificial heat, as is customary in the preparation of 'bay-salt' and 'solar-salt,' and is also the practice at the 'graduation-works' at Montiers, in France, or the weak brine may be brought to the point of saturation and further evapora-

tion effected with artificial heat. The concentrated liquor obtained by the repeated partial freezing of a weak salt water, is treated as a strong brine, the salt being obtained from it by artificial evaporation."

"*Amber*," or *Chemawinite*.—This interesting mineral was found in pieces from the size of a robin's egg downwards, on sandy beaches on the west side of Cedar Lake, a short distance south of the Saskatchewan river. The shore is low and shelving, and the beach runs along the face of a deep wet spruce swamp, the "amber" being everywhere mixed with many small fragments of partly decayed wood. The swamp behind is stated to be underlaid by a compact till with boulders. "Amber."

The most important beach is a little less than a mile in length, and from 80 to 120 feet in breadth. The "amber" is found most plentifully along its ridge, where it constitutes about ten per cent by volume of the sand and woody debris, and holes dug to a depth of two feet showed little or no diminution in its quantity. A number of samples collected from various parts of the beach showed an average of a little more than ten per cent of "amber," which, in natural fragments, weighed forty-six pounds to the cubic foot. The size of the beach were roughly estimated at 316,800 cubic feet, which would yield about 31,680 cubic feet, or 1,457,280 pounds of "amber." It has probably been washed by the river from some cliff or cliffs of Cretaceous clay or sand higher up the stream, and has been carried down and deposited in the marshy and swampy delta west of Cedar Lake. From this delta deposit, it is now being washed out from time to time by the waves of the lake and thrown up on the beach.

Prof. B. J. Harrington, of McGill College, Montreal, has described this mineral and the following are some extracts from his paper:—*

"The substance was in pieces, for the most part very irregular in shape, some being more or less angular, others approximately spherical, and others flattened, discoid or lenticular. Some of the pieces were smaller than a pea, but they ranged from this up to the size of an ordinary bean (about 2 centimetres long). In colour they varied from pale-yellow to dark-brown, and many, when examined by transmitted light, appeared clouded or banded from the presence of black carbonaceous matter. Superficially they were generally dull, owing, perhaps, to chemical change, but on fresh surfaces the lustre was resinous. The fracture was conchoidal. Though electric on friction, they appear to be less strongly so than ordinary amber. Dr. Harrington's description.

"Light-coloured fragments, free from black carbonaceous matter, were selected for examination, and any superficial crust carefully removed by scraping. The hardness of these selected pieces was fully $2\frac{1}{2}$. The specific gravity, as obtained with a quantity of material in the specific gravity bottle, was 1·055 (at 20°C.), and a single fragment gave by suspension with a hair 1·0543 (20°C). Material selected.

* American Journal of Science, Vol. XLII., Oct. 1891, pp. 332-335.

"The material for analysis was finely powdered and dried over sulphuric acid *in vacuo*. The combustions were made with lead chromate in the usual way, and the ash determined with a separate portion in a platinum crucible.

Results of analyses.

"The following are the results obtained :—

——	I.	II.	Mean.
Carbon	80·01	79·91	79·96
Hydrogen	10·37	10·55	10·46
Oxygen	9·53	9·45	9·49
Ash	0·09	0·09	0·09
	100·00	100·00	100·00

Excluding the ash the results become :—

——	I.	II.	Mean.
Carbon	80·08	79·98	80·03
Hydrogen	10·38	10·56	10·47
Oxygen	9·54	9·46	9·50
	100·00	100·00	100·00

"The ash was brick-red in colour, and found to contain silica, alumina, iron, lime, and magnesia.

"The only solvents whose action upon the resin has been tried as yet are absolute alcohol and absolute ether, and the effect of these was ascertained as follows :

Action of solvents.

"One gram of the finely powdered resin was mixed with ten grams of pure quartz sand in a cylinder of filter paper and extracted in Soxhlet's apparatus, in the case of the alcohol for three and a half hours (24 siphonings) and in the case of the ether for two hours (24 siphonings). In each case the sand and filter paper were previously extracted by the special solvent for several hours. The extract from the resin was evaporated in a weighed platinum dish and the residue dried at 100°C. The results obtained were as follows :

	Per cent.
Dissolved by absolute alcohol	21·01
Dissolved by absolute ether	24·84

"The effect of more prolonged action of the solvents has not as yet been ascertained. The alcoholic extract after drying was brownish in colour, while that obtained with ether was only faintly yellow.

"When small fragments of the resin were heated in closed tubes it was found that they began to soften at about 150°C., the point of softening being roughly ascertained by pressure with a platinum rod. At 180-190°C. the fragments were sufficiently yielding to be pressed into one mass by the platinum rod. Heated up to 300°C., the resin did not melt into a flowing liquid, but became soft and elastic, and had darkened a good deal from partial decomposition. Softens with heat.

"Fragments of genuine amber behaved in a similar manner, but began to soften at about 140°C. At 180° they could be readily pressed into one mass, and in the one experiment tried they seemed to darken more readily than the Cedar Lake resin when heated up to 280-300°C. The ordinary statement that amber fuses at 287°C is certainly misleading, the fact being that it begins to soften at a very much lower temperature, gradually getting softer and softer as the temperature rises, but not becoming a flowing liquid until decomposition takes place.

"On heating the Cedar Lake resin in a test tube or retort no crystals of succinic acid were obtained, although they were readily obtained from true amber by similar treatment.

"It is customary to assign to amber the formula $C_{40}H_{64}O_4$, which gives: carbon 78·94, hydrogen 10·53, oxygen 10·53; but this is apparently based upon very insufficient data—so far as the writer is aware, upon the single analysis of Schrotter (carbon 78·82, hydrogen 10·23, oxygen 10·95), which really corresponds much more closely to $C_{39}H_{60}O_4$. Such a substance as amber, too, coming from a variety of localities and originally derived from very different plants can scarcely be expected to agree closely in composition with one definite formula. Formula

"The Cedar Lake resin contains more carbon than the amber analysed by Schrotter and less oxygen, and in this respect comes nearer to Walchowite and to some of the recent copals from India. The relations of some of these bodies will be made plain by the following tables:

—	Carbon.	Hydrogen.	Oxygen.	Ratio of C, H, & O atoms.	Ratio of C, H, & O atoms, taking C = 40.
I. Amber	78·82	10·23	10·95	9·60 : 14·95 : 1	40 : 62·29 : 4·16
II. Krantzite.....	79·25	10·41	10·34	10·22 : 16·11 : 1	40 : 63·05 : 3·91
III. Cedar Lake Resin..	80·03	10·47	9·50	11·23 : 17·63 : 1	40 : 62·79 : 3·56
IV. Copal (Bombay)....	79·70	10·40	9·90	10·75 : 16·83 : 1	40 : 62·62 : 3·72
V. Copal (Calcutta).. .	80·34	10·32	9·34	11·46 : 17·67 : 1	40 : 61·67 : 3·49

I. Phillips's Mineralogy (1852), p. 630. Anal. by Schrotter. II. Dana's Mineralogy (1869), p. 741. Anal. by Landolt. IV. Watts's Dictionary of Chemistry (ed. i.), Vol. II., p. 19. Anal. by Filhol. V. Watts's Dictionary of Chemistry (ed. i.), Vol. II., p. 19. Anal. by Filhol.

"Though resembling amber in some of its characters, the Cedar Lake resin may here be classed provisionally as "retinite," on account of its differing from amber in its deportment with solvents, in not yielding crystals of succinic acid on distillation, and in having a somewhat different ultimate composition. The name retinite as used by some mineralogists is a convenient general term to include such substances as Walchowite, Krantzite, Jaulingite, Rosthornite and the Cedar Lake resin, which last, by way of distinguishing it from other retinites, may be called Chemawinite (from Chemahawin or Chemayin, the Indian name of a Hudson Bay post, not far from where the resin occurs).

Origin.

"Though the origin of this substance is not certainly known, there can be little doubt that it has been derived from one of the Tertiary or Cretaceous lignites occurring on the Saskatchewan. Some of these are known to contain resins, one of which, examined by the writer, was not essentially very different from the Cedar Lake material. It behaved similarly on heating, had a hardness of over 2, a specific gravity of 1·066, and dissolved in absolute alcohol to the extent of 29·30 per cent.

Uses.

"Some of the larger pieces of the Cedar Lake resin might, perhaps, be employed for ornamental purposes (beads, &c.), and possibly the material might be utilized by the varnish-maker."

Nodules of carbonate of iron.

Iron.—Nodules of Carbonate of Iron are present in considerable numbers in the Pierre shales, both on the north side of Riding Mountain and in the banks of the Assiniboine Valley. They were nowhere seen in sufficient quantity to be of any economic importance. A specimen collected by Dr. Bell from the crossing of White Sand River, was found by Mr. G. C. Hoffmann to contain 34·07 per cent of metallic iron.*

Lignite.

Coal.—Lignite was found in the form of carbonized masses of wood or tree trunks, lying in the Benton shale on Swan River, and also in small quantity in the Niobrara shale on Wilson River. The following is a description and analysis by Mr. G. C. Hoffman of a specimen from the former locality :— †

"LIGNITIFIED WOOD.—From Swan River, Manitoba, township 37, range 26, west of the Principal Meridian.

"Has a clear and wood-like structure ; colour black, with a faint brownish tinge ; lustre dull, that of a freshly fractured surface resinous ; fracture uneven, occasionally sub-conchoidal ; hard and tough ; does not soil the fingers ; powder brownish-black ; it communicates a deep brownish-red colour to a boiling solution of caustic potash ; by exposure to the air becomes fissured.

* Rep. of Prog. Geol. Sur., Can., 1875-6, p. 431.
† Ann. Rep. Geol. Sur. Can., Vol. IV., N.S., 1888-9, p. 6 R.

"Analysis by fast coking gave :—

Hygroscopic water	9·66
Volatile combustible matter	43·16
Fixed carbon	43·61
Ash	3·57
	100·00
Coke, per cent	47·18

"Ratio of volatile combustible matter to fixed carbon, 1 : 1·01. It yields a loose fritted coke ; the gases evolved during coking, burnt with a yellowish, somewhat luminous, slightly smoking flame. The ash has a pale brownish-yellow colour,—it is readily fusible at a bright red heat, running into a fluid slag."

Similar lignite was found lying in fresh fragments on the shore of Pemmican Island, having been washed up by the waves from a bed beneath the surface of the lake. This bed is doubtless of Cretaceous age, probably at the horizon of the Dakota formation. Gypsum.

Gypsum.—An extensive deposit of gypsum and anhydrite was found in the Silurian area a short distance north-east of Partridge Crop Lake, and a bed of gypsum fifteen feet in thickness was also passed through in the middle of the Upper Devonian limestones at a depth of 560 feet in the deep well on Vermilion River.

Phosphatic Shale.—A small deposit of phosphatic shale, containing a large number of fragments of the bones of fishes, outcrops on the banks of Wilson River in Section 18, township 25, range XX. The bed may be extensive, but at the time it could not be traced for any considerable distance. Mr. Hoffmann found it to contain 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. If the bed proves to be extensive it may be utilized as a fertilizer in the same way as the coprolite beds are used in England and France. Throughout all the Niobrara shales, however, these fish remains are present in small quantities, and add greatly to the richness of the soils formed by their disintegration. Phosphatic shale.

APPENDIX.

List of photographs taken during the course of the explorations in the summers of 1887-90. Uniform size $6\frac{1}{2} \times 8\frac{1}{2}$ inches.

1887.

1. Valley of the Little Saskatchewan River at Strathclair, Man. July 19.
2. Lake Audet, in the Riding Mountain at the head of the Little Saskatchewan River, Man. July 21.
3. Willow-covered plain by Edward's Creek, Man. July 25.
4. Beach of Lake Dauphin, Man. July 26.
5. Valley River, in Sec. 11, Tp. 24, R. 21, W. Man., looking up the stream. August 8.
6. Valley River, in Sec. 11, Tp. 24, R. 21, W. Man., looking down the stream. August 8.
7. Bank of Drifting River, from gravel ridge east of Duck Mountain, Man. August 9.
8. Face of gravel ridge on north side of Fork River, Man. August 11.
9. "Pitching ridge," north of Valley River, Man. August 16.
10 and 11. Views up and down Valley River from the top of one of the highest of the gravel ridges east of the Duck Mountain. August 18.
12 and 13. Sides of valley of Valley River, Man., showing old Indian houses. August 19.
14. Morainic ridge, two miles below the mouth of Short Creek, on the Valley River, Man. August 20.
15. North end of Shoal Lake, in Tp. 17, R. 23, W. Man. August 26.
16. Noon camp, at the trail crossing of Silver Creek, in Tp. 20, R. 27, W. Man. August 31.
17. Silver Creek, in Tp. 20, R. 27, W. Man. August 31.
18. Village of Russell, Man. September 1.
19. Small lake south of the Angling Lake trail, on Duck Mountain, Man. September 6.
20. One of the Angling Lakes, on Duck Mountain, Man. September 7.
21. Indian Village, near Angling Lakes, Duck Mountain, Man. September 10.
22. Shell River, near trail to Côté's Reserve, Man. September 18.
23. Shell River, in latitude 51° 35′, Man. September 19.
25. Northern Pocket Gopher (*Thomomys talpoides*, Rich.) natural size. Shell River, Man. September 19.
25. Marsh near Fort Pelly, Assa. September 24.
26. Swan River, looking from the Square Plain, Man. September 29.
27. Swan River, from mouth of Oak Creek, Man. October 16.
28. Saulteux Indians from the Upper Assiniboine River. October 16.
29 and 30. Second crossing of Swan River, Man., opposite the old store-house of the H. B. Co. October 18.

31. Poplar forest at second crossing of Swan River, Man. October 24.
32 and 33. Valley of Swan River at the Upper Crossing, north-east of Fort Pelly, Assa. October 30.
34. Swan River, from old Police Barracks, Assa. October 31.
35. Valley of Snake Creek, Assa., looking across. October 31.
36. Valley of Snake Creek, Assa., looking down. October 31.
37. Fort Pelly, Assa. November 1.
38. Stopping Place, on the trail from Russell to Fort Pelly. November 3.
39. Valley of Big Boggy Creek, at the crossing of the Russell and Fort Pelly trail. November 4.

1888.

40. Steep Rock Point, Lake Manitoba. July 1.
41. Camp of Saulteux Indians on the shore of Lake St. Martin, Man. July 4.
42. Chief Wekemowskunk, and family, Lake St. Martin, Man. July 4.
43. Chief Wekemowskunk building a canoe, Lake St. Martin, Man. July 4.
44. Island of red granite in Lake St. Martin, Man. July 4.
45. Waterhen River, Man. July 18.
46. Pile of boulders on Twin Islands, Lake Manitoba. July 18.
47. Monroe Point, Lake Manitoba. July 20.
48. Horse-shoe harbour, Manitoba Island. July 26.
49. Onion Point, Lake Manitoba. August 1.
50. Big Sandy Point, Lake Manitoba. August 2.
51. Small stony island, with young cormorants, Lake Manitoba. August 4.
52. Steep Rock Point, Lake Manitoba. August 5.

1889.

53. Ruins of Old Trading Post, near the Narrows of Lake St. Martin, Man. June 7.
54. Narrows of Lake Manitoba, west side. June 12.
55. Harbour on Cherry Island, Lake Manitoba. June 14.
56. Mossy River, near the mouth. June 22.
57. and 58. Cliff of limestone on Mossy River, just above the old C. P. R. crossing. June 23.
59. Fork River, looking eastward towards Mossy River. June 25.
60. Cliff of till and alluvial clay on Mossy River, just below Fork River. June 29.
61. View down Mossy River, from near the same point. June 29.
62. Brine spring at "Monkman's Salt Springs," Lake Winnipegosis. July 1.
63. Well and ruins of old house on arid flat at "Monkman's Salt Springs." July 1.
64. Glaciated surface of limestone on island off Weston Point, Lake Winnipegosis. July 2.
65. Cliff of Manitoban limestone on Island off Weston Point. July 2.
66. Limestone cliffs at Point Brabant, Lake Winnipegosis. July 4.
67. Point Brabant, Lake Winnipegosis, showing row of elm trees in front of the cliff. July 4.
68. Sloping beach of gravel shoved up by the ice, north-west point of Birch Island, Lake Winnipegosis, July 13.
69. Low cliff of limestone at the north end of Birch Island, Lake Winnipegosis. July 13.
70. Cliff of dolomite hidden among the trees at the north end of Hill Island, Lake Winnipegosis. July 13.

71. Cliff of till 100 yards south of the north point of Hill Island, Lake Winnipegosis. July 13.
72. Our boat off beach of boulders, at the north end of Birch Island, Lake Winnipegosis. July 14.
73. Boulder wall, fifteen feet high, at the north-east end of North Manitou Island, Lake Winnipegosis. July 15.
74. Cliff of nodular dolomite at Devil's Point, Lake Winnipegosis. July 18.
75. Cormorants and pelicans on Cormorant Islands, Lake Winnipegosis. July 18.
76. Groove, ten paces long, in the mud and gravel on the beach, with boulders lying in the upper end of it. Looking S. 25° E., Pelican Bay, Lake Winnipegosis. July 20.
77. Same groove. Looking N. 25° W.
78. Boulder lying at the upper end of a long grove, with clay and irregular pebbles shoved up in front of it. Pelican Bay, Lake Winnipegosis. July 20.
79. Two boulders, lying at the end of a groove twenty-five paces long which runs N. 30° W. through the mud and stones of the beach. Looking south. Pelican Bay, Lake Winnipegosis. July 21.
80. Large boulder on the west shore of Pelican Bay, Lake Winnipegosis. July 22.
81. Irregular nodular limestone shoved up on the beach by the ice. Channel Island, Lake Winnipegosis. July 23.
82. Cliff of Manitoban limestone among the trees in Cameron Bay, Lake Winnipegosis. July 23.
83, 84, 85. Cliff of Dolomite at the base of the Stringocephalus zone on island north of Whiteaves Point, Lake Winnipegosis. July 25.
86. Rocky hill on north end of island west of Whiteaves Point, Lake Winnipegosis. July 29.
87. Large boulder on same island.
88, 89, 90. Swampy Crees in camp at Shoal River, Man. July 30.
91. High beach of rounded pebbles at south end of island off Salt Point, Lake Winnipegosis. August 3.
92. Cliff at Point Wilkins, showing sandstone included in the fragmentary limestone. August 6.
93. Inclusion of sandstone in the broken limestone at Point Wilkins, Lake Winnipegosis. August 6.
94. Cliff of limestone rising forty feet above the water just south of Point Wilkins. August 6.
95. Cliff of thick bedded limestone opposite the mouth of Steep Rock River, Lake Winnipegosis. August 7.
96. Cliff of limestone four miles east of Steep Rock River, Lake Winnipegosis. August 9.
97. Point Wilkins at the buttress and cave. August 9.
98. Point Wilkins from Small Island. August 9.
99. Point Wilkins, showing disturbed beds of limestone. August 9.
100. Point Wilkins looking westward. August 9.
101. Cliff of dolomite at point three miles north of Red Deer River, Lake Winnipegosis. August 12.
102. Cliff of dolomite at point five miles north of Red Deer River. Lake Winnipegosis. August 12.

103. Cliff of dolomite at south end of Rowan Island, Lake Winnipegosis. August 12.
104. View up Red River Deer, Saskn., from its mouth. August 13.
105. Lower Salt Spring, Red Deer River, Saskn. Looking eastward down the stream. August 13.
106. Cliff of sloping limestone on Red Deer River, Saskn., a short distance above the Lower Salt Springs. August 13.
107. Glaciated surface of limestone at Rowan Island, Lake Winnipegosis. August 14.
108. North shore of Lake Winnipegosis at the Western Mossy Portage. August 16.
109. Cast of large orthoceratite in cliff of Winnipegosan dolomite, Whiteaves' Point, Lake Winnipegosis. August 17.
110. Shoal River House, H. B. Co., looking towards Swan Lake. August 21.
111. Shoal River House, H. B. Co., looking along the shore.
112. Cliff of Manitoban limestone at the east point of Rose Island, Swan Lake, Man. August 22.
113. Glaciated surface of limestone on Two Islands, Swan Lake, Man. August 24.
114. Birch River, Man., looking up stream from two miles above its mouth. August 25.
115. Indian Camp on the north side of Birch River, Man. August 25.
116. Site of the Hudson's Bay Company's old trading post at the Lower Crossing of Swan River, Man. August 29.
117. Swan River, Man., looking down the stream from the site of the old Trading Post. August 29.
118. Rocky hill, south of Swan River, at the north-east end of the trail. August 30.
119 and 120. Rounded bosses of Dakota Sandstone on a terrace on the side of Kettle Hill, south of Swan Lake, Man. September 3.
121. Boulder pavement on the south shore of Red Deer Lake. September 12.
122. Site of old Trading Post of Hudson's Bay Company on the south side of Red Deer River, just west of Red Deer Lake. September 14.
123. Red Deer River, Saskn., from same place. September 15.
124. Site of old Trading Post of the North-west Company on the north side of Red Deer River. September 15.
125. Hartmann's Trading Post at Pine Creek, Lake Winnipegosis, Man October. 8.
126. Hartmann's Trading Post at Waterhen River, Man. October 13.

1890.

127. Assiniboine River, Man. Below the mouth of Little Boggy Creek. June 19.
130. Site of old Trading Post of the North-west Company (Grant's House) in the bottom of the Assiniboine Valley. June 19.
131. Bottom of Assiniboine Valley, a short distance further down. June 20.
132. Assiniboine River, near Beulah, Man. June 29.
133. Valley of the Assiniboine from the side of the hill below the site of Boss Hill Fort, north of Virden, Man. July 2.
134 and 135. Assiniboine River, at bridge north of Griswold, Man. July 4.
136 and 137. Lake Clementi, Brandon Hills, Man. July 6.
138. Assiniboine River, near the mouth of Little Souris River, Man., showing cliffs of sand and gravel. July 8.

139. View across the Assiniboine River towards the sand hills, from the site of the old fort above the mouth of Souris River. July 9.
140 and 141. Assiniboine River, at the outcrop of Niobrara limestone and shale below the mouth of Cypress Creek. July 13.
142 and 143. Old Trading Post of the Hudson's Bay Company at Portage la Prairie, Man. July 15.
144. Steamer "Red River," on Lake Winnipeg. July 24.
145. Old Trading Post of the Hudson's Bay Company near the north end of the Tramway at Grand Rapids, Saskatchewan River, Saskn. July 26.
147. Roche Rouge Point, Saskatchewan River, Saskn. July 27.
148. Island, near the Narrows of Cedar Lake, Saskn. July 31.
149. Rabbit Point, Cedar Lake, Saskn. August 1.
150. North-east side of Fort Island, Cedar Lake, Saskn. August 5.
151. North-west side of Fort Island, Cedar Lake, Saskn. August 5.
152 and 153. Cliffs of Niagara limestone on the south-west shore of Cedar Lake, Saskn. August 8.
154. Trading Post of the Hudson's Bay Company at the south end of the Grand Rapids, Saskatchewan River. August 11.
155. Another view of the same. August 14.
156. Saskatchewan River, looking up the stream from Grand Rapids Post towards Potato Island and the foot of the Grand Rapids. August 14.
157. Camp of Geological Survey party, and detachment of North-west Mounted Police at Grand Rapids. August 14.
158. Grand Rapids, Saskatchewan River. Looking up stream from the lower end of the old portage; showing vertical cliff of Niagara dolomite. August 14.
159. Grand Rapids, Saskatchewan River. Another view from a little higher up the stream.
160. Grand Rapids, Saskatchewan River. Looking down stream from the lower end of the old portage.
161. Grand Rapids, Saskatchewan River. Looking across to vertical cliffs on opposite side of river.
162. Grand Rapids, Saskatchewan River. Looking down the gorge from the head of the rapids.
163. Grand Rapids, Saskatchewan River. Head of the rapids, looking across the stream.

GEOLOGICAL SURVEY DEPARTMENT.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

SUDBURY MINING DISTRICT

To accompany Sheet 130, Series of Geologically coloured Maps of Ontario.

BY ROBERT BELL, B.A.Sc., M.D., LL.D.

1888-90.

OTTAWA:
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY.

1891.

H. TOPLEY. PHOTO. DESBARATS & CO., ENGR. & PR., MONTREAL.

COPPER CLIFF MINE, LOOKING WEST.

To Dr. A. R. C. Selwyn, C.M.G., F.R.S., Etc.

Sir,—Herewith I beg to hand you my report on the results of the geological and topographical surveys and investigations in the Sudbury mining district, during the past three seasons, with which I had the honour of being entrusted.

I have the honour to be, Sir,

Your obedient servant,

ROBERT BELL

Geological Survey Office,

Ottawa, 20th March, 1891.

REPORT

ON THE

SUDBURY MINING DISTRICT,

BY ROBERT BELL, B.A.Sc., M.D., LL.D.

INTRODUCTION.

The following report is upon the labours of the last three seasons in what may, for convenience, be called the Sudbury mining district. An epitome of what has been accomplished has already been given in the three summary reports of 1888 to 1890, but all the results will now be collated in a more complete form.

Assistants.

I was assisted in both the topographical and geological work by Mr. A. E. Barlow, M.A., of this department. He was occupied more especially in the south-eastern and central parts of the sheet. His topographical surveys are mentioned more particularly further on, and an account of his geological observations is given along with my own. Mr. A. M. Campbell, of Perth, also assisted us during the three seasons this work was in progress. Mr. Wm. Skynner was engaged upon it for portions of 1888 and 1889, and in 1890 we had the services of three young gentlemen as students, namely: Mr. T. L. Walker, M.A., Mr. H. H. Walker, B.A.Sc., and Mr. H. G. Skill. To all of these gentlemen great credit is due for enthusiasm and patient endurance of the hardships and discomforts incidental to this kind of work.

Acknowledgment of aid.

We are indebted for assistance or information in the prosecution of our labours to Mr. D. McTavish and Mr. T. B. Ross, of the Hudson's Bay Company; to Dr. E. D. Peters, ex-manager of the Canadian Copper Company; Messrs. O. Emery and D. McLaren, of Wahnapitæ; T. J. Kennedy, C.E., of Pogamasing; T. Frood, of Wallace Mine; J. Stobie and C. W. Jessop, of Sudbury: J. R. Gordon, of Creighton; F. L. Sperry, late chemist to the Canadian Copper Company; F. R. W. Daw, manager of the Murray Mine; J. Ferguson, manager of the Dominion Mine; A. Merry; W. Cockburn, of Sturgeon Falls; A. McCharles, of Whitefish; H. Ranger, of Mattawa, and others.

Prof. Williams' description of the rocks.

Professor George H. Williams, of Johns Hopkins University, has made for us a painstaking microscopical examination of a collection of rock-specimens from the district, and his descriptions, which will be again referred to, form Appendix I of this report. Professor T. G. Bonney, of London, has also kindly supplied me with some petrographical notes on the district.

Prof. T. G. Bonney.

List of levels.

Appendix II consists of a list compiled by Mr. Barlow, showing the levels, above the sea, at every mile on the main line and also on the Sault Ste. Marie branch of the Canadian Pacific Railway, which come within the limits of the sheet, and of the principal streams at their intersections by the railway line; also of the levels of the larger lakes as determined by the barometer.

List of Lepidoptera by Major H. H. Lyman.

Our thanks are once more due to Major H. H. Lyman, of Montreal, who has this winter gratuitously determined a collection of Lepidoptera which I had made in the country north of Lake Huron. He finds it to contain fifty-four (54) species, represented by a considerable number of specimens from many localities in the above district. Major Lymam was assisted by Mr. Wm. H. Edwards, Professor J. B. Smith and Rev. Geo. D. Hulst. The list of species forms Appendix III of this report.

Map.

A map has been compiled and drawn by Messrs. Scott Barlow, A. E. Barlow and L. N. Richard on a scale of two miles to the inch, and reduced under the supervision of Mr. Scott Barlow, for publication, on a scale of four miles to the inch, showing the topography and geology of the area investigated. As the geological and most of the topographical features of the district have been as yet unknown, this map, which will accompany the present report, will be essential for reference in connection with the descriptions herein given.

Area and position of the district.

It constitutes sheet number 130 of the general Ontario series and the district which it embraces measures seventy-two miles in length from east to west and forty-eight miles in breadth from north to south. It thus includes an area of 3,456 square miles, or 2,211,840 acres. The town of Sudbury Junction lies ten miles south-east of the centre of the above rectangle. The main line of the Canadian Pacific Railway runs north-west across the sheet, emerging near its north-west corner, not far from Pogamasing Lake, and the Sault Ste. Marie branch, running south-westward from Sudbury Junction, emerges at the south-west corner in the township of Hallam. Sturgeon River crosses the north-east corner, and the West Bay of Lake Nipissing enters the south-east corner. These geographical positions will enable the reader to form a better idea of the size and location of the above district.

Surveys heretofore made.

Nearly half the included lands, or 1,530 square miles, have been laid off into townships, which again have been subdivided into concessions

and lots. These townships are of the more recent form adopted by the Crown Lands Department of Ontario and measure six miles square, each one comprising six concessions, running east and west, and each concession twelve lots. The townships themselves are arranged like squares on a checker-board, and as their subdivisions are all alike, both the concessions and the lots carry the same numbers from one to another throughout. All the township boundaries, or town-lines, the concession lines and every second lot line, called side-lines, are cut out through the woods, and posts, marked with the numbers of the concessions and lots, are planted at the intersections of the above lines. Each lot, therefore, contains half a square mile or 320 acres. For the sake of greater clearness the numbers of the concessions are always designated by Roman numerals and those of the lots by ordinary figures, both on the map and in this report. In tracing out the rocks, we found the surveyors' lines and posts of much service in fixing our positions.

Want of facilities for geological field-work.

The railway track afforded us a means of getting into the district and a sort of basis for operations, but scarcely any common roads or even trails existed* and there are fewer canoe-routes than usual in the Laurentian and Huronian regions of Canada, so that it became necessary to examine a large portion of the area by forcing our way through the bush, which, in most of the district, is unusually difficult to traverse. In some sections the surveyors' lines made it easier to penetrate the thick woods, but as these are cut out merely for sighting, the felled trees and brush and the new growths are as apt to encumber the ground and impede one's progress as the standing forest and underbrush.

General character of the country.

The average general elevation of the district is probably between 800 and 1,000 feet above the sea.† The district, taken as a whole, may be described as hilly and rocky, although a tolerably level tract, six miles wide, extends from near Wahnapitæ Lake south-westward to Vermilion Lake. Parts of this tract are covered by a light coloured fine clayey sand, free from boulders. Some of this land along the line of the railway between Chelmsford and Onaping is being cultivated; but rocky ridges and boulder-covered slopes, alternating with swamps and small lakes, are the rule over the greater portion of the area. In most parts the boulders are not only thickly scattered over the uneven rocky surface, but are often piled on top of one another without any finer materials between them. The trees which originally grew between and even on top of the boulders have generally been killed by forest fires and their trunks have fallen over them in every direction. A second

Difficulties of exploration.

* A colonization road has lately been constructed from Sudbury for eleven miles northwest and three and a half south-west.

† A list of levels throughout the district is given as an appendix.

growth thicket of small prickly spruces entangled with tough young birches has sprung up among the boulders and resists the explorers' progress like a continuous hedge. This, together with the uncertain footing, due to the boulders and the network of prostrate trunks, renders it very difficult to make one's way through these obstructions. Indeed, it sometimes became impossible to do so until we had first chopped a passage through them. Last summer and autumn were unusually rainy, so that whenever we got clear of the boulders and hummocky rocks we were obliged to wade in the water.

Surveys.

Proudfoot's lines.

In addition to the railway and the township surveys, a straight line had been run, in 1888, by Mr. H. B. Proudfoot, P.L.S., for the Crown Lands Department, due north in continuation of the east town-line of Lumsden, to a point four miles and a-half north of the northern boundary of our sheet, and from this point another straight line was run by the same gentleman due west to beyond Lake Pogamasing. Although this latter line was outside of the area with which we were more immediately concerned, still it was of service for tying on our exploratory and micrometer surveys.

Murray's surveys.

Topographical surveys had also been made by the late Mr. Alexander Murray, of the Geological Survey, of Wahnapitæ River and Lake and Sturgeon River, Lake Panache and the canoe-route thence to Wahnapitæ Lake; also of the curving chain of lakes from the latter to Sturgeon River. Mr. Murray had also surveyed the Spanish River from the mouth to a point a few miles above the Great Bend, but this survey had been covered by the township surveys in that quarter. Many topographical features still remained unsurveyed within the area of the present sheet, and these have now been surveyed and located by Mr. Barlow and myself.

Surveys by Bell and Barlow.

Mr. Barlow's topographical work was mainly in the south-eastern part of the sheet, and comprised the West Bay of Lake Nipissing (a re-survey), Panache Lake (a re-survey), the southern branch of Veuve River, Aigin-a-wassing, Elbow and Red Deer Lakes, two western branches of Wahnapitæ River, Ramsay Lake (a re-survey), Vermilion River from Larchwood for eighteen miles upward, in a straight line, and a number of smaller lakes. My own instrumental surveys embraced the Spanish River, from near Spanish Forks to the township of Hyman, Pogamasing Lake, the west shore of Wahnapitæ Lake (a re-survey), the route thence to Vermilion River, and the latter river from the point reached by Mr. Barlow, as far as Proudfoot's east and west line. I also made track-surveys of the route from Bannerman Lake to Onaping Lake, of the latter lake (thirty miles long), Onaping River, the Upper Wahnapitæ

River, Koo-ka-gaming Lake and a number of smaller lakes and rivers. In 1875, while exploring this part of the country geologically, I had improved upon a track-survey of the chain of lakes from Lake Wahnapitæ northward by way of Lakes Mattagamashing and Chini-goo-nichi, and in 1888 I carried my track-surveys north-eastward to the Montreal River. In addition to the foregoing, explorations were made of numerous smaller lakes and streams within the sheet. Some of these were performed by the other assistants or students who have been named, and an exploration of the chain of lakes southward of Pogamasing Lake was made by the late Mr. W. E. Francklyn, who was a member of my party in 1889.

Explanations.

In the topographical and geological descriptions which follow, all distances are understood to be given in straight lines and all bearings refer to the magnetic meridian, unless otherwise stated. The average variation in the district, as stated on the township plans, is about 6° W. in the eastern part of the sheet and 3° W. in the western part. In our geological examinations along the railway tracks, the positions were fixed by the mile-boards, which, on the main line, are numbered from Montreal and on the Sault Ste. Marie branch from Sudbury Junction.

Geographical names.

All existing geographical names were adopted for the map and this report. In some cases the expressive Indian names which had been in use from time immemorial had been replaced by others on the surveyors' township plans. In such instances, while accepting the latter, we have also restored the aboriginal designations upon our map. But it was found that many features made known by our explorations and surveys, to which frequent reference required to be made, had no names whatever, and to these, for convenience of reference, we were obliged to give some distinguishing appellation.

Geology.

In connection with the geological descriptions, passing references will be made to the surface geology and the occurrence of ores or other economic minerals, but the principal part of the information as to these subjects will be reserved for fuller descriptions by themselves in another part of the report.

Lithological names.

Lithologically speaking, there is a great variety of rocks in the district and many of them are of much interest in connection with a study of the problems of metamorphism, etc. A collection of fifty specimens above referred to, mostly from within the district, was submitted for microscopical examination to Professor George H. Williams, of Johns Hopkins University, the well known lithologist. A few specimens, however, were included in this collection from places outside of the district on account of their bearing on its geology, and it was thought that a study of them would be of advantage in this connection. We

Prof. G. H. Williams' report.

are indebted to Professor Williams for the great pains he bestowed on this task. His report forms Appendix I. Mr. Walter Ferrier of this Survey has examined microscopically some thin slices of rocks from the Sudbury district and has given us the benefit of his studies.

Field names for rocks.

In the field, however, it is impossible to make the precise distinctions which may be established by subsequent microscopical study. The most appropriate field names have, therefore, to be adopted, and in the present report these are often adhered to for brevity of description. For example, it is frequently difficult to distinguish between such rocks as diorites, diabases, basalts, gabbros, etc., nor, indeed, is it always of practical importance to do so. But when we were tolerably certain, from the macroscopic characters, of the variety we were dealing with, we called it, in our notes, by its proper distinctive name; but where there was room for doubt, we adopted the general term greenstone. On this point Professor Williams, in his report on The Greenstone-Schist Areas of the Menominee and Marquette Regions of Michigan,* says: "I feel no especial apology is needed for the constant use throughout this paper of the term 'greenstone.' An opinion prevails that this word is antiquated and not consistent with the scientific accuracy now obtainable. The very indefiniteness of this designation, however, constitutes its chief value. It is essentially a field term, and as it is not only desirable, but absolutely necessary to employ. It is often impossible to state with certainty in the field whether a given basic massive rock is a gabbro, a diabase or a diorite; indeed, where such masses have undergone extensive metamorphism, as in the regions here studied, even the most careful microscopical and chemical investigation may prove inadequate to disclose what was the original form."

Similarly it is impossible to give at sight the refined lithological name for every variety of rock of the granitoid class, but the best term for all practical purposes had to be adopted in each case in the field. Granitoid rocks, consisting of quartz, orthoclase, plagioclase, hornblende or chlorite and sometimes a little mica, together with a variety of accessory minerals, were among the commonest we had to deal with. The quartz was generally one of the most abundant constituents, and the rock would then be called a granite, but sometimes it was in small quantity, or it might be scarcely apparent without the aid of the microscope, when it was termed syenite, or if fine grained micropegmatite. Again, the term greywacke may be applied to certain varieties of arkose, argillaceous or felspathic sandstone, volcanic mud or ash, granitic debris, etc. It is often puzzling to discriminate between the numerous varieties of green schists and other crystalline rocks, so-

* Bulletin of the United States' Geological Survey, No. 62, 1890.

that in the field, hard and fast lines cannot be drawn in reference to names for many of the rocks which we had to deal with in this district.

Massive rocks.

The term "massive" was employed in our field-books and it will also be used in this report, not only in connection with crystalline rocks, such as greenstone and granite, but also in regard to any solid or heavily bedded rock in which the stratification was faint or which showed neither cleavage nor lines of division along the bedding.

Divisions of the rocks.

The rocks of the district represented by the map may, for the present, be divided into three groups, in the following ascending order: (1.) A gneiss and hornblende-granite series—Laurentian. (2.) A series comprising quartzites, massive greywackes, often holding rounded and angular fragments, slaty greywackes with and without included fragments, drab and dark grey argillites and clay-slates, dioritic, hornblendic, sericitic, felsitic, micaceous and other schists, and occasionally dolomites, together with large included masses or areas of pyritiferous greenstones. This group constitutes the ordinary Huronian of the district. (3.) A division consisting of a thick band of dark-coloured silicious volcanic breccia and black slate (generally coarse), overlaid by drab and dark grey argillaceous and nearly black gritty sandstones and shaly bands. The breccia is underlaid in places by quartzite conglomerate. (4.) In addition to these, dykes of diabase and gabbro cut through all the foregoing and are therefore newer than any of them, although they may not belong to a later geological period. The geographical distribution of these different divisions, their characters, their relations to each other and various facts in regard to them will be given further on.

Distribution of the rocks.

The rectangle covered by the sheet is traversed from south-west to north-east by a belt of Huronian rocks of the above character (2), flanked on the south-east side by gneiss, and on the north-west by a mixture of gneiss and hornblende-granite. The gneiss of the south-east corner of the sheet is of the characteristic Laurentian type, and in the northern and north-western parts there is a good deal of similar rock, but associated with it and bordering the Huronian belt on its north-west side, there is a large development of reddish hornblende-granite and quartz-syenite, which are not always characteristic of the Laurentian system. But these rocks pass into the gneisses and are so mingled with them on both a large and small scale that it becomes impossible to make a separation, and we have been obliged to indicate them all by one colour on the map.

A distinct geological basin.

In the central part of the sheet there is a distinct basin of less altered rocks, being the third division in the above classification, which runs from the township of Trill north-eastward near the South Bay of Lake Wahnapitæ, a distance of thirty-six miles with a breadth of

eight miles in its central portion. These are, perhaps, unconformable to the older Huronian rocks on which they rest, and may be upper Huronian or possibly lower Cambrian. As will be seen by the map, this well-defined basin constitutes an important feature in the geology of the district.

A tongue of gneiss and granite.

To the south-east of it, or in the middle of the belt of older Huronian rocks, a tongue of gneiss and hornblende-granite runs parallel with this trough, a slightly greater distance each way, or a total length of thirty-nine miles, with a breadth of two to three miles. For the greater part of this distance it is separated from the newer basin by a belt of quartzites, greywackes, felsitic and hornblendic schists. It is joined by a narrow neck, in the township of Trill, to the great body of hornblende-granite to the north-west. On the south-east side of this tongue, and almost separated from it by a band of diabase, is a second and parallel belt of similar gneiss and hornblende-granite extending from the township of Denison into Blezard, a distance of eighteen miles, with a breadth of a mile and a-half. As a rule, the gneisses and hornblende-granites of both these belts are finer grained or less thoroughly crystalline and more darkly coloured than those of the great area lying to the north-west of them. In addition to these two almost detached belts of gneissic and granitic rocks, there is a small isolated inlier of red hornblende-granite on the west side of Outlet Bay, Lake Wahnapitæ, and one of gneiss in the fourth concession of Denison.

A second belt of gneiss and granite.

Part of the great Huronian belt.

Our second or Huronian division of this district forms part of the great belt of these rocks extending from Lakes Superior and Huron nearly to Lake Mistassini. In the central part of the sheet it is very much contracted, being only from ten to twelve miles wide, including the two inlying belts of gneiss and hornblende-granite, but its geographical breadth increases rapidly both to the south-west and north-east. Its north-west boundary or line of contact with the great hornblende-granite area to the northward, in going north-east, crosses Spanish River in the south-western part of the sheet, four miles above the great south-western bend of this stream in the township of Shakespeare, and after throwing off, in the township of Trill, the long tongue already described it continues north-eastward to the west shore of Lake Wahnapitæ, having the basin of newer rocks (3) on its south-eastern side nearly the whole way. From the west side of Lake Wahnapitæ, the boundary turns north-west, crosses the Vermilion River and then both of Proudfoot's lines a short distance west of their point of intersection. The Laurentian area thus forms a promontory, the eastern extremity of which touches Lake Wahnapitæ. Southward of this are the eastern extremities of the basin of newer rocks and the Laurentian tongue just

Its N.-W. boundary.

referred to. Around these three, as a whole, the rocks of the second division sweep with eastward curves, in an anticlinal form, which become more and more divergent and the strata more nearly horizontal as we approach Sturgeon River at the eastern limit of the sheet. It will be seen by the map that the principal topographical features in this section, including Sturgeon River itself, all curve parallel with the trend of the rocks. Strata run in sweeping curves.

Quartzites are the predominating rocks in the Huronian belt from the south-west corner of the sheet eastward to the township of Broder, but they are interstratified with a considerable proportion of greywacke and include a number of the greenstone areas. Around Lake Panache they are associated with dolomites and in the township of Denison with schists, gneiss, diorite, breccia, agglomerate, etc., which will be described further on. Between Lake Panache and the shore of Lake Huron and thence westward to the mouth of Spanish River, including the La Cloche Mountains, the quartzites are very largely developed. The bedding is either nearly vertical or stands at high angles. The more massive or durable wide bands form high east and west ridges, on the steep slopes of which the exposures of white marble-like rock form a striking contrast to the dark green of the coniferous trees. The straight intervening valleys are occupied by lakes, swamps or marshes and streams. The highest parts of the La Cloche Mountains rise to elevations above Lake Huron varying from 755 feet north of Great Cloche Island to 1,180 feet at eight miles north of Collins Inlet. The great quartzite belts which form these mountains appear to double round in the space between Lake Panache and Lake Huron and to be repeated in the high ridges forming the backbones of the long points which jut out south-westward towards Manitowaning Bay. Lake Panache discharges into Lake Huron through a series of narrow east and west lakes lying at successively lower levels and supplied by the short rapid streams or waterfalls that break, at right angles, through the lowest gaps in the quartzite ridges which hold up the water of each one above the level of the next below, the whole chain being called Whitefish River. Quartzites predominate. La Cloche mountains. Lake Panache to Lake Huron.

Impure magnesian limestones are found at several places along the northern side of Lake Panache. They are generally fine grained and semi-crystalline, of light greyish colours and always contain a large proportion of silica, in the form of grains and threads or strings. The purer of two specimens from the north shore of this lake, analyzed by Dr. T. S. Hunt, gave 55·10 per cent. of carbonate of lime and 6·5 per cent. of carbonate of magnesia, the balance being insoluble matter. The exposures of limestone on this lake do not all appear to belong to one band; indeed, they may constitute a number of great masses wholly or partly formed by a process of segregation or concretion and Magnesian limestones.

may be unconnected with each other. At one part of the shore, where the limestone is well exposed, Mr. Murray estimated its thickness to be 150 feet. A band of impure light greenish grey dolomite, weathering brown, crosses the Wahnapitæ River at Island Portage, about three miles below the outlet of the lake. The rocks are here nearly vertical, but undulate a good deal, and I estimated this band to have a thickness of at least 300 feet.* The rocks around Lake Panache and thence by the canoe-route to Lake Wahnapitæ are described by Mr. Murray in the Geological Survey Report for 1853-56, pages 178–190.

Dolomite on Wahnapitæ River.

Contracted part of Huronian belt.

In the central or contracted part of the Huronian belt the greywackes constitute a large proportion of the whole, and they include a number of areas of greenstone, ranging from a few chains up to one nearly eleven miles in length. The Wahnapitæ River, for the first nine miles below the lake of the same name, runs nearly south, crossing the Huronian rocks diagonally and it then meets the Laurentian gneiss and is deflected south-west for eight miles along the boundary between these systems, after which, for the next three miles, it gradually enters upon the older rocks and then turns due south and follows that course till it falls in the rocky delta of the French River.

Wahnapitæ River.

Huronian rocks on Wahnapitæ River.

The rocks which it traverses in the upper nine miles referred to, consist of thinly bedded and more or less felsitic quartzites which have evidently been affected by pressure and shearing and generally show a fluted, striated or ligniform appearance on the bed-planes. They are mostly light grey and fine grained. The strike is north-eastward and the angles of inclination are always high. They are sometimes interstratified by slatey bands.

The line of junction between the Laurentian and Huronian systems runs unusually straight, in a nearly north-eastward course from the township of Broder to beyond the Wahnapitæ. It is not improbable that a considerable fault coincides with this section of the common boundary between the two series, as the strike of the adjacent Huronian rocks is not always parallel to the course of the dividing line. An example of this may be seen where the Canadian Pacific Railway crosses the river, the line between the two sets of rocks being here in the bed of the stream. If the course of this supposed fault be continued north-eastward, from a point where the boundary turns more to the east, it would cross the outlet of Wash-ki-gamog Lake where the Huronian strata are greatly disturbed and the clay-slates altered in character, as was first noticed by Mr. Murray in 1856.† The only

Supposed fault.

Disturbed strata.

* Geological Survey Report for 1875-76, page 296.

† Geological Survey Report for 1853-56, page 174.

other rocks observed on or near this part of the Wahnapitæ were two exposures of greenstone and the band of dolomite mentioned above.

Rocks of Lake Wahnapitæ.

Quartzites are the prevailing rocks on the south side of Lake Wahnapitæ and on most of the adjacent islands and they are also largely developed along the valley of the upper Wahnapitæ River to beyond the north limit of the sheet. They are fine grained and mostly massive along both sides of this part of the river. The strike is everywhere north-westward and the inclination at high angles; but in some places the stratification is very obscure. Greywackes and volcanic ash-beds occur between this part of the stream and Vermilion River and will be described in connection with the geology of the latter.

Disturbance and mingling of rocks.

At the west side of Lake Wahnapitæ, where the Huronian strata come into contact with the Laurentian syenites or granites and gneisses, there is evidence of great disturbance and crushing, the rocks of the two series being much broken up and intermixed along the junction. This is what might have been expected where a point of the older and more solid and resisting set extends so far into the midst of the other, which almost everywhere bears evidence of having sustained great lateral pressure. Specimens 1 to 4 in Professor Williams descriptive list in the appendix are from the largest island in the mouth of West Bay, which lies on the borders of the two systems.

North River.

In 1875 I examined North River or the chain of lakes with falls and rapids between them, which stretches northward from the south end of Lake Mattagamashing to the edge of the sheet, and found only light coloured quartzites in that part of the route*. Since that time we have explored the country between this canoe-route and the Upper Wahnapitæ River and found the rocks to consist of quartzites also, except a little argillite south-east of Sam Martin's Lake, a ridge of diorite, running north-west from the head of Boucher Lake, an area of diorite between Mattagamashing Lake and Portage Bay and the high ridge of the same rock mentioned by Mr. Murray as occurring between this bay and the main body of Lake Wahnapitæ.

Upper Wahnapitæ River.

East of Lake Wahnapitæ.

On either side of a curving chain of lakes from Portage Bay to the eastern edge of the sheet, drab-coloured argillites and clay-slates are the prevailing rocks. In the central part of Mattagamashing Lake they pass into a somewhat slatey greywacke with pebbles of granite, or syenite, white quartz and a few of red jasper, usually sparingly scattered through it, constituting what Mr. Murray described as slate-conglomerate.

Slate-conglomerate.

On the south-east side of Portage Bay and thence north-eastward along Lake Mattagamashing to where it turns east, slate—or greywacke-

* Geological Survey Report for 1875-76, page 297.

conglomerate, is the prevailing rock; but from thence to Lake Maskinongéwagaming and in the country between these lakes it is bluish green and drab clay-slate with distinct cleavage. Drab-coloured grey-wacke-conglomerate is largely developed on the west side of Wash-ki-gamog Lake and dark greenish argillite on the east side, while green, red and grey quartzites are associated with these rocks around the southern part of this lake. Clay-slates and slate-conglomerates are found around Murray Lake and thence to Sturgeon River. In addition to the masses of diorite at the southern extremity and near the meeting of the two arms of Lake Mattagamashing, other comparatively small areas of the same rock occur on the western sides of both Lower Mattagamashing and Maskinongéwagaming Lakes, at the south end of Wash-ki-gamog and at the outlet of Murray Lake, and again in the fork of the Maskinongé and Sturgeon Rivers.

Diorite masses

Angles of dip.

Along the east shore of Lake Wahnapitæ and the north-western part of Lake Mattagamashing, the general eastward inclination of the strata is at tolerably high angles, but elsewhere, in the north-eastern corner of the sheet, the dips are comparatively low, ranging mostly from 10° to 30°, except at the south end of Lake Wash-ki-gamog, where there is much local disturbance with high dips. Indeed, the quartzites which make their appearance here may be brought up in connection with the continuation of the fault, which, as above stated, is supposed to run along the straight part of the Laurentian and Huronian boundary.

A gentle anticlinal.

As Mr. Murray pointed out,* a gentle anticlinal seems to run northward up the basin of Lake Maskinongéwagaming, where the clay-slates are about horizontal and on either side dip to the east and the west at low angles.

Koo-ka-gaming Lake.

Massive dark grey or drab argillite is the principal rock all around Koo-ka-gaming Lake. On the west side of the narrows, near the north end, there is a thick bed of grey quartzite, in the argillite, dipping due east at an angle of 10°. Dark crystalline diorite forms a bluff on the east side at the north end of these narrows, and this rock is found on two islands off their south end, also on a point on the east side of the lake near its south end, and on some of the islands to the north and the south of this point. Around Edith Lake, which lies a short distance north of Mattagamashing Lake, the rocks are all drab-coloured argillites, lying nearly horizontally. Towards the northern part of the lake they become very silicious.

Edith Lake.

Straight valley.

Edith Lake has an elevation of more than 100 feet above Mattagamashing Lake, and from the mouth of the brook discharging the former,

* Geological Survey Report, 1853-56, page 174.

a well marked valley, with high slopes on either side and paved along the bottom with naked boulders and cobble-stones, runs north-north-eastward in a very straight course for the junction of the Obabika River with the Sturgeon. Where the latter strikes the northern boundary of the Laurentian gneiss, two miles below the junction of the Maskinongé, it is deflected eastward at a right angle from its former course and then gradually enters the gneissic area. The details of the geology of the shores of Lake Wahnapitæ and of the route from Portage Bay on its east side to Sturgeon River, are so fully given in Mr. Murray's Report for 1856 that it will be unnecessary to repeat them here. (*See* Geological Survey Report for 1853-56, pages 171-179.)

Sturgeon River.

Murray's description.

General Description of Vermilion River.

Vermilion River rises in Ni-nip-ska-gaming Lake, a long narrow sheet of water lying about three miles east of Onaping Lake and running north and south or parallel to it. It discharges northward, but the outlet soon turns eastward, and then south-eastward, and holds this direction all the way to Onwatin Lake, about three miles north of the township of Garson. In this part of its course it cuts off the angle formed by Proudfoot's east-and-west and north-and-south lines, the post marking their intersection being about a mile east of the first intersection and two miles north of the second. My instrumental survey extended up to the east-and-west intersection, or three miles beyond the northern edge of the sheet and our explorations reached a point six miles still further north. Below Ni-nip-ska-gaming Lake the river passes through Pi-mitchi-wanga, O-mitchi-wanga and Tonadus Lakes.

Source of Vermilion River.

Extent of survey.

From Proudfoot's east-and-west line all the way to Onwatin Lake, a distance of twenty-two miles in a straight line, the river passes through a succession of narrow lakes connected by stretches of rapid river flowing in rocky defiles and having usually one or two and sometimes more falls with portages in each stretch, so that the general descent must have a considerable grade. Previous to the present survey these lakes had no names and, for the sake of convenience of description, we were obliged to give them those which appear upon the map. The principal tributaries of this part of the river coming within the limits of the sheet are a brook from the east at its northern edge and Ka-wa-wa-ski-gama River, a large branch from the west which falls into Fraser Lake.

Character of river.

Names.

Tributaries.

Stratified Huronian rocks extend down from the intersection of the river with Proudfoot's east-and-west line to the junction of Black Ash Brook, from the east side, a distance of eleven miles in a straight line, the

General character the rocks

course of the river being about south-east. Here the stream enters upon an area of hornblende-granite, micropegmatite and gneiss, and its course becomes about south for a distance of nearly eight miles or to the head of Bass Lake, where it emerges upon the volcanic breccia. Its general course over the latter rock is southward to Onwatin Lake, but it makes a large bend to the eastward at Marshy Lake, from which a canoe-route goes north-eastward to the West Bay of Wahnapitæ Lake.

Change in character of the river.

At Onwatin Lake an entire change takes place in both the character and the course of the river. So great is this change that the Indians regard Onwatin (Smooth or Calm) Lake as a river-head from which the stream below derives its name; Onwatin (not Vermilion) River being its Indian designation. It may here be remarked that, as a rule, all over the vast Archæan country inhabited by the Outchipwai Indians, most of the rivers bear the same names as the principal lakes, which in each case are regarded as their source. From Onwatin Lake the river flows with a gentle current, as a rule, all the way to Vermilion lake, in a general west-south-westerly direction, slightly bowed to the north-west, the distance in a straight line being twenty-seven miles; but its channel is so exceedingly tortuous that the actual length of the stream is about three times as great. A fall of about fifty feet occurs at Larchwood, where the Canadian Pacific Railway crosses the river, but besides this there are only a few small rapids, although the river is frequently blocked by great jams of driftwood, each of which renders a portage necessary.

Very tortuous stream.

Relation of rivers to geological basin.

Throughout the above section the river flows entirely upon the same rock-formation. At Onwatin Lake, it enters upon the north side of the elongated basin of unaltered argillaceous sandstones and shales, and follows the gentle sweep of their strike all the way to Vermilion Lake, the two lakes lying in corresponding positions nearly at the geographical extremities of this member of the series. In Vermilion Lake the course of the river doubles round and now flows east-north-eastward to the north-west corner of Creighton. The general upward bearing of Whitson Creek coming from the opposite direction is in continuation of this course as far as the north-west corner of Garson, the two streams almost completely surrounding the central part of the geological basin just referred to. The area thus included is tolerably level and is singularly devoid of streams or lakes, thus contrasting with the country outside of this basin. As will be seen by the map, the higher granitic country to the north sends down numerous streams which all join the above section of the Vermilion at right angles. Those between Onwatin Lake and the junction of the Onaping before falling into the Vermilion unite to form the three streams called Pa-wa-tik (Rapid), Sagi-tchi-wai-a-gama (Swiftmouth), and Ping-wi-i-min-kan-

Level country devoid of lakes.

Streams from the north.

i-wi (Sand Cherry) Rivers, while the Vermilion itself above Onwatin Lake and also the Onaping have similar physiographical characters and belong to the same class.

From the above-mentioned point in the township of Creighton, where Whitson Creek joins the Vermilion, the general course of the latter turns at right angles and flows due south transverse to the strike of the gneisses and diorites as well as of the Huronian quartzites and schists, as far as McCharles Lake*, where it crosses the line of the Canadian Pacific Railway. Between Vermilion and McCharles lakes the river is interrupted by seven falls and rapids, requiring portages to be made in order to pass them.

River crosses the strike.

Seven portages.

From McCharles Lake the general course of the stream is west-south-west to its junction with the Spanish River at the west town-line of Foster, the distance being twenty-one miles. In this section it flows altogether upon the greywackes, quartzites, felsites, &c., of the lower local division of the Huronian rocks and in the direction of their average strike. Its width varies much, but its principal expansion is Lake Wabagizhik, on the north-west side of which there is a large area of diabase.

W.S.W. course to the mouth.

Geology of Vermilion River.

Following the above general description of Vermilion River, an account of its geology will now be given. Around the outlet of Omitchiwanga Lake, or four miles in a direct course above Proudfoot's east-and-west line, grey diabase is exposed and on the eastern shore of Tonadus Lake, at two miles and a half above this line the rocks consist of dark greenish-grey argillite. Greywacke of the same colour as the last named rock is exposed on the river at half a mile above the line.

Above Proudfoot's line.

Proudfoot's line was examined from the corner post for a distance of seven miles west or for six miles from the river, and the country was also explored for a short distance to the eastward of this post. No rock was observed between the river and the corner post, but eastward of the latter the rocks in the first mile consist of dark greenish-grey argillites, quartzose greywackes and greywackes containing hornblende, all striking N.W. and S. E. On the western shore of a good sized lake, a mile and a quarter east of the post, the last mentioned rocks are again exposed, while from its south-western extremity reddish hornblende-granite of medium texture extends to the south-westward.

East of Vermilion River.

*This lake, which extends for three miles and a half eastward of the Vermilion River in the township of Graham, was formerly called "Vermilion Lake" on the township map, but as this name was preoccupied by the larger lake in the township of Fairbank, another name became necessary and we called it McCharles Lake in honour of Mr. Æ. McCharles, who resides on its northern shore and is doing much to promote the mining industry.

West of Vermilion River.

As already stated the river intersects the east-and-west line referred to a short distance west of the first mile post. Following this line, the steep ascent on the west side of the river exposes a very dark coloured silicious conglomerate with small white quartz pebbles. Between the second and third mile posts (from the corner) the rocks are massive,

Greywacke-conglomerate.

coarse grey quartzite and grey quartzose or greywacke-conglomerate, the pebbles of which are mostly of white quartz and grey aplite or binary granite. The last exposure of this rock occurs about a quarter of a mile east of the three-mile post and the first one of Laurentian rock at one-eighth of a mile west of the same post. Between three and five miles and a-half (also from the same post) the rocks consist of very

Qnartz-syenite.

massive but rather fine-grained light pink and grey aplite, with the exception of a streak, twenty or thirty yards in width, of green schist, containing cubes of iron pyrites and running a little east of north. At five miles and a-half a short interval of coarsely crystalline hornblende and felspar rock occurs, beyond which, to the seventh mile, there is a

Gneiss.

moderately fine-grained quartzose syenite-gneiss and a more coarsely crystalline quartz-felspar rock without foliation. After leaving the valley of the Vermilion River going west, Proudfoot's line passes over almost bare rock, with clumps of small Banksian pines as far as I followed it.

Below Proudfoot's line.

Below this line the river flows south-eastward till we reach Black Ash Brook and the general strike of the rocks is in the same direction. They consist of quartzites, greywackes, argillites and clay-slates. On the south-west side of Proudfoot's Lake (between the intersections of the two lines of the same name) there is a coarse grey quartzite, so massive that the lines of stratification can only be traced in some parts. The dip is N. E. $< 60°$. At the outlet of this lake or half a mile above

Quartzite conglomerate.

the intersection of Proudfoot's north-and-south line, a grey quartzite with small white quartz pebbles dips N. 20° W. $< 65°$. This abnormal dip is, perhaps, due to the proximity of an area of red hornblende-granite to the eastward of it. From this line, for three miles downward, grey or greenish grey and drab clay-slates, some of them suitable for flagging, are the only rocks exposed. The course of the river conforms with the strike, which is generally about S. 35° E. and the inclination is to the north-eastward at an average angle of 60°.

Black Ash Brook.

The river continues in the same general course for six miles more (nine miles in all from the line) to Black Ash Brook, where it passes off the Huronian system. The rocks for these six miles consist of quartzites, alternating with argillites and clay-slates, with some greywackes. An island at the commencement of this section was named

Camp Island.

Camp Island for the convenience of local description. In this vicinity a dark grey quartzite dips N. 30° W. at a high angle, while a few

chains further down the same rock dips N. 40° E. < 30°. Close to the latter, and apparently underlying it, there is a massive drab-coloured argillite which shows no stratification.

Campbell Lake, measuring upwards of a mile in each direction, was discovered at two miles and a-half north-east of Camp Island. Between the river and this lake several ridges of greywacke of different shades and textures were crossed, the strike being generally northward, but varying to 10°, 15° and even 20° to the east of north. On the shores of Campbell Lake the rocks consist of, (1) greywacke with patches of quartz pebbles, of all sizes, and silicious inclusions which weather to a sponge-like surface and, (2) silicious volcanic breccia, holding sponge-like quartz fragments and patches. On an exploration from Camp Island in the opposite direction, or south-west from the river, as far as Proudfoot's north-and-south line, the only rock met with was at three-quarters of a mile, and consisted of a fine-grained greywacke, which showed no stratification. Campbell Lake. Camp Island to Proudfoot's line.

Three-quarters of a mile below Camp Island, massive quartzite appears, and at a quarter of a mile further massive greenish-drab argillite, striking N. 21° W., the dip being vertical. Pot-hole Falls, with a descent of thirty-five feet, occur at a mile and a-quarter below Camp Island. Here a cliff on the south-west side of the river shows sections of ancient pot-holes much larger than the present stream would appear capable of forming. In this vicinity massive greenish-drab argillite, massive ash-grey quartzite and grey silicious conglomerate with pebbles of hornblende-granite occur, striking, respectively, S. 62° W., S. 68° W. and N. 70° W. The bedding of the first and last is on edge, but in the other case the dip is S. 22° E. < 15°, showing the existence of a fault or other disturbance. Half a mile further down there is another fall, and here the rock is indurated greenish-drab clay-slate, striking due west vertically, while its cleavage, which is also vertical, runs N. 15° W. Ka-ko-zhish Falls, twenty-five feet high, occur a little more than half a mile below the last fall. A dyke of diabase, over 100 feet wide, here runs N. 65° W. and greenish-drab clay-slates, on its north-east side, strike N. 20° W.; but ten chains further down where the river enters Otter Rock Lake, similar slates strike N. 50° W. and dip N. 40° E. < 80°. On the east side of this lake the rock is fine-grained massive greywacke, while on the north side it is dark bluish clay-slate, striking N. 55° W. < 90°. A ridge of angular fragments of banded greenish-grey slate crosses this lake. Bluffs of grey quartzite overlook the north-east side of Gibson Lake and a grey quartzite-conglomerate is found at its head. A short distance above the head of this lake there is a portage past a rapid, a quarter of a Pot-hole Falls. Ka-ko-zhish Falls. Otter Rock Lake. Gibson Lake.

mile long. At the foot of this rapid, the rock is a massive, rather coarse light grey quartzite, running N. 50° W. < 90°.

Mowat Lake.

Mowat Lake lies two miles and a half east of this point, and in the interval there are two ridges of massive grey quartzite. This lake is two miles long and discharges at its south-east extremity, where the rock is grey quartzite. But on its south-west side, greywacke occurs, passing into dark blue-grey slate and striking S. 65° E. < 90°. In the hills overlooking this side of the lake, dark coarse slate and grey quartzite are seen striking N. 50° W. < 90°. A traverse was also made south-west from the foot of the above portage as far as Ka-wa-wa-kash-ki-gama River, three miles distant and the following rocks were noted; at a quarter of a mile. light grey quartzite, striking north-west: at half a mile, dark grey greywacke without observed bedding; at one mile and a quarter, dark grey clay-slate, striking north-west; at two miles, a ridge of grey diabase, running about north and south. The last named river was explored for some distance up and down, but no fixed rock was found in its bed.

Ka-wa-wa-kash-ki-gama River.

First gneiss.

Glossy green schists appears at the mouth of Black Ash Brook and massive pink gneiss on the opposite side of the Vermilion, being the first occurrence of gneiss in descending the stream. Half a mile above the junction of the Ka-wa-wa-kash-ki-gama, reddish gneiss strikes N. 10° to 40° W., and half a mile below it a similar rock occurs with folded lamination. Reddish gneiss, with an occasional band of grey, continues for four miles and a half below the above branch river, the prevailing strike being N. N. E., but in one case it is N. N. W. At the end of this distance the river makes a very sharp elbow to the S. S. W., and falls over a large diabase dyke which runs N. N. E. From this dyke down to the head of Bass Lake, a distance of two miles and a half, the rocks consist of rather fine-grained dark reddish-grey hornblende granite. The same rock was found by exploration to extend to a distance of three miles eastward of this part of the river, and from other explorations we know that rather coarser varities of hornblende-granite, along with gneiss and some diorite, extend to the west side of Lake Wahnapitæ.

Large dyke.

East of river,

Bass Lake.

At the head of Bass Lake the river enters upon the dark volcanic breccia described in a former part of this report, and this rock is exposed in a number of places as far as Onwatin Lake. The strike is S. 35° W., at the above locality, and S. 40° W. half a mile above and again half a mile below Marshy Lake. The breccia is very massive as far as the head of the long rapid just before the river falls into Onwatin Lake, where it becomes coarsely slaty with a "lumpy" cleavage and strikes S. 45° W. At the outlet of Marshy Lake a dyke of rather light grey diabase about 400 feet wide crosses the river and appears to

Volcanic breccia.

Great diabase dyke.

run about ten degrees south of west and probably causes the great bend which the river makes in this part.

Onwatin to Vermilion Lake.

From Onwatin Lake all the way to Vermilion Lake, as already stated, the river flows with the strike along the north-western side of the basin of grey argillaceous sandstones interstratified with softer beds. From a point three miles and a half, in a straight line, from the inlet of Onwatin Lake as far as the middle of the township of Lumsden, all the numerous southward bends of the stream touch the outcropping edge of the same band of the formation, which, with a southward dip, sweeps round in a gentle northward curve between these points. In this interval the sandstones and the slaty beds are generally dark grey, and the latter are sometimes black. The sandstone is characterized by disseminated grains of transparent quartz and it also holds occasional ovate spots of a different hardness and a lighter colour than the average, measuring from a few inches up to three or four feet in diameter. These weather, on exposed surfaces, into oval and rounded depressions, the larger of which are locally known as "Nanabozhoo's snowshoe tracks." These are well seen on the rock-surfaces at Larchwood where the Canadian Pacific Railway crosses the river and they are again met with at Chelmsford on the opposite side of the synclinal. Below Larchwood the argillaceous sandstones with the oval depressions on weathered surfaces are exposed frequently in the banks of the river for the first half of the distance to Vermilion Lake. The dip is south-east at high angles and the strike very straight, the bedding never being curved or disturbed. In the lower half of the distance nothing but sand is to be seen along the river.

Character of sandstone.

Oval depressions in surface of rock.

Below Larchwood.

The rock just described under the name of argillaceous sandstone might also be called arkose or greywacke, but for the sake of distinction, these names are reserved for the rocks of the older division in this district, which generally bear more distinct evidence of being made up of the débris of granite or quartz-syenite. They have a great similarity to the dark grey silicious rocks which are scattered so abundantly in the form of boulders around the shores of James' Bay and over the country to the south and west, and which occur *in situ* on Long Island, Eastmain ; and they also resemble the dark grey greywacke or felsitic sandstone at the mouth of Churchill River on the west side of Hudson Bay.

Comparison with similar rocks elsewhere.

Vermilion Lake.

The country on the south side of Vermilion Lake is hilly and somewhat rugged, the highest elevations being towards the west end. The rocks of these consist of coarse black schist full of foreign fragments, mostly of quartz-syenite. The cleavage strikes S. 60° W., and dips to the south-eastward at an angle of 55°, but no distinct bedding could be observed. These rocks form part of the black breccia band, else-

where described, and contain, as usual, a good deal of iron pyrites.

Black slate.

Further east, on the south side of the lake, the rock is a fissile black slate with vertical cleavage, striking parallel to the shore. At the first portage below the lake, which is past a fall on lot 10, concession VI, Creighton, the black slate is full of cubes of iron pyrites. The cleavage is vertical and runs 5° north of west. On this lot, and only a short distance west of the portage, a good sized vein containing galena and iron pyrites cuts across the slate. Other veins in Fairbank and Creighton are being tested for gold.

Mineral-bearing vein.

River turns south.

Whitson Creek from the east joins the river at the foot of this fall, and now the general course of the stream turns south and flows across the strike of the rocks as far as McCharles Lake, on the south side of the Sault Ste. Marie branch of the Canadian Pacific Railway. As already stated, the general descent of the river is rapid, and seven portages occur in the interval. On lot 11, concession V of Creighton, about a mile below the first portage, grey quartzite and greywacke occur, striking S. 60° W. Greenish-grey fine grained hornblendic schist is met with on the next lot to the west (No. 12, con. V), and grey quartzite is found in Fairbank, two miles to the westward of this locality. Schist similar to the last occurs half-a mile above the second portage, which is at the north end of lot 1, concession III, Fairbank, about three miles from the first portage. Here the rocks are light and dark grey quartzites, containing much felspar and passing into greywacke. The strike is S. 60° W. Quartzite occurs on the north end of lot 3, concession III, a mile west of this portage, and it was traced thence south-westward for upwards of two miles, when it became flanked on either side by fine-grained gneiss.

Huronian rocks.

Levy River.

Along the north-western margin of the gneiss in the valley of Levy River to the north-eastward of this part of the Vermilion there is a belt of dark greenish-grey and almost black felsitic schist with chlorite and black mica in fine scales covering the cleavage surfaces. This rock corresponds with the "hälleflinta" of Norway. It is exposed at Emma and Moore Lakes; also on the section of Levy River between them and for some distance to the northward of it, and again on the islands and points in the northern part of White Water Lake, as well as to the north-west of the boundary of the gneiss at the point where it is crossed by the Canadian Pacific Railway near this lake.

Rock like "hälleflinta."

The third portage occurs two miles below the second on the south end of lot 11, con. II, Creighton. Here the rock is all a dark grey hornblende-gneiss striking S. 60° W. At the fourth portage, half a mile further down there is a dark rather coarsely crystalline diorite, much pitted over most of the exposed surfaces. The fifth portage begins about a mile below the fourth, and is a quarter of a mile long.

Hornblende gneiss.

Here the rock is reddish gneiss, mostly of light shades. Some parts of it, however, are coarse and massive, resembling granite and other parts finer and more darkly coloured than the average. The stratification is not very distinct, but it runs about west-south-west. At the foot of this portage, which is on the south end of lot 11, con. VI, Graham, a greenstone dyke, eleven feet wide, runs N. 73° E. The gneiss continues nearly to the head of the sixth portage on lot 1, con. IV, Denison. At this portage the rock is soft felsitic schist, the cleavage surfaces of which glisten with fine scales of mica. It passes into greywacke, some beds being massive and silicious, approaching quartzite. The strike is N. 55° W. $<$ 90°. Similar soft grey schist with finely glistening surfaces continues for a mile below the sixth portage. Here the cleavage is almost vertical with a south-westward strike, and the exposed edges are eroded into holes elongated in the direction of the cleavage. Half a mile below this portage the river touches the west town-line of Denison, where a ridge of diorite crosses it and several large quartz veins, with a westerly course, are found at the same locality. A little molybdenite was the only other mineral observed in these veins. Between the town-line of Graham and the crossing of the Canadian Pacific Railway, at the seventh portage, a massive fine-grained bluish-grey greywacke occurs, striking S. 80° W. $<$ 90°. At the head of the seventh portage the rock is bluish and greenish-grey soft felsitic schist, passing into greywacke, and striking S. 70° W. $<$ 90°. On the railway line, a short distance west of the river, there is a cutting through dark, and in parts almost black, splintery clay-slate. Following the line, at one-third of a mile west of the river, a massive grey greywacke, with a few beds of dark shale, stands nearly vertically and strikes N. 75° W. Grey greywacke, in beds from three inches to two feet in thickness, striking due west with a southward dip of 85°, continues to Whitefish Station on the north end of lot 1, con. I, Denison.

Reddish gneiss.

Felsitic schist.

Quartz veins.

Crossing of the railway.

The geology of the lower part of the river will now be described from the mouth upward to the intersection of the Canadian Pacific Railway. A long rapid occurs just before the Vermilion River joins the Spanish, necessitating a portage of three-quarters of a mile in length. At the lower end of this portage a grey schist, striking S. 45° W., occurs, while just above its upper extremity the rock is a yellow quartzite, striking S. 80° W., and dipping southward at an angle of 60°. In the rapids at the outlet of Lake Wabagizhik and on the first point on the north-west side of the lake a tough splintery grey diabase occurs, with calcspar in the joints, but to the north-westward of this rock there is a light grey quartzite which strikes S. 70° W. and comes out upon the river below the rapids just referred to. The promontory near the

Lower Vermilion River.

Lake Wabagizhik.

middle of the north-west side of the lake consists of a light grey quartzite with some beds of greywacke, but the rock of all the rest of the shore as far as the inlet appears to be a grey diabase, which, in some places, is mottled and more coarsely crystalline than the average.

Large area of diabase.

This forms part of a large area of this rock, extending from the northern part of Foster to the VIth concession of Lorne. Nickeliferous pyrrhotite has been found in this rock on lots 1 and 2, con. III, Nairn, and on lot 11, con. V, Lorne.

Lorne.

On the south side of the inlet of Lake Wabagizhik, a bluish-grey silicious argillite dips S. 60° E. $<$ 10°. Two miles above this lake, or at the centre of lot 8, con. III, Lorne, the river falls 35 feet, nearly perpendicularly, over a dyke of fine-grained greenstone 30 feet wide running about S. 80° W., or parallel to the south side of this part of the river. The rock on the north side of this dyke is silicious greywacke schist, while on the south side it is light grey quartzite. The latter rock occurs at the next fall, half a mile further up.

Lake Ella. Quartzites. Dyke.

Lake Ella is connected with the Vermilion River by a short marshy channel in lot 6, con. II of Lorne. This lake is surrounded entirely with quartzites of different characters, excepting at the points and on an island on the south side which form parts of a large dyke of speckled grey diabase running west-south-west. The general strike of the quartzites is nearly east and west. They contain some bands of an arkose character. On the point near the middle of the north-west side of the lake, two masses of greenstone from 50 to 100 feet in diameter are included in the quartzite, and on the next point to the south-west on this shore, a mass of the same rock mixed with fine-grained grey quartzite rests unconformably upon the eroded edges of the quartzite beds, with fragments of the latter of all sizes more or less mixed with greenstone, intervening.

Lorne.

Above Lake Ella a schistose greywacke is found on lot 5, con. III, Lorne. The course of the river, which is straight in this vicinity, is probably determined by a greenstone dyke running S. 36° W. along its south-eastern side. The next upward stretch of the stream is at right angles to the last and lies between two dykes of dark heavy decomposing greenstone, the first of which runs N. 40° W., and the other appears to be quite parallel to it at a distance of a quarter of a mile to the north-east. Light and dark grey and greenish grey quartzites prevail everywhere in this part of Lorne and continue thence into Louise. Between the two dykes just mentioned a grey felsitic quartzite dips S. 30° W. $<$ 45°.

Louise.

Throughout the township of Louise and thence to the intersection of the Vermilion by the Canadian Pacific Railway, quartzites, generally largely mixed with felsitic material, are the only rocks met with

near the river. The dip is never less than 45° and is usually nearer the perpendicular. The commonest direction of the strike approaches east and west, but it varies greatly, especially in the vicinity of the greenstone area in the southern part of Denison and the northern part of Louise. Deposits of pyrrhotite have been found in connection with this latter rock at eight localities in concessions I and II of Denison and concession VI of Louise. Felsitic quartzites, or greywackes, with some quartzites of a purer kind are found throughout the Whitefish Indian Reserve, with the exception of a few comparatively small areas of greenstone. Pyrrhotite.

General Description of Spanish River.

The Spanish River having been topographically unknown above the township of Hyman, it became necessary to make a micrometer survey of it, between this locality and the northern boundary of the sheet. This was accomplished by going down stream from a point above the intersection of the Canadian Pacific Railway near Spanish Forks, and after reaching the township of Hyman, the geological examination of the river and the country on either side was continued all the way to the junction of Vermilion River. Micrometer survey.

At Spanish Forks, sixty-four miles by the railway, north-west of Sudbury, two large streams, one from the north and the other from the west, unite to form the main Spanish River, which is the largest stream flowing into Lake Huron west of French River. From the Forks, downward, the course of the Spanish is remarkably straight, bearing S. 13° E. for twenty-two miles, or to the north-west corner of the township of Hart. Here it assumes a course of S. 21° W. for six miles, or to The Elbow, where it turns north-west, forming less than a right angle with its former course and then, sweeping round a semicircle, it gains a point five miles west-south-west of The Elbow, from which it runs S. 15° W. for eighteen miles to the great south-west bend. From the latter, its course is a little north of east for eighteen miles further to the Great (N.E.) Bend in the southern part of Drury. Between the Great Bend and Lake Huron, a distance of forty-four miles, its course is tolerably straight and bears S. 73° W. Spanish Forks. Main courses of river.

The Canadian Pacific Railway crosses the Upper Spanish River three miles above Pogamasing Station, which is nine miles below Spanish Forks. At this station perpendicular cliffs of red hornblende-granite rise to a height of about three hundred feet above the river. Four miles below Pogamasing Station the stream enters a narrow valley with steep bluffs of red hornblende-granite on one side or the other and often on both sides. This character continues, with a few Crossing of Canadian Pacific railway. Narrow valley

short widenings of the valley and a few exceptions in the nature of the rocks forming its slopes, which will be described further on, till we arrive within four miles and a-half of the great south-west bend, where the river emerges upon the Huronian belt.

Rapids.

Between Pogamasing and the great south-west bend there are many rapids in the river, but only five portages, and these all occur in the first three miles below The Elbow.

Branches.

Agnes River, from the north-west, falls in at the fifth portage. The other principal tributaries are Blue Water River from the west, ten miles below Pogamasing, Onaping Creek from the east, three miles further down, Geneva Creek, also from the east, four miles below the last, and the West Branch, eight miles above the great south-west bend. Numerous rapids and falls occur between the last named locality and the Great (N.E.) Bend, but these will all be noticed in the geological description of the river.

Pogamasing Lake and the Chain of Lakes to the southward of it.

Position of the lake.

Pogamasing Lake, of which a micrometer survey was made, lies parallel with the Spanish River, at an average distance of one mile west of it. The point at which the Canadian Pacific Railway crosses the river is opposite the middle of the lake and the brook which discharges it falls into the river one mile further up. There are three portages, all of about equal length, about half a mile in each case, from the river to the lake, one at each extremity and one at the middle. The lake

Dimensions of the lake.

is ten miles in length and has an average width of three-quarters of a mile. Its surface, by barometric readings, is 77 feet over Spanish River at the instersection of the railway. A post of the Hudson's Bay Company, which has been long established, stands on an island in

Rocks.

the centre of the lake, mid-way between its extremities. The rocks on the shores of the lake consist of the prevailing hornblende-granite, which is all red except on an island near the northern extremity, where it is grey, and dykes of diabase, which were observed in three places, all running nearly parallel with its greater length.

Chain of lakes.

A canoe-route, following a chain of lakes with a general southward course, leaves a bay on the west side of Pogamasing Lake, two miles from its southern extremity. The first lake of this chain, four miles and a half long, was named Kennedy Lake in honour of Mr. T. J. Kennedy, C. E., of Pogamasing. From it the Mogo River flows south,

Another chain of lakes.

and just below the lake is joined by a stream from another chain of lakes, which we also explored, leading from the southern extremity of Pogamasing Lake. After passing through three other lakes, Blue Water Lake, in the new township of Craig, is reached. A rapid and crooked river of the same name leaves the east side of this lake and

discharges its waters into Spanish River, only two miles and a half distant. The rocks along both of the above chains of lakes consist of red hornblende-granite, except at two miles south of the outlet of Kennedy Lake, where a band of green crystalline schist with a south-west strike crosses one of the lakes. Blue Water River, through its whole course, flows upon a band of dioritic and greywacke schists, which form a westward spur of the Straight Lake Huronian outlier, to be more fully described further on. Blue Water Lake. Rocks.

Geology of Spanish River.

As already stated, Spanish River was surveyed topographically, as well as geologically, from a point a few miles above the crossing of the Canadian Pacific Railway, north of Pogamasing station, to the township of Hyman, where I connected my work with the township survey; and below this the surveys of Mr. Murray and the Crown Lands Department are continuous, so that henceforward it was not necessary to do any more topographical work, and attention was given entirely to the geology. The rocks found along the river and by exploration on either side have been already referred to in the general geological description of the district, but for the sake of convenience of reference and for practical purposes further details of the geology of this stream will now be given. As in other parts of this report the distances stated will be understood to be measured in straight lines, and the bearings will all be by the compass. Extent of new survey. Geological details.

From the crossing of the Canadian Pacific Railway downward, the rocks all along the river consist of the prevailing reddish hornblende-granite of the surrounding country, which has a medium texture, until we arrive at a point six miles and a-half from Pogamasing station, or just below the junction of a brook from the east, where a narrow band of distinctly foliated red and grey gneiss crosses the river. Its general dip is south at an angle of 60°. This is in the run of a wider belt of gneiss which crosses the railway one mile to the eastward between mile-boards 491 and 492. The same belt continues to widen to the eastward and on the canoe-route between Bannerman and Onaping Lakes it has a breadth of about three miles. Reddish hornblende granite. Band of gneiss.

In the opposite direction, at two miles and a-half west of this occurrence of gneiss on the Spanish River, green schist, striking south-west, with the red hornblende-granite on either side of it, was found on one of the lakes of the chain running northward from Blue Water Lake. In the township of Craig the river enters at right angles upon a spur of the Straight Lake Huronian outlier in the 4th lot of the Vth concession. Blue Water River, from the lake of the same name, two miles and Green schist.

a-half to the westward in Craig, falls in at the north end of lot 3, concession IV.

Schists and greenstone on east side of the river.

The rocks of this spur are well exposed on the burnt hills on the east side of the river, opposite the mouth of this branch. They consist principally of schistose greywacke, mingled with massive and schistose greenstone. The greenstone occurs both in broken dyke-like forms, running in different directions, and more abundantly as irregular masses of all sizes, which have somewhat rounded borders. In the latter case the greenstone is serrated at the contact, the indentations corresponding with the abutting ends of the alternating hard and soft layers of the greywacke and taking the same direction as the latter, as if they had influenced the greenstone when it was in a soft state. The hard layers in the greywacke consist of fine grained to vitreous quartzite and vary from a fraction of an inch to several inches in thickness. The strike of the schist is N. 75° E. and the dip northward at angles of 70° to 80°. On mining location F, at this locality, a belt of the schistose greywacke, which weathers to a reddish brown colour, is strongly impregnated with pyrrhotite and pyrite, the proportion of these sulphides in some places being sufficient to constitute a self-roasting ore. No analysis of this ore has been made by the chemist of the Survey, but it is reported to contain a promising quantity of nickel.

Sulphides.

Westward continuation.

This spur of Huronian rocks was traced westward up the whole length of Blue Water River, but not beyond the lake of the same name. However, on the meridian line six miles westward of the west townline of Craig, the late Mr. Salter, P.L.S., indicated the occurrence of quartzite in the strike of this belt (W. by S.), and it is not improbable that it reappears there and may continue a considerable distance to the westward. Nickeliferous pyrrhotite was discovered and several mining locations were taken up along the Blue Water River subsequent to our survey of Spanish River and the exploration of Blue Water Lake and River by the late Mr. Francklyn, who was a member of the party.

Hornblende-granite.

Greywacke conglomerate.

About a mile and a-half below the Blue Water branch, on lot 2, con. III, the red hornblende-granite is again exposed and continues for four miles along the river with the exception of two exposures of greenstone, one of which is opposite the mouth of Onaping Creek. Greywacke-conglomerate makes its appearance at the above distance and the same rock is again seen half a-mile further down, where it is partly of a massive form and partly schistose. In some parts the rock is full of rounded pebbles of grey quartz-syenite. The strike is S. 35° W. At half a-mile and again at one mile below this the east bank of the river consists of reddish grey hornblende-granite, flanked on the west by soft greenish schist with a little dolomite. Coarse gneissoid schist

with included boulders makes its appearance at an eastward bend of the river a mile and a quarter above The Elbow. It strikes S. 60° W. and dips to the south-eastward at an angle of 70° under the red hornblende-granite. Schist holding boulders.

Just at The Elbow a narrow tongue of grey schistose greywacke extends south-eastward into the hornblende-granite, which is here of a greyish colour. A short distance northward of the river, about a mile below The Elbow, there is a bluff of bedded trappean rock resembling diorite, largely mixed with impure dolomite which weathers to a reddish brown colour. The bedding is vertical and strikes north-west and south-east. Two of the five portages above mentioned, occur close together at a mile and a-half below The Elbow. At the upper one the prevailing red hornblende-granite holds streaks of green schist and some small veins of a pure looking magnetite. Crystalline greenstone, supposed to belong to a dyke, running north-westward, appears in the bed of the river at the lowermost of these portages. Agnes River falls in from the northward three miles below The Elbow, or immediately opposite the head of the fifth portage. Opposite the foot of this portage there is a dyke of medium grained grey olivine diabase, 240 feet in width, running N. 40° W. Referring to a sample of this rock, Professor G. H. Williams says: "The microscope shows this specimen to be a fresh aggregate of olivine, reddish augite, plagioclase and ilmenite, with accessory apatite, and biotite. Its diabase or ophitic structure is very typical."—(See fuller description in Appendix I.) The dyke is exposed along the northern margin of the river. Above it rises a bank of boulders, 200 feet high, mixed with some gravel and earth, and forming a conspicuous feature in the valley. From its brink a level gravelly plain, off which the forest has been completely burnt, extends for more than a mile to the north-westward or to a large brook from that quarter which falls into the main stream a mile and a-quarter below Agnes River. A mile below the latter, a brook comes in from the southward and near it, patches of dolomite occur in the red hornblende-granite. Rocks at The Elbow. Impure dolomite. Magnetite. Large dyke. Bank of boulders 200 feet high. Dolomite.

Below these affluents, the Spanish River resumes its southerly course and the reddish hornblende-granite is exposed almost everywhere in the banks for a distance of seventeen miles or to the foot of a straight south-south-easterly stretch two miles long. The West Branch joins the main river two miles above the head of this stretch. Its upward course is about west for the first four miles, above which it turns northward and at one part it is said to come within about six miles of Blue Water Lake. Half-a-mile up this stream a rock consisting of a mixture of green schist and fragments of granite was met with. At the bend four miles up there was found a fine-grained "pinkish to brownish crypto-crystalline banded rock, which might be macroscopically described Granite for 17 miles. West Branch. Rocks of the West Branch.

as a banded jasper or felsite. The microscope shows that it is a clastic rock consisting mostly of quartz which has been almost wholly re-crystallized nnder the influence of intense pressure and that it has thus had the parallel structure developed in it by an elongation of its grains in one direction that is commonly known as "stretched." (See Professor Williams' description of specimen 36 in Appendix I.) Salter's first meridian west of his principal one passes through this locality, which corresponds with the north-west corner of township 111, and on the map of this survey quartzite is here indicated. It probably belongs to a band of Huronian rocks which does not extend quite so far east as Spanish River.

Salter's notes.

A mile below the long straight stretch of the river above referred to, and at a short distance back from the west bank, a bluff was found consisting of a coarsely crystalline blackish and greyish dioritic rock, apparently the side of a dyke. The next rock to be seen is at one mile further on, and consists of white and light yellowish-grey quartzite, dipping S. 40° E. $<$ 70°. A similar rock, with a bluff of greenstone rising above it, occurs three-quarters of a mile further down and dips N. 50° W. $<$ 60°. This is a mile and a-half above the south-western bend, below which the river turns at right angles and flows eastward as far as the township of Drury. At the bend itself there is a coarsely crystalline hornblende rock with pitted surfaces. Three miles and a-half below the bend the western town-line of Baldwin crosses the river and in that distance grey quartzites and greywackes are exposed, the strike varying from east to north-east with high angles of dip. A quarter of a mile above the town-line of Baldwin, two masses of greenstone occur in the quartzite, but both appear to be small. From the west town-line of Baldwin for the next two miles eastward, or across lots 12 to 9, inclusive, in concessions V and VI of that township, the rocks consist of grey and greenish-grey greywackes and greywacke-schists, the strike being from N. 60° to 65° E. and the dip nearly vertical.

Quartzites.

Hornblende rock.

In crossing lot 8, concession VI (Baldwin), the river, for a quarter of a mile, contracts to a narrow gorge with a fall of fifteen feet. At the upper end of this gorge the rock is a glossy greywacke schist, running N. 72° E. and at the lower end it is a dark grey clay-slate, running N. 77° E. $<$ 90°. From lot 7 to lot 5, concession VI, the rock is a fine-grained grey slaty sandstone running N. 72° E. $<$ 90°. On lot 4 of the same concession, a glossy black slate occurs on the south side opposite an island in the river. A grey glossy ligniform schist striking N. 75° E. $<$ 90° is exposed for some distance along the river on lot 2, near the foot of a large island. On lot 1, concession VI, just below this large island, the rocks in the bed of the river consist of fine-grained

Narrow gorge.

Black slate.

pink quartzite, in thin layers, interstratified with rough-surfaced black slate, dipping southward at a high angle, while at a greater elevation there is exposed a heavy band of dark green mica-schist forming the top of a long ridge. Pink quartzite. Mica schist.

A traverse was made across the township of Hyman along its western town-line and the rocks were found to be as follows: In the southern half of concession I, they are light coloured quartzites and silicious greywackes, while in the northern half a bluish grey slaty greywacke prevails. At one place this contains a band of garnetiferous hornblende biotite "augen" gneiss, which, although a normal rock of that name, evidently forms a part of the quartzite and greywacke series in which it is incorporated. The geological relations and microscopical character of this rock indicate clearly that it has been metamorphosed out of some clastic whose composition has been favourable to the change under the conditions to which it has been subjected. It corresponds with No. 34 of Professor Williams' list in Appendix I (*q. v.*). In the southern part of concession II, a green glistening schist with rounded concretions was met with, followed near the middle of the same concession by a flaggy grey ribboned quartzite. A short distance north of the post between concessions II and III the town-line passes over a hill of light grey quartzite. A greenstone dyke running S. 78° W. was met with in the southern part of concession IV. This was followed at a short distance northward by a hill of slaty quartzite and in the middle of this concession by another hill of a more solid variety of the same rock, running N. 85° W., with a nearly vertical dip. Dark grey silicious greywackes were found in concessions V and VI. Boulders of red hornblende-granite became more abundant before reaching the north-west corner post of Hyman and this rock had been ascertained to occur *in situ* a short distance further north in the course of a traverse which had been made by the writer, eastward from the junction of the West Branch with the main Spanish River. Rocks in Hyman. Gneiss. Genesis of the gneiss. Quartzites. Hornblende granite.

Another traverse was made to the south of the Spanish River along the town-line between Baldwin and Nairn, which is a continuation of the line just described. On leaving the river in this direction a ridge of close-grained diorite was found to run south-westward across the middle of concession VI. This is followed by greenish-grey felsitic quartzite or greywacke in the southern part of the same concession. White quartzite was met with across the whole of concession V and into concession IV, and from our examinations elsewhere, quartzites appear to extend to the Spanish River on the opposite side of the Great Bend. Traverse south from Spanish River.

Continuing down Spanish River from the intersection of this township boundary, dark grey diabase is met with at the south-east corner Rocks of Spanish River.

of lot 12, con. I, of Hyman. This exposure is on the north-west side of a mass which appears to be more than a mile in length in a north-easterly direction. At the narrows of the river on the east side of the same lot there is a coarse grey glistening schist and a small quantity of a dark greenstone. Below the narrows on the next lot (11 in the Ist con.) a glossy dark bluish grey schist and a slaty greywacke strike north-east along the flank of the above-mentioned diabase mass. A fine-grained hornblende rock also occurs at this locality. Close by, where the line between lots 10 and 11 intersects the north bank of the river, quartzite occurs, dipping south at an angle of 55°. In the north-west part of lot 9, con. I, a dyke of gabbro, 70 feet wide, crosses the river with a north-west course.

Glistening schist.

Dyke.

Where the river enters the north-west corner of lot 8, con. I, there is a portage on the north side past a chute with a fall of 15 feet. Here there is an extensive exposure of rather fine-grained silver-grey mica schist, with crystals of staurolite thickly scattered over the cleavage surfaces. In the middle of lot 5, con. II of the same township (Hyman), the river passes through a rocky cañon, or narrows, with grey schist on the northern side and the northern flank of a ridge of fine-grained splintery greenstone running N. 70° E. on the southern. At a rapid in the north half of lot 3 con. II, a bluish-grey satiny schist strikes due north and south, the dip being east at an angle of 45°. This sudden change in the strike is accompanied by an equally sudden turn in the course of the river.

Mica schist with staurolite.

Satiny schist.

Kettle Fall, with a descent of 20 feet, is on lot 2, con. II (Hyman). The rocks here are grey and satiny schists with a three-feet band of of nearly black horneblende schist, all striking N. 76° E. with a southerly dip of 75° There is a vein of hyaline quartz varying from 3 to 5 feet in thickness at this place, but no other mineral or ore was observed in it. Immediately below Kettle Fall the schists are disturbed, but at a short distance on they have a general dip to the west at an angle of 70°. The next portage is on the right side of the river, on the line between lots 2 and 1, con. I (Hyman) and opposite the west end of an island. Here the rock is a glossy grey finely-arenaceous schist, nearly on edge and striking N. 85° W. A grey glistening schist, standing vertically and striking N. 75° E., occurs at the fall on the south side of the island which has just been referred to. Nickeliferous pyrrhotite has been found in promising quantity on the southern side of a mass of greenstone on the north-east quarter of lot 3, con. I, Hyman.

Kettle Fall.

Grey schists.

The Spanish River enters the township of Drury in lot 12, con. I, and a hill of dark-coloured greenstone occurs on the south side of the stream on the same lot. A soft bluish-grey schist striking east-

Drury.

Bluish grey schist.

ward with the course of the river is found on the next lot, 11, con. I, and on the north-east corner of lot 9, con. I, there is glossy green schist but without strong cleavage. On the south-east corner of the same lot a rather finely crystalline grey diorite forms a small hill between the river and the Canadian Pacific Railway which passes within a few hundred yards of the stream. Green schist.

From this lot the river enters the township of Lorne, and from the last-mentioned locality a soft greyish-green glistening schist continues for a mile down the stream. The next rock met with is in the southern part of lot 11, con. VI of Lorne, and consists of what appears to be a fine grained, greenish-grey silicious felsite with spots and threads of grass-green and pink colours. It does not exhibit any cleavage or bedding. A knob of tough splintery grey diorite occurs on the south end of lot 12, con. VI. Lorne. Green schist.

The river now passes into the township of Nairn. At a considerable fall on lot 1, con. V of this township, a dark, almost black, clay-slate is largely exposed. It strikes S. 80° W., and dips southward at an angle of 45°. A small hard black dyke was observed cutting these slates at the foot of the portage, which is on the south-east side of the river. Nairn. Dark clay-slate.

A distinct moraine, composed of boulders, cobble-stones and gravel, and causing a short steep rapid, crosses the river on lot 4, con. V of this township (Nairn). Its general course is about at right angles to that of the glacial striæ, which are distinctly seen a short distance above and below, bearing S. 60° W. On lot 5, con. V, half a mile below the intersection of the moraine, the striæ run under an overhanging rock on the north-west side of the river, grooving both the wall and roof. A greenstone area, rising in some parts into comparatively high bare hills, extends along the north-west side of the river from lot 6, con. V, to lot 11, con. III, a distance of three miles. The glacial groovings are very conspicuously displayed along the south-eastern flank of the greenstone on lot 6, con. IV. On lot 8, con. III, the greenstone is associated with hard green schist, the cleavage of which runs east and west. A grey hydro-mica schist, running south-west occurs where the Canadian Pacific Railway crosses the river in the centre of lot 11, con. II. In the south-west corner of Nairn the river makes a double or reversed curve like the letter S, in crossing a greenstone area, one portion of which is soft and another hard. Moraine. Striæ. Ice-grooved wall and roof. Greenstone area. Schists.

The Spanish River now crosses the north-west corner of the township of Foster. In the south-west corner of lot 12, con. VI, it falls twenty-five to thirty feet over a strong band of light grey quartzite, which dips due south at an angle of 70°. The Vermilion River joins the Spanish on lot 12, con. V, just below this fall, and as this brings Foster. Quartzite band.

us to the edge of the sheet the latter river was not followed any further and I proceeded to examine the Vermilion River. The late Mr. Alexander Murray made a topographical and geological survey of the Spanish River from this point to Lake Huron, as well as to a point above the Great Bend, but he did not work along the Vermilion.

Onaping Lake and River.

Topographical and Geological Description.

Form and position.

Onaping Lake is a long, narrow and straight sheet of water, running about due north and south (ast.) and having an elevation of 1,417 feet above the sea, as determined by barometer. Its southern extremity lies east a few degrees south, twelve miles from Pogamasing station and north a few degrees east, thirteen miles from Cartier station. It has a total length of about twenty-six miles. In the lower six miles or up to the intersection of Proudfoot's east-and-west line, its greatest breadth is a mile and a half, but north of that, it seldom exceeds half a mile and most of it is not over a quarter of a mile. It has two outlets. The smaller one, called Onaping Creek, from its most south-westerly extremity, flows south-westward and falls into Spanish River, thirteen miles below Pogamasing station. The larger is the Onaping River and it leaves the lake four miles and a half east-north-east of the first outlet, at the foot of a bay on the east side.

Two outlets.

Courses of Onaping River.

The general course of the Onaping River is south-south-east and it joins the Vermilion one mile above Larchwood on the Canadian Pacific Railway, or twenty-four miles in a straight line from its head. In the first four miles, the course is south-east, then it is due south (ast.) to within four miles of its junction with the Vermilion, where it turns east by north to that stream. Besides numerous small brooks from both sides, it receives four good sized branches from the east, the first at three miles from the outlet, then Michaud's River at six miles, next a brook at one mile above the north townline of Levack and lastly Kinniwabik River, a quarter of a mile north of the southern town-line of the same township. It is interrupted by numerous rapids and falls all along, except in the last four miles. Onaping Lake is most easily reached by canoe from the Canadian Pacific Railway at Bannerman Lake, by ascending Onaping Creek and some small lakes parallel to it, the distance being nine miles.

Branches.

Rapids and falls.

Route.

Dioritic breccia.

On the railway about a quarter of a mile west of Bannerman Lake there is a confused mixture of schists and dioritic breccia which may be on a line of disturbance extending south-westward from the southern extremity of Onaping Lake. A similar mixture is crossed on the Creek a mile and a half north-east of the railway, beyond which green

schists extend to a short distance north of the northern town-line of Moncrieff. Gneiss is exposed along the route in places for the next three miles northward and then red hornblende-granite and gneiss to Lower Onaping Lake. A spur of the latter rock runs north-east across the lake just named, but Huronian rocks are found on either side of it and they extend to the foot of Onaping Lake. These rocks here form an isolated basin measuring about four miles north-east and south-west by about three miles north-west and south-east. The principal varieties of rocks of this basin or outlier consist of slate-conglomerates with well rounded pebbles and boulders, mostly of binary granite, quartz, quartzite and schists and coarse arenaceous or greywacke conglomerates, together with some pale pink quartzites and bluish and greenish-grey felsites, argillites and slates. On an islet one mile south-west of the rapid at the head of the lake there is a brecciated mixture of dark hard slate, diorite and quartzite, while the rest of the islet consists of red felspathic quartzite, half altered into a fine grained binary granite. At various places around this lake, the matrix and finer parts of the greywacke-conglomerates appear to be undergoing alteration, or they show a tendency to pass into a granitoid rock.

Gneiss.

Huronian outlier.

Slate-conglomerate.

Other rocks.

Brecciated mixture.

Alteration into granite.

The basin of Onaping Lake appears to owe its origin to denuding agencies which have acted on a north and south dyke or set of dykes of greenstone, cutting the hornblende-granite, which, with some gneissic patches, is the country rock on both sides. The largest of these patches occurs at the wide part of the lake studded with islands, about half way up. Portions of a large dyke, running north-north-eastward, form some of the points and islands along the east shore, near the south end, and parallel to it an unusually long uninterrupted view may be obtained up the lake. Northward of Proudfoot's line sections of dykes and patches of greenstone adhering to the granite walls may be seen here and there all along. In the central part of the lake a narrow bay, on the west side, seven miles long, runs parallel to it, separated by a high tongue of land one mile wide. Towards the north end two narrow lakes, parallel to the main one and four miles long, occupy a position on the west side corresponding with this bay. Onaping Lake is surrounded on all sides by hummocky granite hills, which are comparatively low except on the sides of the narrow bay above mentioned, where they are three or four hundred feet high.

Origin of lake basin.

Large dyke.

Long narrow bay.

Surrounding country.

Gneiss occurs on the shores of the bay out of which Onaping River flows, but from the outlet for a mile and a-half we cross red hornblende-granite, and this is followed by six miles of red and grey gneiss. Below this the rock is again red hornblende-granite to the second concession of Levack. But about the middle of this concession, or a mile and

Geology of Onaping River.

Hornblende granite.

a-quarter above the mouth of the Kinniwabik River, the north-west flank of a range of hills from the north-east comes to the river, the rock of which is very distinctly banded reddish-grey gneiss, which is much contorted and shows numerous small dislocations, but the general strike is S. 65° W. It is cut by irregular straggling dykes of greenstone, full of angular fragments of the wall rock. A dyke only two feet and a-half broad of nearly black porphyry, with widely scattered white crystals and running S. 55° W., cuts both the gneiss and the older dykes. Some coarsely crystalline veins of felspar which occur here hold large crystals of magnetite.

Distinctly banded gneiss.

Black porphyry.

Great belt of grey diabase.

The whole breadth of concession I of Levack, on the course of the river—upwards of a mile—is occupied by a transverse section of a great belt of rather coarsely crystalline grey diabase, which we have traced from the north-east corner of this township, south-westward into Trill, a distance of about eighteen miles. This belt is widest where it is crossed by the Onaping River, and gradually diminishes to a point at either extremity. To the north-eastward its course is marked by a straight valley, down which the lower part of the Kinniwabik River flows, but between the Onaping and Windy Lake it is covered by a great accumulation of sand, gravel and boulder-earth, forming hills in that direction. Windy Lake lies about mid-way on its course and, from this circumstance, it might be called, for distinction, the Windy Lake belt. The south-eastern boundary of this belt and the southern town-line of Levack intersect the river almost together, but at an angle with each other. Below this intersection the red hornblende-granite continues to be met with along the river for two miles, or to the junction of Windy Creek, below which the river enters upon the belt of dark silicious volcanic breccia and its underlying quartzite conglomerate. The falls of the Onaping River, close to the line of the Canadian Pacific Railway, are over this breccia. Between the foot of the falls and the junction of the river with the Vermilion, there are a few exposures of a coarse black slate, with large grains of quartz, overlying the breccia. The gneiss and hornblende-granite, above described, all along the Onaping River, are cut here and there by dykes of diabase, most of which have a northerly course.

Straight valley.

Windy Lake.

Hornblende granite.

Volcanic breccia.

Coarse black slate.

Dykes along Onaping River.

The Straight Lake Huronian Outlier.

Its extent.

This irregular basin of the upper rocks has a breadth of eight miles on the line of the Canadian Pacific Railway. It sends a spur westward as far as Blue Water Lake, in the township of Craig, and a longer one south-westward to The Elbow of Spanish River. These have already been referred to in connection with the description of this stream. We

propose to call this basin the Straight Lake outlier, as its rocks and deposits of economic minerals are already best known in connection with this lake and the railway station of the same name. Name.

The rocks within it consist principally of greywacke-schists, quartzites, quartzite or greywacke-conglomerates, green schists, hard sandstones, greenstones and some dolomites. In addition to these, black slates occur upon the western side of the first hill west of the outlet of Geneva Lake, and also, to a small extent, close to the outlet itself.* Rocks of the outlier.

The eastern lobe of the outlier surrounds Geneva Lake and is almost separated from the rest of the basin. The Canadian Pacific Railway passes the outlet of this lake which is three miles north of Cartier station. Coming from the south-east, on the line of the railway, different varieties of the common red hornblende-granite of the district are found to extend for two miles and a-quarter beyond Cartier, but here the granite becomes mixed with coarse breccia and conglomerate. This is followed by ash-grey greywacke, 100 yards in width, and next by a bed of fifteen feet of grey to dove-coloured fine-grained dolomite, weathering dark brown. The dolomite strikes N. 45° E. and the bedding is about vertical. It is followed to the northward by coarse felsitic sandstone and silicious greywacke-conglomerate or breccia. The pebbles and fragments in the latter weather out conspicuously and consist of other varieties of greywacke, hornblende-granites like the prevailing varieties found *in situ* in this region, black slate and black and white quartz. The strike varies from N. 30° to N. 60° E. These rocks continue, without change, for half a mile up the track and at the end of that distance they are found to enclose large masses or small areas of the greywacke, partially altered into fine-grained granite or syenite with all the outward appearance of the more thoroughly crystalline varieties. The rock also includes considerable masses of the latter and areas or patches of boulders of it crowded together, with the interstices filled by crushed or broken fragments of the same rock. At the outlet of Geneva Lake this syenite or granitic greywacke includes some black slate and a patch of impure dolomite thirty feet thick. A short distance northward of the outlet the greywacke becomes more argillaceous and shows lines of bedding dipping eastward at an angle of 45°, independent of the cleavage. Greywacke-conglomerate forms the shores of the outlet arm and of most of the western side of the lake, and it is also well seen along the railway track in the same vicinity. Geneva Lake. Coarse breccia. Dolomite. Conglomerate. Enclosed masses. Patches of boulders. Conglomerate on west shore of lake.

The rocks of the eastern part of Geneva Lake consist principally of light yellowish-grey quartzite containing a good deal of felspathic matter, but the islands in the mouth of the large bay on the south-east side Quartzite.

*These are probably a continuation of a band of black slates near Bannerman Lake examined by Dr. Selwyn in 1883.

Syenite. are formed of grey syenite, and an islet in the outlet arm is composed of the same rock. A mile and a-half north-east of the outlet there is an Dolomite. islet of thinly bedded light grey, dove-coloured and whitish dolomite. striking N. 35° E. and dipping to the westward side at an angle of 80°. The rock is compact and has a conchoidal fracture, but it is traversed by threads of quartz which prevent it from taking a good polish. The same dolomite band is exposed on the point just southward of the above islet, but it could not be found on the northern side of the lake towards which it strikes.

At the north end of lot 1, con. I, Moncrieff, on the tote road at a distance of two miles north-north-west of Cartier station, the reddish hornblende-granite of the surrounding country becomes mixed with green diorite, having a dull fracture, enclosing fragments of grey granite and all mingled confusedly together forming a coarse breccia. Coarse breccia On the west side of this is a massive fine grained rock having the general appearance of syenite or granite, but apparently resulting Altered greywacke. Magnetite. from the alteration of massive greywacke. It is cut by numerous thin veins of quartz and fine grained magnetite, but the ore did not exceed six inches in thickness in any of the veins examined. A patch of brown-weathering dolomite, five or six feet in diameter, was observed in this rock. The hornblende-granite extends northward nearly to the fourth concession of Moncrieff.

Dyke. On lot 4, con. III, Moncrieff, there is a dyke seventy-five feet wide and running a little east of north, composed of greenish-grey coarsely crystalline diabase. The late Mr. Salter mentions trap-rock as occurring on his meridian line at what is now the north-west corner of Moncrieff. This would appear to be in the run of the above dyke. The junction of the Laurentian red hornblende-granite, on the south, Greywacke. with the greywacke to the north occurs on the north end of the lot just mentioned. The latter rock is grey and somewhat thinly bedded and strikes S. 75° W. The tract between this and Bannerman Lake Light greenish quartzite. is occupied by massive quartzite, some of which is of a light grassy green colour. At the west end of Bannerman Lake, a small belt of hornblende-schist in the quartzite shows the strike to be S. 70° W. < 90.

The breccia or volcanic agglomerate on the railway, a short distance north-west of Bannerman Lake, has been referred to in describing the route to Onaping Lake. The 485th mile-board stands on this rock. Half a mile further north-west and continuing thence for half a mile on, or to the crossing of Onaping Creek by the Elongated quartz pebbles. railway, there is a dark blue or nearly black close-grained rock, holding long thin lenticular pebbles of grey quartzite. The strike is S. 60° W. In this interval, at a short distance north-east of the Agglomerate. track, there is a ridge of coarse agglomerate. Quarter of a mile west

H. TOPLEY, PHOTO. DESBARATS & CO., ENGR. & PR., MONTREAL.

ROAST YARD, COPPER CLIFF MINE, LOOKING EAST.

of Onaping Creek, greywacke occurs, striking S. 65° W. Half a-mile further, in the same direction, a dyke of bluish-grey crystalline diabase, about 100 feet wide, appears and it continues parallel with the railway track—about W. N. W.—for a quarter of a mile. It weathers brown and decomposes at the joints and angles, leaving rounded or boulder-like masses. This brings us to the 487th mile-board. A dyke, which may be a continuation of the last, appears half a mile further on, and again on the north side of Straight Lake at a short distance east of the station of the same name. From the above mile-board to this station—about two miles and a-quarter—the country rock consists of grey slaty greywacke with small scales of light-coloured mica on the cleavage planes, which dip about S. 20° W. $< 70°$. Straight Lake station is near the commencement of the hornblende-granite and gneiss which continue thence all the way to the northern and western borders of the sheet.

Diabase dyke.

Slaty greywacke.

General Remarks on the Rocks of the District.

It will be seen from the foregoing report and from Professor Williams descriptions, that the Huronian rocks of the Sudbury district, as elsewhere, are largely of a volcanic nature. Many of them which are stratified and even distinctly sedimentary, may, nevertheless, have been primarily volcanic, but have become modified by the action of water. They have probably been volcanic ashes, dust, mud or other ejectamenta and may have been thrown directly into the sea, as there was probably little land, or possibly none at all, at that stage of the earth's history. Even molten matter poured into the sea might easily break up to form some of these deposits, or if in sufficient mass it might remain nearly intact and finally cool in that position, afterwards becoming covered and incorporated in the sedimentary strata. The dark silicious breccia, which, with a thickness of several thousand feet, runs from the township of Trill nearly to Wahnapitæ Lake, affords positive proof of volcanic action with explosive violence, on a large scale. This rock may, however, be of Lower Cambrian age.

Volcanic nature of Huronian rocks.

Original state.

Proof of volcanic activity.

The greywackes which constitute the most abundant class of rocks of the Huronian series in this district consist of granitic debris, more or less comminuted; and, out of the same materials, by the modifying action of water, a considerable proportion of the other rocks of the series could have been and probably were formed. The commonest form of the greywacke is a grey or ash-coloured rock, which in hand specimens resembles sandstone, but on the large scale it seldom shows very distinct bed-planes and is generally massive or has a tendency to coarse slaty cleavage. It breaks more easily than quartzite and may

Greywacke described.

be readily bruised or scratched, showing that a considerable proportion of its components are softer than quartz. But under this name we may include several varieties, ranging from rocks approaching quartzites through different modifications, like sandstones, to others approaching argillites. At other times the rock is more or less filled with pebbles or broken fragments, or both, constituting conglomerates and breccias. Occasionally the finer materials act as a mere filling between closely crowded pebbles, angular fragments or boulders. With apparently similar composition and texture, the rock may be either roughly cleaved or slaty, or it may be amorphous. Both varieties may contain pebbles or fragments, or be tolerably free from them. The fragments, from the largest to the smallest size, usually consist of red and grey aplite or binary granite, and the matrix appears to be derived from the same rock, but in a more finely comminuted state. Most of the commoner varieties may be regarded as composed of this granite, reduced to a very finely fragmental condition, but with a considerable proportion remaining as good sized grains and small and large fragments.

Varieties.

Cleavable varieties.

Nature of enclosed fragments.

When the greywacke becomes fine grained and slaty, with pebbles scattered through it, the rock may be called a slate-conglomerate, but the late Mr. Alexander Murray sometimes extended this term also to the more massive varieties containing pebbles and broken fragments, but without cleavage. In addition to granitic pebbles, the slate-conglomerates often contain others of red and black jasper and white quartz.

Slate-conglomerate.

The greywackes appear to be susceptible of being easily restored to crystallic granite again. In many places the characters and conditions of the rock, as seen on the large scale, and also when examined by the microscope, show that this metamorphism is going on. Under different physical conditions and variations in the composition, felsite, granite and gneiss have been formed out of it. The quartzites and clay-slates alternate with each other, or are found geographically close together and they appear to have resulted from the separation and arrangement of the constituents of greywacke by water, the grains of quartz, with a greater or less mixture of those of felspar, being deposited by themselves to form the quartzites and the finer and lighter mud being carried further on to form the slates.

Metamorphism of greywacke.

Origin of quartzites and clay-slates.

The quartzites of the Huronian system may be regarded as the more silicious forms of the same rocks or those varieties which have been rendered comparatively free from the felsitic or softer constituents of greywackes. It is worthy of remark that the quarzites which form so large a proportion of the Huronian rocks along the north shore of Lake Huron and thence inland as far as the Great Bend of the Spanish River and the township of Broder in the north-eastern extension of the

Quartzites.

Quartzites diminish towards the N.E.

belt, diminish greatly in volume and pass into greywackes, and further on, into clay-slates, before reaching the eastern margin of the sheet. It would be noticed, however, from the descriptions in a former part of this report, that in the country to the northward of Lake Wahnapitæ, the quartzites again become largely developed. As a general rule the different subdivisions of the Huronian rocks in any region, do not maintain their thickness very far on the strike, but diminish more or less rapidly to a point, their places being at the same time filled by a corresponding thickening of the members on either side. The quartzites do not appear to form an exception to this condition, but owing to the fact that they withstand denudation better than the majority of the rocks associated with them, they become more conspicuous in proportion to their volume than the others, and their relative proportions are therefore apt to be over-estimated.

Again developed.

Prominence of quartzites.

The clay-slates and quartzites are generally closely associated together, and both are found in connection with the greywackes. This is the case in the country between the Wahnapitæ and Sturgeon Rivers, and the same thing was observed along Montreal River and between it and Lake Temagami. These slates are generally drab or bluish-green, or brownish and purplish. They are sometimes distinctly banded across the cleavage-plans; and at the northern outlet of Lake Temagami, where a handsome greenish variety occurs, they are streaked with irregular and interrupted black bars, which consist of hornblendic material. This variety was much prized by the ancient Indians as an ornamental stone and a variety of articles made from it have been found in many places in the Provinces of Ontario and Quebec and in several of the Northern States.

Clay-slates.

As already stated, the trappean rocks of the district consist of (1) extensive masses, together with many of smaller size, incorporated with the other Huronian rocks and probably contemporaneous with them, and (2) dykes which cut through all the members of the series. The following are the three principal varieties of the first class. Within the area of the first division shown on the sheet there are nearly fifty masses of highly crystalline diorite of a medium texture, and a dark green or greyish-green colour, characterized by the presence of disseminated spots and crystals of pyrite or sometimes of pyrrhotite or chalcopyrite. These masses constitute the first variety and they are generally, but not always, considerably elongated in the direction of the strike of the adjoining rocks. They measure from less than a quarter of a mile to about eleven miles in length. The strata among which they are included, being now highly inclined, these elongated masses may represent sections of what were originally overflows of the molten rock upon the then nearly horizontal surface, while those having

Greenstones.

Fifty areas of diorite.

Elongated.

The reason.

more compact outlines may have filled hollows or they may have been early intrusive masses.

Character of country.

These greenstone areas are not marked by any constant topographical characters by which they may be recognized. The surface of the country which they occupy does not differ from that of most other rocks, except in a few cases. These areas are diversified by lakes and streams, much in the same manner as that of the latter. This may be due to the fact that different parts of the same masses decompose differently under eroding agencies, some portions yielding readily, while others are hard and resisting.

Coarse grey diabase.

The second variety is a massive grey rock, generally more coarsely crystalline than the last, and always appears to be a diabase or to consist principally of pyroxene and felspar. In this the above-mentioned sulphides are generally more sparingly disseminated than in the first class.

Two belts.

There are two principal belts of this rock, both of them cutting the Laurentian and both having a general north-easterly and south-westerly course. One of them runs from Whitson Lake south-westward into the township of Creighton. It has a breadth of about one mile and a-half in the middle and diminishes regularly towards each end. The other large belt of this variety has been traced from the north-east portion of Levack south-westward across Windy Lake, nearly to Hyman, a distance of about eighteen miles. It is upwards of a mile wide in the middle and runs to a point in either direction. This has already been referred to as the Windy Lake belt, in describing the geology of the Onaping River. A third belt, about five miles long, from the vicinity of Sagi-tchi-wai-a-ga-mog Lake, runs south-westward into Morgan.

Windy Lake belt.

Slaty and brecciated diorites.

The third variety is a more or less slaty greenish diorite, which in places becomes brecciated, the included fragments being of all sizes, from very large boulders down to small pebbles, and consisting principally of quartzites and granites or syenites. The diorite belt which borders the south-eastern side of the tongue of granite and gneiss from Garson to Graham belongs to this class, as does also the belt in the Vth and VIth concessions of Denison.

Coarse crystalline hornblende-rock.

There is also a very coarsely crystalline dark green amphibolite or hornblende-rock, examples of which may be seen on lot 4, concession V, Blezard, just east of the Stobie mine; along the north-west side of the same belt in the Vth concession of McKim; near the McConnell mine in the IVth concession of Snider, and again at the south-west bend of the Spanish River.

Quartziferous hornblende-rock.

A massive quartziferous hornblende-rock or diorite is not uncommon in the Huronian series in other regions, but in the Sudbury district we have what may be a form of this rock, modified by water—a rock which

may be called a stratified quartz-diorite. It is made up of rather thin beds, the lower part of each of which consists of a layer of quartz grains, the coarser being at the bottom and the finer higher up, while the upper part is a mixture of hornblende and felspar debris.

Gneiss and felsite.

Reference has already been made to the apparent alteration of greywacke into granite in the township of Moncrieff and around Lower Lake Onaping and also as to the passage of another variety of greywacke into gneiss in the township of Hyman. Some of the gneiss on lots 10 and 11 in concession III of Garson bears a strong resemblance to the latter and it is possible that much of the gneiss of the long inliers of the contracted portion of the Huronian belt in the Sudbury district may have resulted from the metamorphism of greywacke.

Altered greywacke.

In the centre of the township of McKim a belt of altered greywacke runs from the Copper Cliff mine and smelting works north-eastward to the VIth concession. Professor Williams describes an average specimen of this rock from lot 6 concession IV, about three-quarters of a mile north of Sudbury, as a pale grey compact felsite, and its components do not differ from those of unaltered greywacke except that they have lost their clastic appearance. On the railway track, one mile north-west of Sudbury, there is a more compact and silicious variety of this rock, which, on a fresh surface exposed in a cutting, shows bunches or spots, each a few inches in diameter, marked by long scattered imperfect crystals of black hornblende. At a short distance off these bunches have the appearance of foreign inclusions, but on closer examination they were found to be continuous with the rest of the rock. On lot 4, concession VI of McKim, about a mile south of the Stobie mine, where this belt of rock is pinching out, it shows a distinct gneissoid structure, both macroscopically and microscopically. In some places near the south-eastern margin of this area of altered greywacke, there is a rather fine-grained, ash-coloured rock, which might be called an altered volcanic mud, in some parts of which white grains of andesine are disseminated. Dr. Selwyn has called this variety "rice-rock." Examples of it may be found near the Canadian Copper Company's smelting furnace, on the hill north of Sudbury and again on lot 5, concession III of McKim. It also occurs at Lake Panache.

Hornblendic bunches.

"Rice-rock."

GENERAL CHARACTER OF THE HURONIAN ROCKS OF THE DISTRICT.

Classes of rocks.

The descriptions of the field geology of the district in the foregoing pages and those of Professor Williams of the microscopical characters of the rocks contained in Appendix I, show that the Huronian belt in this district is made up of igneous or crystalline masses, metamorphic rocks derived both from these and from sedimentary strata, together with

unaltered or only slightly changed clastics, which have been generally sedimentary, but with some exceptions.

Their metamorphism.

Notwithstanding the sedimentary character of a considsrable proportion of these rocks, even they appear to have been nearly all derived directly from igneous or volcanic products, by undergoing a greater or less modification by water. Since their consolidation they have been subjected to metamorphosing influences, and have been more or less altered according to the different local conditions, such as their attitude, exposure to pressure, shearing, &c., as well as their own inherent susceptibility to change. They may, therefore, as a class, be appropriately termed pyroclastic. The primarily volcanic, as well as the derived rocks, have also undergone some degree of change, as, for example, in the case of the volcanic glass-breccia above referred to, (whether Huronian or a little newer) where the pumice has been completely silicified, and again in the case of some of the diorites, which were originally massive, but in which a textural change and a schistose cleavage have been developed. A careful study of these rocks, both in the field and under the microscope, in connection with such points as the above, might throw much light on various questions regarding the metamorphism of rocks in general.

Pyroclastic rocks.

Changes in massive diorites.

Economic Minerals.

Nickel and copper.

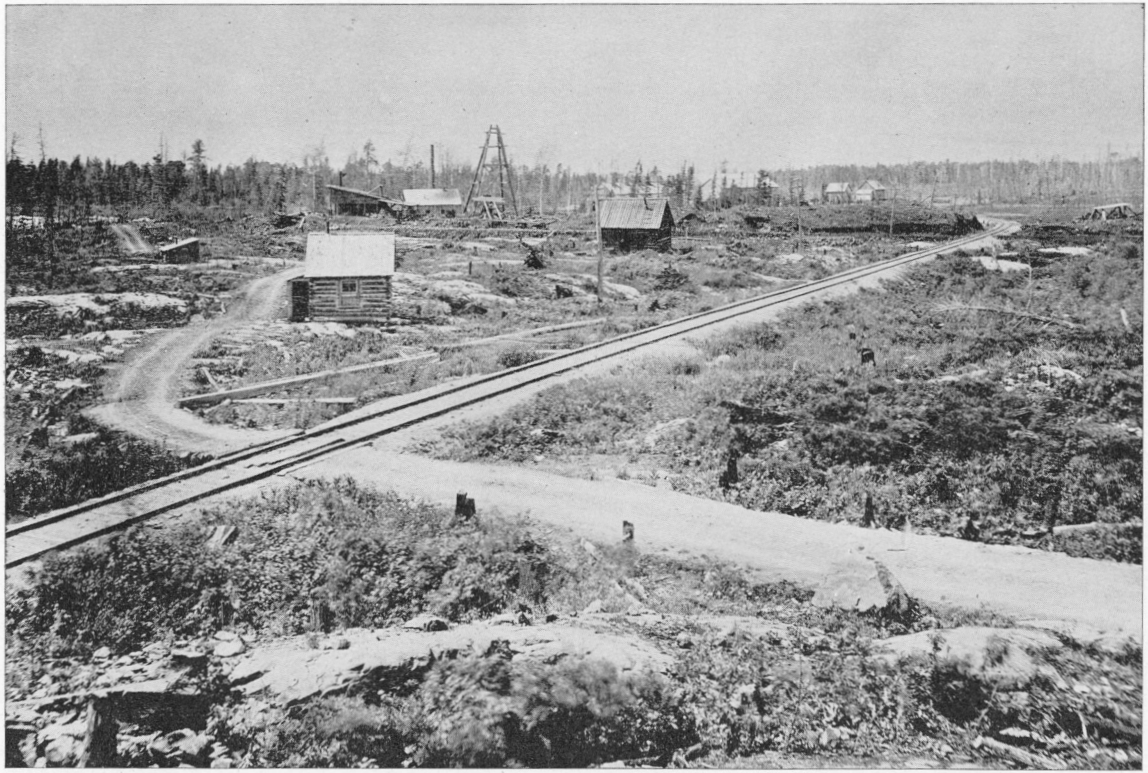
Nickel and Copper.—In the Sudbury district these metals are so intimately associated as to make it necessary to describe them together. They occur as mixtures of chalcopyrite and nickeliferous pyrrhotite. In some instances the copper is in larger proportion than the nickel, but in perhaps the majority of cases the percentage of nickel predominates. The principal occurrences of these ores yet known are indicated on the accompanying map, from which it will be seen that they are always associated with the greenstones and also that their commonest situation is at the contact of these with some other rock, especially granite or gneiss. These mixed ores have now been found over an area extending on the strike, from the Wallace mine, on Lake Huron, north-eastward to the northern shore of Lake Wahnapitæ and transversely from the south-eastern boundary of the Huronian belt in this district north-westward to the western part of the Straight Lake outlier, beyond the Spanish River.

Occurrences shown on map.

Area of occurrence.

Associated with the greenstones.

The ores are always found in intimate association with the greenstones, and in addition to the economic occurrences, these rocks always hold specks, crystals and often small patches of both pyrrhotite and chalcopyrite disseminated more or less abundantly throughout their mass. The existence of nickel in the sulphides of these greenstones



H. TOPLEY, PHOTO. DESBARATS & CO., ENGR. & PR., MONTREAL.

GENERAL VIEW OF MURRAY MINE, LOOKING NORTH-WEST.

First discovery.

was first ascertained by Dr. T. S. Hunt in 1856. Mr. Alexander Murray, assistant provincial geologist, in that year explored Salter's meridian line, running northward from Whitefish Lake and in what is now the township of Waters he found a "green magnetic trap," of which he says:* "Specimens of this trap have been given to Mr. Hunt for analysis and the result of his investigations shows that it contains magnetic iron ore and magnetic iron pyrites generally disseminated through the rock, the former in very small grains; titaniferous iron was found associated with the magnetic ore, and a small quantity of nickel and copper with the pyrites."

Wallace Mine in 1848.

Mr. Murray visited the Wallace mine in 1848 and collected samples of the ore. In his report for that year (page 44) he says: "With a view of ascertaining the quality of the nickeliferous portion of the ore, a specimen of it, as free as possible from the copper pyrites, was submitted to analysis by Mr. Hunt, who found it to contain 8·26 per cent. of nickel with a trace of cobalt; but as nearly two-fifths of the specimen consisted of earthy materials, which might readily be separated by dressing, the quantity of nickel in the pure ore which this would represent would equal nearly 14 per cent."

Abundance of pyrrhotite.

In the Sudbury district, pyrrhotite is more generally diffused and more abundant than in any other known region of Canada and the unusual richness of this pyrrhotite in nickel, as compared with that of other parts of the Dominion, is somewhat remarkable. The latter circumstance may point to a common deep-seated origin of the accompanying greenstones, whether they occur at the surface among the Huronian or the Laurentian rocks.

The causes which brought about the deposition of the ore-bodies in their present positions and the mode of their formation are not very manifest.

Determining causes.

It has been already stated that the larger ore-masses are found principally at the junction of the greenstones with some other rock. But there is also another circumstance which appears to influence the occurrence or localization of the ores, namely, the crossing of these lines of junction by lines of fracture or by the greenstone dykes which cut all the rocks. Some of the greenstones along certain lines hold abundance of angular fragments of other rocks, especially quartzites, and this brecciated condition appears to be favourable to the accumulation of the ore. This variety of the rock is found near the Dominion or Blezard, the Stobie, Copper Cliff, Crean and Vermilion mines.

Form of ore bodies.

The larger ore-bodies all resemble each other in most respects. Their general outline appears to be approximately lenticular, judging

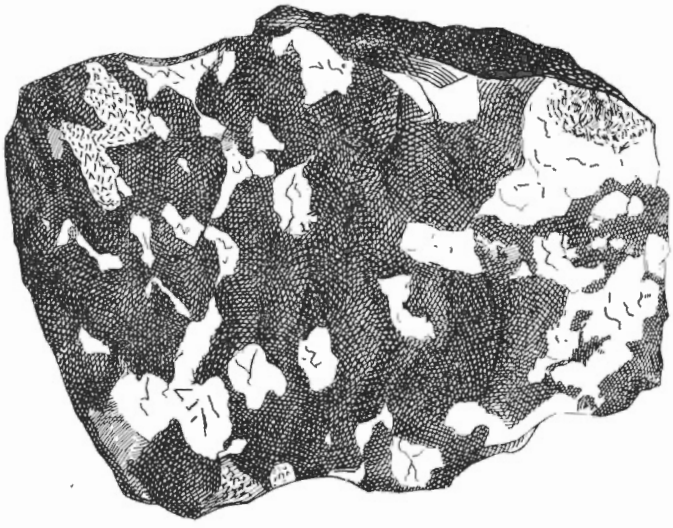
* Report of Progress of the Geological Survey for 1853–56, page 180.

from the surface indications, but none of them have yet been sufficiently worked to prove their form, in depth. Their greatest superficial diameter is always parallel to the general strike of the enclosing rocks.

Brecciated mixture of ore and rock.

In each case the ore-mass consists of a brecciated or agglomerated mixture of the pyrrhotite and chalcopyrite along with the country rock.

FIGURE 1.



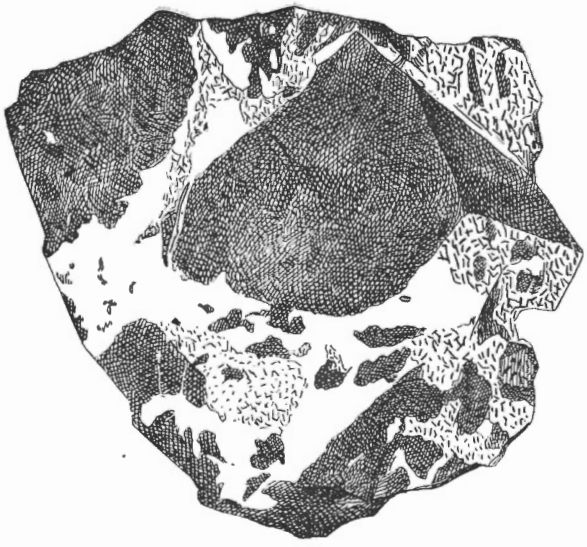
This figure represents a specimen, natural size, of ore from the Copper-cliff Mine.
The shaded portion represents diorite.
" white " " chalcopyrite.
" hatched " " pyrrhotite.

Mixed sulphides.

The included fragments of the latter are both rounded and angular, and vary in size from that of pebbles to large boulders, but the average is a few inches in diameter. Immense blocks or "horses" also occur in the midst of the ore, and at the Stobie mine some masses of the country rock run through the deposit in the form of thick walls or partitions, both transverse to and parallel with the general strike. Where the stony inclusions are widely separated, large quantities of the mixed sulphides have accumulated between them, but where the former are closely crowded together the amount of ore is correspondingly small. Besides being frequently intimately mixed together in the form of grains, the two sulphides are also commonly intermingled as spots and patches of all sizes. When the pyrrhotite is the more abundant ore, the patches of chalcopyrite may be said to be incorporated in it and vice versa, but the two interlock or ramify with each other so intimately that it is

impossible to separate by mechanical means even the coarser portions for metallurgical treatment, to say nothing of the finer mixture in the form of grains

FIGURE 2.



This figure represents a specimen, $\frac{3}{4}$ natural size, of ore from the Murray Mine.
The shaded portion represents diorite.
" white " " chalcopyrite.
" hatched " " pyrrhotite.

The chalcopyrite of the larger patches is generally nearly pure, but the pyrrhotite is almost always mixed with a considerable percentage of stony matter in the form of large and small grains. This may indicate that the former has been segregated out of the mixture by some secondary process subsequently to the general deposition of the mass. The chalcopyrite often shows a tendency to run in the form of branching strings or to partially surround the smaller stony inclusions. In one of these brecciated ore-deposits which occurs on lot 3, con. V of Levack, the spaces between the greenstone fragments are sometimes filled partly by pyrrhotite and partly by light-coloured crystalline granitoid vein-matter. This circumstance may be of interest in connection with questions as to the mode in which the spaces between the rocky fragments in all these deposits have been filled with ore.

Impurities in the pyrrhotite

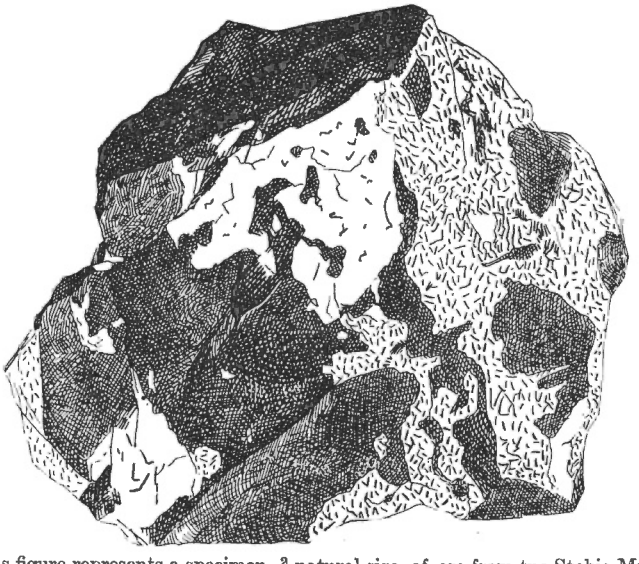
Granitoid filling.

The general character of the deposits seems to indicate that they have originated primarily from a state of fusion. Their intimate

Origin of the ore.

association with greenstones, which are of igneous origin, would show this, as well as the fact that these greenstones themselves fuse at

FIGURE 3.



This figure represents a specimen, $\frac{2}{3}$ natural size, of ore from tne Stobie Mine.
The shaded portion represents diorite.
" white " " chalcopyrite.
" hatched " " pyrrhotite.

about the same temperature as the sulphides. But they may have been subsequently more or less modified by other agencies. The occurrence of crystals of felspar, quartz and apatite in some of the deposits, and of laminated iron pyrites in one place in the Copper Cliff mine indicate the action of aqueous solution.

Possible partial modification by solution.

Greenstones impregnated with the sulphides.

The greenstone wall-rocks of the deposits, as well as the included fragments of the same material, are generally much impregnated with these sulphides in the form of isolated globules or kernels, usually from the size of peas to that of hazel nuts, besides irregular strings and patches. A fresh surface of the rock will in one case show the two sulphides in separate spots thickly intermingled, while another section may show the spots to consist entirely of the one or the other. These disseminated sulphides exist in all proportions relatively to the greenstone matrix until they replace more than half the latter and constitute a self-roasting ore. To the south-west of the Stobie mine in the strike of the principal deposit there, smaller ore-masses are found for a distance of more than a mile, and these are connected with each other by a belt of somewhat slaty diorite full of disseminated ore of this kind. These impregnations have not been found in the clastic

Continuation of ore-bearing belt of Stobie mine.

rocks adjoining the greenstones at any of the deposits, while their abundance in the latter rocks goes to show that the larger or more concentrated deposits have also had an igneous origin like the smaller ones enclosed in the diorite.

Copper. At the Vermilion mine, on lot 6, con. IV, Denison, a shaft called No. 1 had been sunk in diorite to a depth of about twenty feet on a promising vien of chalcopyrite. On exposure to the weather, the ore Blue tarnish. is remarkable for becoming tarnished of a deep purplish blue colour like that of bornite. The vein occurs in diorite, and is about four feet wide, but without distinct walls or any veinstone except a mixture of the country-rock. The upper ten feet were decomposed to a loose Sperrylite. gossan, holding fragments of rock. The new mineral Sperrylite (arsenide of platinum with a little tin) was found by washing this material, and Mr. R. R. Hedley informed me that he had found 12 dwts. of gold to the ton in one assay of ore from this shaft. A few specks of gold were seen in iron-stained spots on the weathered surface Gold. of the diorite close to the shaft. At about fifty yards to the southward of the shaft, massive beds of quartzite and greywacke terminate abruptly almost at right angles against the cleavage of a dioritic schist holding large and somewhat angular fragments of quartzite, along with many small ones, all mingled together. A belt of diorite runs east and west across the township of Denison, in the Vth concession, and Across Denison. along its southern border, copper pyrites has been found on almost every lot, but as yet no openings have been made to test the extent of these deposits. Two or three masses of a fine-grained mixture of py- Pyrite and blende. rite and blende occur on lot 10, con. VI of Creighton. They are said to be large, but we had not an opportunity of examining them.

The mines from which ore has been sent to market or smelted in the district are the Stobie, the Copper Cliff and the Evans belonging to the Canadian Copper Company, the Blezard and the Worthington belonging to the Dominion Mineral Conpany, and the Murray mine belonging to Messrs. H. H. Vivian & Co. In order to ascertain the average percentage of nickel and copper as determined by the treat- Percentage of metals in the ores. ment of large quantities by these companies, I applied to the secretary of the Canadian Copper Company and the managers for the other two companies, all of whom have kindly furnished me with the desired information. On 18th March, 1891, Mr. H. P. McIntosh, secretary of the Canadian Copper Company wrote: "The output of our mines for last year averaged as follows:— Mines of the Canadian Copper Company.

	Copper.	Nickel.
Copper Cliff mine	6·24 per cent.	3·69 per cent.
Evans mine	2·84 "	3·62 "
Stobie mine	1·99 "	2·00 "
Average of all	4·32 "	3·52 "

You will note that the average of the total output is more than one-third the total of the three mines; this is accounted for by estimating the average according to the amount of ore mined, which is the proper way. We have not done sufficient work at the Vermilion to give you any reliable data, but the ore taken out there, now on the dumps, assays about 16 per cent. copper and about 13 per cent. nickel."

Mines of the Dominion Mineral Company.

Mr. George Attwood, M.E., manager for the Dominion Mineral Company, under date of 18th March, 1891, wrote: "The 'Kies' or metallics of the Blezard mine average 4 per cent. nickel which is accompanied by about 2 per cent. copper. The above is the result of many hundreds of assays, also of the practical working on a large scale. The nickel ore at the Worthington varies very much, and we have had assays from 2 per cent. to 38 per cent. nickel. Large shipments of clean ore have gone about 9½ per cent. nickel and 3 per cent copper. We have also shipped some clean copper ore from the Worthington mine assaying 18 per cent. copper and 2½ per cent. nickel."

Vivian Co.'s mine.

Mr. F. R. W. Daw, manager for Messrs. H. H. Vivian & Co., writing on 20th March, 1891, said: "The average percentage of the ore smelted here (Murray mine) is as follows:—Nickel 1·5 per cent., copper 0·75 per cent. The matte or first metal will average 8·5 per cent. for nickel and 4 per cent. for copper."

Range of nickel contents.

The percentage of nickel in samples of the pyrrhotite ores from the numerous deposits of the district has generally been found to range from less than 2 per cent. to nearly 5 per cent., while selected specimens of the sulphides of nickel found at some of the mines have given from about 30 to 40 per cent.

Rich nickel ore.

The Dominion Mineral Company has shipped in the spring of 1891, a small quantity of dressed ore from the Worthington mine, containing in the neighbourhood of 30 per cent. nickel.

Proportions of nickel to copper.

From the description already given of the mixed nickel and copper ores of the Sudbury deposits, it would naturally be expected that the relative proportions of these metals would vary greatly. These variations are illustrated by the following tests; Mr. F. L. Sperry, late chemist to the Canadian Copper Company, in November, 1888, made assays of nine different samples of the ores from the mines of this company, and found them to show extremes of 1·12 per cent. and 4·21 per cent. of nickel, the average being 2·38 per cent. and of 4·03 per cent. and 9·98 per cent. of copper, the average of the latter being 6·44 per cent. Mr. G. C. Hoffmann, chemist to the Geological Survey, had, in 1890, assayed four samples* of pyrrhotite from as many different

Mr. Sperry's tests.

Mr. Hoffmann's tests.

* Collected at the following localities:—
Nairn, lot 2, con. III. Nickel, 1.95, with traces of cobalt.
Lorne, lot 11, con. V. Nickel, 1.95 with traces of cobalt.
Drury, lot 3, con. III. Nickel and cobalt, 2·01.
Neelon, lot 12, con. III. Nickel, 3.10.

deposits in the district, and found from 1·95 per cent. to 3·10 per cent. of nickel, the average being 2·25 per cent. Since that time, by your direction, analyses of eight samples of these ores from seven different localities have been made in the laboratory of the Survey with the following results:

They show the percentage of nickel contained in the samples just as they were collected, or without the separation, of any portion of the gangue.

1. From S. ½ lot 6, concession II, Denison. Pyrrhotite, disseminated through a quartzose gangue. It contained nickel, 1·55 per cent.; cobalt, none.

2. From lot 7, con. II, Levack. Pyrrhotite disseminated through a quartzose gangue. It contained nickel, with a trace of cobalt, 2·36 per cent.

3. From lot 7, con. II, Levack (from a different part of the same deposit as the last). A coarse-grained pyrrhotite. It contained nickel, 4·13 per cent.; cobalt, none.

4. From lot 3, con. IV, Levack. Pyrrhotite with a little copper pyrites in a gangue of diorite. It contained nickel, with a trace of cobalt, 1·96 per cent.

5. Ross Location, 3 miles north of the centre of the north town-line of Morgan. Pyrrhotite with a small amount of copper pyrites. It contained nickel, 2·75 per cent.; cobalt, none.

6. Location W 7, east side of Waddell's Lake. Pyrrhotite with a little copper pyrites in a gangne of diorite. It contained nickel, 2·00 per cent.; cobalt, none.

7. Boucher's mine on the north-east side of Lake Wahnapitæ. An intimate association of copper pyrites in a gangue of diorite. It contained nickel, 1·57 per cent.; cobalt, none.

8. Vein on lot 10, con. VI, Creighton. An association of a dark grey schistose rock and white quartz, carrying zinc-blende and some pyrrhotite. It contained neither nickel nor cobalt.

The above results are not intended to apply to other than the particular specimens examined.

Lead and zinc

Lead and zinc.—Galena and zinc-blende have been found, but, as yet, apparently, only in small quantities, at several places in the belt of black slate and volcanic breccia. One of these is on lot 4, con. V of Fairbank, near the outlet of Vermilion Lake; another is on lot 8, con. IV of Dowling, near Onaping Falls, and a third occurs on the Pawatik or Rapid River, about a mile and a-quarter from Vermilion River, where Mr. Stobie informed me he had found these ores in small quartz veins cutting the breccia. A vein of blende and pyrite on lot 10, con. VI of Creighton, has been already mentioned.

Galena has been found in small quantities with the pyrrhotite at the Copper Cliff Mine, and on lot 6, con. III of Graham. It also occurs in small quartz veins in dioritic schist on lot 5, con. IV of Denison.

Gold.

Gold.—Fifteen samples collected in 1890 were submitted to Mr. Hoffmann for assay for gold and silver, and the following are his results :—

15 assays.

Locality.	Gold, per ton of 2,000 lbs.	Silver, per ton of 2,000 lbs.
Simon Obonsoing's mine on lot 8, con. III of Moncrieff—Quartz, honeycombed by the dissolving away of iron pyrites	Trace.	None.
Vein of quartz, 50 feet wide, and running N. and S. on W. side of Little Clear Lake, 2 miles W. of dam at outlet of Lake Wahnapitæ	None.	do
Vein 9 inches wide on East side of Waddell's Lake	Trace.	do
Vein No. 1 on mining location W.R. III, township 40 (S.E. of Lake Wahnapitæ). Property of Mr. Donald McLaren	0·117 oz.	do
Vein No. 2 on same location	None.	do
Location M. III, at S. extremity of Lake Mattagamashing, a short distance N. E. of Lake Wahnapitæ. Property of Donald McLaren	1·167 oz.	0·233 oz.
Near line of C.P.Ry. 480¼ miles West of Montreal	Trace.	None.
N. E. corner township of Plummer. Silicious veinstone containing grey copper ore. From Mr. James Stobie.	do	do
Middle of large vein of bluish-grey quartz, Ophir mine, Lot 12, con. III, Galbraith	0·175 oz.	do
Foot or North wall, West end Ophir mine	Trace.	do
Hanging, or South wall, West end Ophir mine	do	0·175 oz.
Near hanging wall, Eastern opening Ophir mine	0·583 oz.	None.
Lot 5, con. IV, Denison, No. 3 shaft	Trace.	0·525 oz.
E. ½ Ross location, 3 miles N. of middle of N. townline of Morgan (decomposed pyrites)	None.	None.
Simpson's mine, lot 11, con. II, Graham, near Whitefish Station on C. P. Ry.	0·350 oz.	do

Gold-bearing veins.

Numerous veins of quartz, some of which are of large size, have been discovered in the north-western part of Creighton and the eastern part of Fairbank. Their general course is N.N.E. Openings have been made on some of these veins by Mr. J. R. Gordon and specimens sent for assay to Prof. Heys, of Toronto, and others, who report the occurrence of gold in several instances.*

Limestone.

Magnesian limestone.—The purer deposits of dolomite which have been described as occurring at Lake Panache and also those of Geneva Lake and near Cartier Station, as well as the band which crosses Wahnapitæ River at the Island Portage, are apparently suitable for burning into lime, and they may also be found useful in connection with metallurgical processes in the district.

* Specimens of quartz from gash veins in these townships have been assayed by Mr. Hoffmann with the following results :—
Fairbank, lot 2, con. IV. No gold or silver.
Creighton, lot 11, con. V. No gold or silver. (Two assays.)

H. TOPLEY, PHOTO. DESBARATS & CO., ENGR. & PR., MONTREAL.

MATTE IN STOCK, COPPER CLIFF MINE.
July, 1890.

APPENDIX I.

NOTES ON THE MICROSCOPICAL CHARACTER OF ROCKS FROM THE SUDBURY MINING DISTRICT, CANADA.*

By Prof. George H. Williams, Ph. D. (of Johns Hopkins University).

(Collected in 1889–90 by Dr. Robert Bell.)

The suite of rocks from the Sudbury mining district entrusted to me for examination consists of forty-seven specimens, exclusive of two from Labrador and one from Hudson's Bay.

These rocks consist largely of distinct clastics derived from granitic or gneissic debris. With them occur many undoubted eruptives, whose origin was contemporaneous or subsequent to the deposition of the clastics, and with which the origin of the ores appears to be intimately connected.

Both clastics and eruptives have been subjected to extensive metamorphism and recrystallization, which has frequently resulted in the partial or complete obliteration of the original structure. The writer has frequently insisted (Bull. U.S. Geol. Surv., No. 28, p. 9; Bull. Geol. Soc. Am., Vol. I, p. 552; etc.) that a definite sequence of physical condition may produce from rocks of the most diverse origin, ultimate results that are indistinguishable. An eruptive granite and a sedimentary arkose may, under like conditions, be so recrystallized and metamorphosed as to produce gneisses which the microscope cannot separate and upon whose origin this instrument is able to throw no certain light.

As illustrations of progressive changes of this character in both clastic and eruptive rocks, this suite of specimens from the Sudbury region is particularly instructive. We may find the typical arkose with its felspar just beginning to break down into sericite (Nos. 22 and 25); and we may trace this alteration to the development of a continuous sericite matrix in which the quartz grains of the original rock are imbedded (No. 8, 9, 12, 13, 18, etc.). In similar rocks we may also see the new crystallization biotite, epidote or chlorite. In this way gneisses may result which retain little or no trace of clastic structure, and which might have originated from the crushing of a granite (Nos. 19, 23, 26, 27, 30). Hence it is not to be wondered at that the origin of certain of the holocrystalline rocks must always remain in doubt.

* A similar collection of rocks from the Sudbury region has been described by Prof. T. G. Bonney (Quart. Jour. Geol. Soc., vol. 44, p. 32, Feb., 1888), who reaches about the same general conclusions in regard to them as the present writer.

Many of the intrusive rocks still retain, even when greatly weathered, the unmistakable signs of their true character and source. But these masses, like those of clastic origin, are subject to metamorphism and recrystallization under altered physical conditions, which may in time obliterate entirely the minerals and structures that are such certain guides as long as they survive. Such changes we may see in progress in the Copper Cliff rock (No. 5) while enough of the original character remains to definitely fix the nature of the mass. In Nos. 32 and 40, however, the metamorphism has progressed so far that we are only warranted in assigning the rocks to the class of eruptives, after having traced out the progress of their alterations step by step. No. 43 affords another example of such changes in progress in eruptive rocks, where, however, the nature of the alteration is quite different from that seen in No. 5.

Apart from their alterations, some of the eruptive rocks of this collection possess an unusual intrinsic interest. This is noticeably the case with No. 46, quartz-hypersthene gabbro; No. 39, variolite; No. 43, hornblendic pyroxenite; Nos. 35 and 42, vitrophyre tuff; and No. 47, micropegmatite.

Appended is a classified list of the fifty specimens, followed by descriptions of each one in regular succession.

I.—Rocks Whose Clastic Structure is Plainly Visible.

No. 1. Conglomerate. West side of largest island in the west bay of Wahnapitæ Lake.

24. Conglomerate sandstone or greywacke. South side of Bay Lake, Montreal River.

20. Conglomerate sandstone or greywacke. Five miles N. E. of inlet of Echo Lake, St. Mary's River.

9. Coarse arkose with sericite matrix. East side of Maple Mountain, South of Montreal River.

8. Finer arkose with sericite matrix. Sturgeon River, near junction of Obabika River.

12. Arkose with little sericite matrix. South side of Little River, Lake Temiscaming.

18. Arkose with much sericite matrix. Thirteen miles up Upper Wahnapitæ River.

22. Arkose with felspar in process of sericitization. Montreal River, four miles above Temagami Branch.

25. Arkose with felspar in process of sericitization. N. E. side mountain, near Wendabin's House, Lady Evelyn Lake.

No. 13. Quartzite grit with sericite matrix. High Pond, east side of Maple Mountain.

17. White sandstone, with kaolinized felspar. Four miles N. E. of inlet of Echo Lake.

28. Felspathic sandstone or quartzite. Gold Mine, south side of Wahnapitæ Lake.

II.—Rocks Distinctly Clastic, but Partially Recrystallized.

No. 36. Stretched quartzite. Three miles up West Branch of the Spanish River.

41. Arkose with granite fragments partially recrystallized. Quarter of a mile N. W. of Copper Cliff mine.

33. Sandstone, partly recrystallized. The Hill, north side of Sudbury Village.

14. Greywacke, with iron in felspar. 455½ miles west of Montreal, on main line of Canadian Pacific Railway.

III.—Highly Crystalline Rocks, Probably Derived from Clastics.

No. 6. Felsite. Canadian Pacific Railway track, between Sudbury and the Murray mine.

7. Felsite. 300 yards east of the Copper Cliff mine.

15. Felsite. North side of Copper Cliff mine.

16. Felsite. Southern part of Lady Evelyn Lake.

19. Felsite. Foot of first portage below Rabbit Lake, between Lakes Temagami and Temiscaming.

23. Biotite epidote gneiss conglomerate. Three-quarters of a mile N. W. of Copper Cliff mine.

27. Metamorphosed greywacke conglomerate. 200 yards S. E. of Copper Cliff mine.

26. Biotite gneiss. Railway track, one mile south of Stobie mine.

30. Sericite chlorite gneiss. Smelting furnace, Copper Cliff mine.

IV.—Rocks with no Indications of Clastic Origin.

No. 2. Granite (with allanite?) West side of largest island in west bay of Lake Wahnapitæ. (In contact with No. 1.)

3. Granite. Same as last.

4. Granite. Same as last.

11. Coarse granite. One mile south of Crow's Nest Rock, west side of Lake Temiscaming.

31. Fine hornblende biotite granite. Ridge three-quarters of a mile west of Stobie mine.

No. 45. Crushed granite. Canadian Pacific Railway line, half a mile S. E. of Murray mine.

34. Garnet augite gneiss. West town-line of Hyman, two and a-half miles north of Spanish River.

44. Garnetiferous hornblende schist. Vermilion mine, one-third of a mile S. W. of the boarding house.

V.—Undoubted Eruptives.

No. 5. Uralitic gabbro. Shaft of Copper Cliff mine.

10. Similar rock, much more altered. Wall rock of shaft No. 2, Vermilion mine.

10. Similar rock, still more altered. Wall rock of shaft No. 2, Vermilion Lake.

32. Fine-grained diorite (cf. No. 5.) Ridge west of Stobie mine,

40. Hornblende schist or amphibolite. Murray mine.

35 & 42. Vitrophyre tuff. Lowest High Fall of the Onaping River.

46. Quartz-hypersthene gabbro. Dyke at Blezard mine.

48. Olivine diabase. Great dyke at foot of fifth portage, Spanish River.

49. Diabase (altered). Country rock of the Bruce mines.

39. Variolite. Ottawa Islet, Hudson Bay.

38. Diabase porphyrite. Nachvak, Labrador.

43. Hornblende pyroxenite (changing to talc). Nachvak, Labrador.

47. Micropegmatite. Eagle Rock Lake, Township of Levack.

Descriptions of the above Rocks.

No. 1. *Greywacke Conglomerate.*—West side of the largest island in West Bay, Lake Wahnapitæ. Well rounded granular quartz-felspar pebbles, two inches in diameter, cracked and scaled, imbedded in a fine compact black matrix. Section shows the pebbles to be made up of large felspar grains (mostly orthoclase) which are much broken and displaced. They further show indication of having been squeezed, in an undulatory extinction. These felspar grains are cemented by a recrystallized mosaic of chalcedonic quartz grains, which varies considerably in its fineness. It is well known that, under intense dynamic action, the quartz of a rock may be completely recrystallized into a mosaic of interlocking, fresh looking grains, while the felspar retains its original character and is only broken or optically disturbed. (cf. Rosenbusch, Mass. Gest., 2nd Ed., p. 41 ; Lehmann, Altkrystallinische Schiefergesteine, p. 250.)

The microscope shows the fine-grained matrix in which these pebbles are enclosed, to be composed of very minute sericite scales, which have resulted from the decomposition of felspar substance, together with extremely small quartz grains. This clay-like matrix contains numerous small angular fragments of quartz, orthoclase, and plagioclase. The structure of this rock is in every respect typically clastic, and it may be designated as a greywacke-conglomerate.

No. 2. *Granite.*—Same locality as No. 1. Rock of medium grain and somewhat porphyritic, through the presence of larger crystals of white orthoclase.

The section shows ordinary granitic quartz with fluid inclusions; orthoclase in large individuals, as well as in the finer-grained portion of the rock; plagioclase (oligoclase); and biotite, which is altered to chlorite, either wholly or in part. This section also contains a deep brown mineral, which is probably allanite. It is surrounded by a rim of epidote, as in the allanite-granites of Maryland. (cf. W. H. Hobbs: Am. Jour. Science (3) xxxviii, p. 223; and Tschermak's Min. and Petrog. Mitth. xi, p. 1, 1890). This rock shows the evidence of dynamic action to a slight degree, but has not the faintest indication of clastic origin.

No 3. *Granite.*—Same locality as Nos. 1 and 2. This rock is a granite like the last, except that it has a finer and more even grain, *i.e.*, is without porphyritic crystals.

The section shows under the microscope granitic quartz, orthoclase, plagioclase, biotite, with a little magnetite and pyrite. The biotite is much less altered than in the preceding specimen, showing only occasional chloritization in streaks. There is no allanite or epidote observable in this section.

No. 4. *Granite.*—Same locality as Nos. 1, 2 and 3. The specimen is much darker and finer-grained than the last described rock, but the two varieties closely resemble one another.

The microscope shows granitic quartz, orthoclase extensively kaolinized, plagioclase, and biotite which is about half altered to chlorite. There is also some magnetite and pyrite.

This section is traversed by a narrow vein composed of quartz, orthoclase, plagioclase and chlorite. It is worthy of note that all the felspar of this vein presents a striking contrast to that of the rest of the rock in being quite clear and fresh. The place of the biotite of the granite is, however, here wholly taken by chlorite. There is also in this vein an extremely fibrous mineral in matted tufts. It is closely related to the chlorite and may be chrysotile or asbestus. The grain of this rock is fine; its structure is typically granitic.

No. 5. *Uralitic Gabbro or Gabbro Diorite*—Shaft, Copper Cliff mine. Country-rock of the Copper Cliff copper-nickel pyrites.

A medium-grained massive greenstone or trap, containing both chalcopyrite and pyrrhotite. This rock is undoubtedly of eruptive origin, and from its present mineralogical composition it might be called a biotitic diorite. Both its hornblende and biotite are, however, of secondary origin, and have been derived from some pre-existing constituent which was in all probability pyroxene.

The microscope shows that the light portions of this section are composed of an interlacing network of idiomorphic felspar laths, whose fine striations show them to be plagioclase. The union of these felspar crystals to considerable irregular areas free from bisilicate prevents their producing a typical diabase or ophitic structure in the rock. The place of this felspar toward the more acid end of the plagioclase series is indicated by its local alteration tc kaolin, rather than to calcite. Most of the felspar is penetrated by minute hornblende needles, and it is also often sprinkled with magnetite. Associated with the felspar are apatite needles, and a relatively small amount of quartz which fills up the interstices between the felspar laths.

The ferro-magnesian constituents of this rock (hornblende and biotite) are, like the felspar, grouped into aggregates which occupy irregular areas. The hornblende is dark green and strongly pleochroic. It occurs in clusters of small needles and grains which by their arrangement and structure bear every evidence of being secondary after pyroxene. The hornblende of the outside of these clusters is more compact and more darkly colored than that in their centre ; and, while the remains of a pyroxene core could not in any case be definitely substantiated, the resemblance of this to other hornblende is too close to be mistaken. (cf. G. H. Williams : Gabbros and Associated Hornblende Rocks of Baltimore, Md., Bull. U.S.G.S., No. 28, Pl. I, Fig. 2, Pl. II, Fig. 1. Max Schuster : Neues Jahrbuch für Min., etc., Beil. Band V, p. 565.)

The biotite, which is less in amount than the hornblende, is of a copper red color and strongly pleochroic. It also bears strong indications of secondary origin. Both the hornblende and the biotite, but especially the latter, surround the ore (pyrite) in a way to suggest that the metamorphism to which they owe their origin, was in some way genetically connected with the deposit of the copper and nickel.

There can be little doubt that this rock was once an intrusive gabbro or diabase, which, owing to some subsequent metamorphism, has had its pyroxenic components changed to secondary hornblende or uralite. During the chemical and molecular changes which brought about the alteration, the felspar was filled with minute hornblende

needles, biotite was produced, and perhaps the copper and nickeliferous iron sulphides took their present form and position.

No. 6. *Microgranitic Rock* (possibly a recrystallized clastic arkose or greywacke).—One mile north-west of Sudbury. Appears to the unaided eye as a pale grey felsitic mass, without prominent grains or porphyritic crystals.

The microscope shows the slide to be composed of an evenly granular mosaic of quartz and felspar (orthoclase), interspersed with an abundance of biotite and considerable muscovite. Highly refractive epidote granules also occur and the biotite is rarely altered to chlorite. Traces of pyrite are also present.

The rock is not typically granitic, and yet it bears no certain evidence of clastic origin. The quartz and felspar grains interlock, and the biotite has evidently originated *in situ*. No outlines of originally clastic grains can be detected, though it is not impossible that this specimen may represent a metamorphosed and recrystallized clastic composed of granitic minerals.

No. 7. *Microgranitic Rock.*—300 yards east of Copper Cliff mine. A pinkish grey felsitic rock, much like the last described.

The microscope shows the structure of this rock to be much like that of the last described. Its composition is also similar, except that biotite is absent. Muscovite also is present in much smaller amount. The ferro-magnesian silicates are very sparsely distributed, and are mostly chlorite, with perhaps a trace of green hornblende. Epidote is present as in No. 6. The rock is mostly an even mosaic of quartz and felspar grains (orthoclase and microcline), the latter mineral being much more abundant that in No. 6. It is often stained with iron hydroxide which gives the pinkish tinge to the rock. The microscopical evidence of the genesis of this specimen is about the same as that obtained for the preceding (No. 6). The two succeeding specimens (8 and 9), although to the unaided eye apparently quite like the last two, are shown by the microscope to possess a typically clastic structure, which places their fragmental origin beyond all doubt.

No. 8. *Arkose Sandstone or Greywacke.*—Sturgeon River near junction of the Obabika. Pale greenish-grey fine grained rock of felsitic appearance.

The microscope at once disclosed the pronounced fragmental character of this rock, which is not so apparent to the unaided eye. Angular or slightly rounded grains of less than a millimetre average diameter, are imbedded in a fine felt-like matrix consisting principally of sericite (hydromica or kaolin). The angular grains are of the granitic minerals, quartz, orthoclase, microcline and oligoclase, with rarely a granule of reddish zircon. One fragment of well marked micropeg-

matite (granophyre) was also observed. The grains vary much in size and shape. Many of them are broken and their pieces only slightly dislocated. There is no mica in this rock, but there is a little chlorite, filling the narrower interstices between the grains.

The ground mass or cement of this rock is proportionately small in quantity. It is a confused mass of minute sericite scales, being the argillaceous product of decomposing felspar substance.

No. 9. *Coarser reddish Arkose.*—East side of Maple Mountain, south of Montreal River. This specimen, upon a superficial examination, does not look unlike a rather fine-grained granite. It is, however, a clastic arkose sandstone like the last, but of somwhat coarser grain. The grains are mostly angular, and often much fractured. They consist of quartz, orthoclase and plagioclase. Neither mica nor chlorite occur in this section, except as a component of the sericite ground-mass or cement, which is here relatively more abundant than in the last-described specimen. Stains of ferric hydroxide are abundant and impart the reddish color to the rock.

No. 10. *Greatly altered Greenstone (Gabbro ?)*—Shaft 2, Vermilion mine, Denison. The country-rock of the auriferous quartz vein.

A fine grained, evenly granular, greenish grey rock, with a somewhat silvery lustre.

The microscope shows this to be an extremely changed basic eruptive, probably originally a gabbro or a diabase. It appears to be a rock much like No. 5, but in a much more advanced stage of alteration. There is now no trace of its original structure nor of its original pyroxene. It is a confused aggregate of brown biotite, in rather sharp crystals, somewhat changed to chlorite, green hornblende fibres, epidote, quartz, calcite and sericite. The hornblende has, in all probability, resulted from the uralitization of pyroxene. The felspar of the original rock has also completely disappeared, and is now replaced by the micaceous mineral (sericite) and calcite. The quartz is all secondary, as is also the epidote and a little chlorite. In this confused mass are still numerous needles of apatite, which have survived all the alterations. Small grains of ilmenite, surrounded by leucoxene rims, are also present.

Rocks quite like this have been studied in many regions, where they can be traced with certainty into basic eruptives of normal character, and it is not impossible that specimens might be collected at this locality which would establish positively both the original form and the course of alteration of the present specimen.

No. 11. *Coarse-grained Granite.*—Lake Temiscaming, west side, one mile south of Crow's Nest Rock.

Macroscopically a coarse aggregate of grey quartz, reddish felspar and a pale yellowish alteration product.

The microscope shows a typically granitic structure, with orthoclase and microcline and a little striated plagioclase, and quartz. The rock is considerably altered, the felspar being opaque from this cause. The micaceous constituent, once present, has wholly disappeared, and is now replaced by a pale greenish-yellow sericite, containing iron in the form of magnetite. It also contains some sharp yellow needles (probably rutile). There has also been considerable potash mica (muscovite) developed at the expense of the orthoclase. There are further present in this granite as accessory constituents: zircon, in sharply defined reddish crystals; sphene, greatly altered; and a small amount of apatite.

No. 12. *Arkose Sandstone or Greywacke.*—South side Little River, Lake Temiscaming.

A dark grey, even and fine grained rock.

The microscope shows this to be composed of more or less rounded grains of granitic minerals—quartz, orthoclase, microcline and oligoclase—cemented by proportionately little sericite and chloritic material. The grains are all of the same average diameter, and plainly show by their character their derivation from granite while they appear to have suffered but little abrasion by running water. The dark color of this rock is largely due to the great amount of chlorite in its cement.

No. 13. *Quartzite Grit.*—High Pond, Maple Mountain, west of Lady Evelyn Lake and south of Montreal River.

This is a pale yellow rock, resembling a quartzite, but with distinct and more or less rounded, pebbles which in appearance closely resemble their matrix. Sericite is also abundantly visible to the unaided eye.

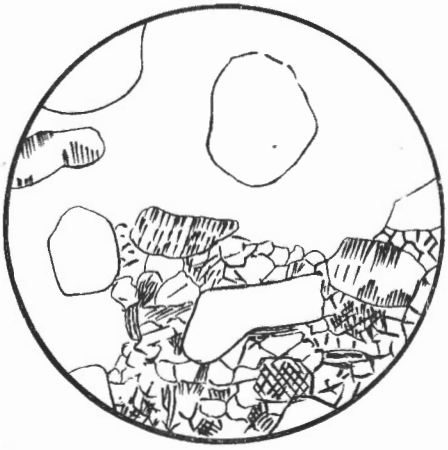
The miscroscope shows this rock to be composed of angular or but slightly rounded grains of granitic quartz, full of fluid inclusions, which are imbedded in a ground-mass of sericite and finer quartz fragments. These quartz grains or fragments differ greatly in size, but are under a millimeter in diameter. Felspar substance is now rare. It, however, was once present, but under the influence of dynamic action, it seems to have passed into sericite or muscovite. In a matrix of this character, medium sized pebbles are imbedded. These differ from the matrix principally in having a more silicious ground-mass, *i.e.*, they are freer from the sericite. They are, however, coated by a membrane of sericite, as is apt to be the case with squeezed conglomerates or grits. The rock shows distinct evidences of the action of pressure, and the development of its mica is probably due to this agency. A large fragment of the reddish zircon, like that in slides 8 and 11, was also observed in this section.

No. 14. *Greywacke.* 455½ miles west of Montreal, on the main line of the Canadian Pacific Railway.

A dark-bluish grey rock in which minute quartz fragments and grains are very apparent to the unaided eye.

Under the microscope numerous angular or somewhat rounded grains of granitic quartz of various sizes appear, imbedded in a finer aggregate of felspar, quartz, chlorite and mica. The dark color of the rock is due to minute dust-like inclusions of an opaque substance which crowd the felspar grains. They seem generally to be developed along cleavage cracks and appear to be of secondary origin, as they sometimes cover the whole felspar grain so as to make it almost opaque, and at other times are developed only in certain parts of the grain. The felspar substance is furthermore somewhat changed to mica and considerable chlorite is also developed. Reddish zicron and a little brown tourmaline are also found in this rock. The black opaque substance of this rock is not carbon, as it cannot be burned away by heating. It is some oxide of iron not easily dissolved by hydrochloric acid as is magnetite. By heating it is reddened, and may be ilmenite. See Figure 4.

FIGURE 4.



Section of specimen 14, from the main line of the Canadian Pacific Railway, 455½ miles west of Montreal. Greywacke, showing grains of quartz embedded in a finer aggregate of felspar, quartz, chlorite and mica.

No. 15. *Felsite or Microgranite.*—North side of Copper Cliff mine. A light colored evenly granular rock, containing very occasional black spots.

Under the microscope this is an aggregate of interlocking quartz and felspar grains with almost no trace of a ferro-magnesian constituent. Only minute needles and flakes of green hornblende are very sparsely disseminated, and these may make up the black spots visible in the hand specimen, though none of these were intersected by the thin section. The felspar is mostly orthoclase, with a little microcline and oligoclase. It is slightly kaolinized. Minute crystals of zircon are also rarely visible. There is nothing in the structure of this rock to indicate its clastic origin, although it is not impossible that it may be a recrystallized arkose. The constituents, especially the quartz, indicate by their undulatory extinction the action of pressure. (This rock may be compared with Nos. 2, 3 and 4.)

No. 16. *Microgranite or Felsite.*—South part of Lady Evelyn Lake. A fine compact pale grey rock, dotted with minute green specks.

The microscope shows this specimen to be an extremely even aggregrate of quartz and felspar grains, containing disseminated areas of chlorite. The separate grains are noticeable for having almost exactly the same shape and size throughout the rock ; still they form an interlocking mosaic and appear to have originated *in situ*. The felspar is mostly orthoclase, and the structure is typically that of a microgranite. No porphyritic crystals whatever are discernable. The ferro-magnesian silicate is wholly replaced by chlorite. It is not impossible that this rock may have been derived from the consolidation and recrystallization of an arkose. Its structure is not conclusive on this point.

No. 17. *White Sandstone.*—Log rollway, four miles north-east of inlet of Echo Lake.

This rock looks like a white and slightly felspathic quartzite, but its clastic character is apparent upon closer examination, even without the aid of the microscope.

The section of this specimen appears under the microscope to be a mass of variously shaped, but mostly rounded quartz grains. There is but very little true cement, but the quartz grains have undergone enlargement by the deposition of interstitial silica so that they frequently interlock by irregular sutures. This silica is optically continuous with the quartz grain which it surrounds, as described by Irving and Van Hise. (U. S. G. S., Bull. No. 8.) There is also some felspathic substance present in this rock which is considerably kaolinized. Rutile in deep yellow grains and crystals is also quite abundant, while the quartz encloses occasional zircon crystals.

No. 18. *Fine-grained Arkose or Greywacke.*—East side of Upper Wahnapitæ River, 13 miles north of mouth.

Compact, greenish-grey vitreous-looking rock, resembling a felsite.

The microscope shows small angular fragments of quartz with a little kaolinized felspar, distributed through an abundant sericite matrix. This has mostly resulted from the alteration of felspar substance, although it is mixed with some smaller quartz grains. The clastic origin of this rock is beyond a doubt.

No. 19. *Microgranite or Felsite.*—Foot of first portage below Rabbit Lake (between Lake Temagami and the foot of Lake Temiscaming.)

Compact brown felsitic rock.

The microscope shows this specimen to be comparable with No. 16 from Lady Evelyn Lake. It is an even grained mosaic of quartz and felspar ; the latter mineral (on account of the thickness of the section) being reddish and nearly opaque. The place of the ferro-magnesian constituent is now occupied by chlorite. Crystals of magnetite, which are sometimes accompanied by yellow rutile needles, occur near the chlorite. The shape of the grains in this specimen suggests, even more strongly than in the case of No. 16, a possible clastic origin.

No. 20. *Coarse conglomeratic Sandstone or Greywacke.*—Five miles north-east of inlet of Echo Lake.

Variagated rock of uneven coarse grain, containing good sized pebbles of white quartz.

The thin section of this specimen shows both rounded and angular quartz grains of very variable size imbedded in a moderately abundant sericitic matrix. Its appearance is closely like that of slide No. 9 from Maple Mountain. The quartz grains and pebbles exhibit the influence of pressure, many of them having an undulatory extinction and not infrequently being broken and displaced in the matrix.

No. 21. *Conglomerate (or Agglonerate?).*—Outlet of Lake Maskinongéwagaming.

Large rounded pebbles of a granular mottled rock in a black compact matrix.

The microscopic section of this specimen shows both kinds of rock and the contact-line between them. The pebbles are extremely altered, rather coarse grained diabase (dolerite). The structure of this rock is still sufficiently preserved to make its nature and origin certain, although its original mineral constituents are now entirely altered. Its lath-shaped felspar crystals have decomposed to a semi-opaque grey saussuritic mass, while its augite is now replaced by chlorite of a pale green color. Even its ilmenite has wholly disappeared, as such, but it has left an unmistakable record behind in the characteristic skeleton forms produced by the rhonbohedral parting, and now composed of dark grey leucoxene which has resulted from its alteration. Pyrite is also present in this altered diabase. The matrix of this rock is unmistakably clastic

in its character. Small angular and slightly rounded quartz grains with some felspar, are enclosed in a chloritic base, containing brightly polarizing sericite or kaolin.

No. 22. *Arkose Sandstone.*—Montreal River, four miles above Temagami Branch.

A reddish grey granular rock of medium even grain.

The microscope shows this to be an even grained mixture of somewhat rounded quartz grains with an equal amount of felspar (orthoclase, microcline and oligoclase). The minerals and their proportions are those of a granite, and yet the appearance of the grains and their relations to one another at once disclose the clastic character of the rock. The felspar, except a few of the largest grains, is quite changed to kaolin or sericite, although its external characters are still plainly discernable. This renders this specimen of peculiar interest in showing the origin of rocks like Nos. 9 and 20, whose sericitic matrix has, in all probability, passed through a similar stage in its development out of the felspar substance.

No. 23. *Biotite-epidote Gneiss (or Gneiss-conglomerate).*—Three quarters of a mile north-west of Copper Cliff mine.

This small specimen consists of two distinct portions: a dark, fine grained, micaceous rock, and a light felspathic one. The true relations of these two portions cannot be made out from the material at hand. The latter rock may be a nest or "eye" secretion such as are frequent in the gneissic rocks; or it may be a pebble. The extreme sharpness of the contact between the two portions points rather to the latter hypothesis.

As seen under the microscope, both portions of this specimen are gneisses. The darker portion, of which there is but very little in this section, is a fine grained aggregate, consisting mostly of biotite and epidote (or zoisite) with both felspar and quartz. The mica and epidote have certainly crystallized *in situ*, but they surround small transparent areas of quartz or felspar which look as though they might represent former fragments.

The lighter portion of the specimen is a felspathic gneiss, of uneven grain. It contains comparatively small amounts of the same biotite and epidote occurring in the darker portion, which have here also crystallized in their present position. No part of this rock now shows an undoubted clastic structure. If it was ever a sedimentary deposit, it has undergone very extensive recrystallization since its consolidation.

No. 24. *Banded coarse and fine conglomeratic Sandstone or Greywacke.*—South-west side of Bay Lake, Montreal River.

A portion of this specimen is quite like No. 20, but this alternates with much finer grained layers, which alone are represented in the thin section.

The section shows an aggregate of angular and subangular quartz grains with some felspar. Between these grains much chlorite has been developed, which, together with the magnetite present, gives the dark color to this layer.

No. 25. *Arkose Sandstone.*—North-east side of mountain, near Wendabin's house, Lady Evelyn Lake.

A reddish white rock of medium grain, which closely resembles a granite in macroscopic appearance.

Under the microscope the clastic nature of this rock is at once apparent, especially when it is viewed with a low power between crossed Nicol prisms. The grain varies considerably in its coarseness in different parts of the section. Quartz, orthoclase and plagioclase fragments are thickly crowded and connected by comparatively little sericitic matrix. This can, however, be seen to be forming at the expense of the felspar substance. There has been some enlargement of the grains by subsequent growth, so that, in spite of their clastic character, they often interlock with irregular sutures.

No. 26. *Dark fine-grained Biotite Gneiss.* (Extremely metamorphosed clastic).—Railway track, 1 mile south of the Stobie mine.

A dark-colored compact rock, which gives in the hand specimen but little clue to its true character.

Under the microscope this rock appears as a fine-grained mixture of biotite and quartz, to which a small proportion of felspar is added. The mica has evidently crystallized *in situ*, and exhibits a decided parallelism in the position of its flakes. This produces a somewhat indistinct gneissic structure, which is hardly observable at all in the hand specimen. Moreover, the mica is not evenly distributed through the rock, but is concentrated in bands which surround oval or lenticular areas. These are always elongated in the direction of gneissic structure and are composed of quartz, with occasionally a little felspar. The material which composes these elongated areas differs extremely in the coarseness of its grain, and appears to have been entirely recrystallized, although the form and distribution of the areas strongly suggest their being former pebbles. The only other constituent observed in this specimen consists of minute highly refractive granules surrounding grains of iron ore. They are the variety of sphene known as leucoxene.

My interpretation of this rock is that it was once a clastic greywacke, like many of the others represented in this collection, but that

it has subsequently undergone such complete metamorphism that a large amount of biotite was developed anew in it, while most of the quartz was recrystallized. These extensive changes have, however, gone on without entirely obliterating the original clastic structure of the rock.

No. 27. *Metamorphosed Greywacke Conglomerate.*—Two hundred yards east of Copper Cliff mine.

This is a pale pinkish, felsitic rock in which large and small irregularly shaped pebbles are very faintly traceable in a matrix that differs from them in external appearance only in being slightly darker.

The contrast between pebbles and matrix is much stronger under the microscope than it is in the hand specimen. The former (the pebbles) are composed of a granular aggregate of quartz and felspar, the latter being in proportionately small amount; while the matrix consists mostly of quartz and epidote. The latter mineral is in very minute highly refractive granules which are crowded into a nearly opaque mass until they are resolved by a high magnifying power. This epidote has originated in its present position as a result of metamorphism. The pebbles themselves also show the effect of metamorphism by dynamic action, being pressed and distorted in shape, as well as frequently broken and their fragments more or less displaced.

No. 28. *Felspathic Sandstone or Quartzite with large quartz pebbles (?).* —Lake Wahnapitæ Gold mine.

A vitreous white quartzite full of reddish felspar grains and containing large areas of pure white quartz, whose nature cannot be made out from this specimen.

The section, which is from the finer grained portion of this rock, shows under the microscope an appearance like that of No. 22. Angular or sub-angular quartz grains that have undergone some secondary enlargement, are mingled with felspar which is changing, though it has not yet entirely changed to a sericitic ground-mass.

No. 29. *A dark greenish-grey cryptocrystalline rock.*—Island in Lady Evelyn Lake.

This is a light colored felspathic sandstone, with an abundant sericitic-ground mass or matrix, much like the last described specimen, except that there has been no enlargement of the quartz grains to speak of.

No. 30. *Sericitic Chlorite Schist.*—The smelter, Copper Cliff mine near Sudbury.

A dark grey compact rock with small whitish blotches, and a quite distinct cleavage caused by the parallelism of the mica flakes.

This specimen, which was probably once a clastic, has undergone extreme metamorphism, whereby most of its original characters have

been obliterated. It is now a fine grained aggregate of quartz and sericite, with which is associated considerable pale green chlorite and a minute quantity of opaque iron oxide. The sericite and chlorite have a distinct parallelism in arrangement, producing a cleavage. Within this uniform mass, which makes up by far the larger portion of the section, are irregular and ill-defined areas much richer in quartz. These correspond to the lighter colored blotches in the specimen and may represent former pebbles which have been recrystallized and well nigh obliterated by the metamorphism. A small vein of quartz passes two-thirds of the way across the section and terminates within it. The indications are that the chlorite of this rock has been derived from biotite, and its sericite from felspar, although neither of these original constituents is now present.

No. 31. *Fine-grained Hornblende Biotite Granite.*—Ridge three quarters of a mile west of Stobie mine.

It is of course impossible for me to tell whether this rock may not possess in the field a parallel structure which would entitle it to be called a gneiss, but as far as this small specimen is concerned its structure is typically granitic.†

The constituents of this rock are quartz, orthoclase, microcline, oligoclase, biotite, hornblende, zircon, magnetite and epidote. The structure of this rock is typically granitic, but it shows a decided evidence of the action of pressure both in the disturbed optical behavior of the felspar, and in the peripheral granulation (Germ. Randliche Kataklase) produced by a rubbing of the grains against each other. (cf. Rosenbusch: Mass. Gest. 2nd. Ed., p. 42.) The ferro-magnesian components are not evenly distributed through the rock, but are aggregated in groups which consist mostly of hornblende and biotite, along with considerable reddish zircon. There is also scattered generally through the rock a small quantity of biotite. The latter mineral is of secondary origin. The opaque iron oxide of this rock resembles magnetite, but it is probably titaniferous, as each grain is surrounded by a highly refractive transparent border, which has all the properties of leucoxene (titanite).

No. 32. *Fine-grained Diorite.*—Country-rock of the ridge just west of Stobie mine.

A fine-grained dark hornblendic rock, without any foliation visible in the small hand specimen.

The microscope shows this rock to be a fine evenly granular aggregate of felspar, hornblende, biotite and magnetite, which is practically

† No indication of foliation was observed at this locality. The rock is extensively exposed and is all massive.—R. BELL.

free from quartz. The felspar is for the most part unstriated (which indicates, but does not prove, that it is orthoclase). If analysis should show that orthoclase were much the more abundant felspar, the rock would be more properly termed a syenite. The general character of the rock is, however, rather that of a diorite. Hornblende of the usual green variety, rarely with well-defined crystal form, is abundant. Associated with this is considerable biotite. The opaque iron oxide is surrounded by leucoxene borders. Apatite needles abound in the felspar, and quartz is only sporadically present. The structure of the rock, as seen in the section, is granular, and it is not impossible that it may have originated from the metamorphism of a basic eruptive containing pyroxene, although no trace of this mineral is now present. The specimen in comparable with No. 5 (the rock immediately associated in the ore of the Copper Cliff mine) without, however, there being here the certain proof of derivation that there exists.

No. 33. *Recrystallized Sandstone.*—The Hill, Sudbury Village.

A light grey, distinctly clastic though fine-grained rock. It has no pronounced cleavage in the hand specimen, but is somewhat evenly jointed.

The microscope shows this to be a fragmental rock composed mainly of quartz, in which considerable recrystallization has gone on. Good sized and quite irregularly shaped quartz grains are imbedded in a fine-grained mass, which also consists in large part of quartz mingled with some felspar substance. The quartz frequently shows the optical disturbance which is indicative of the action of pressure, and the interlocking of the grains proves that there has been considerable growth or enlargement since deposition. Chlorite has been extensively developed in the matrix of this rock. The only other minerals noticed were magnetite in minute specks and an occasional grain of zircon. A quartz vein of small dimensions crosses the thin section.

No. 34. *Garnetiferous Hornblende Biotite "Augen" Gneiss.*—West line of the township of Hyman, one mile north of Spanish River.

This is a normal gneiss, much "stretched," whose darker and finer grained portion bends around elongated lenses or "eyes," composed essentially of quartz. Minute crystals of red garnet are abundant, particularly around the edges of the quartz lenses.

The microscope shows the lenses or "eyes" of this specimen to be composed almost exclusively of large interlocking quartz grains, which bear witness by their undulatory extinction to the action of great pressure. The mass of the rock which encloses these lenticular areas is an aggregate of felspar (both orthoclase and plagioclase) quartz, biotite, hornblende, garnet, and iron oxide. The felspar, quartz and

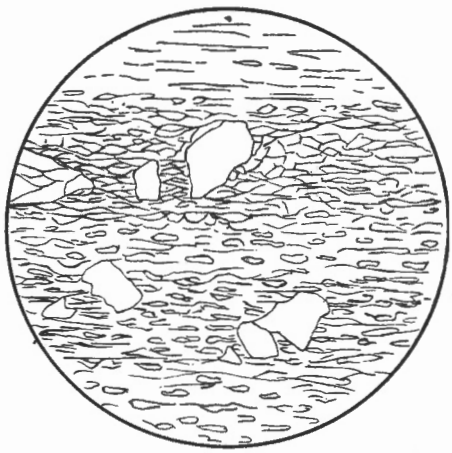
biotite present no peculiarities worthy of note. The hornblende is intensely trichroic, as follows: $\mathfrak{a}$ pale yellow; $\mathfrak{b}$ very dark yellowish-green; $\mathfrak{c}$ dark bluish-green; absorption: $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. It occurs in irregular patches or in prismatic crystalloids, associated with the biotite in matted aggregates. It has evidently originated *in situ*. The garnet is in good sized grains or imperfect dodecahedral crystals in the matrix of the rock. It also occurs in very minute, but very imperfect dodecahedrons in the quartz of the "eyes."

The structure of this rock is granular as far as its quartz and felspar are concerned, and shows the effect of pressure in the crushing of its grains. The interlacing or membranous (Germ., flaserig) structure characteristic of a gneiss is imparted altogether by the arrangement of its mica and hornblende. The recrystallization of all the components of this rock has been so complete that it can now only be spoken of as a gneiss. There is nothing in its structure to indicate whether it has been produced by dynamic metamorphism from a clastic arkose, from an eruptive granite, or whether it has always possessed the characters which it now exhibits.

No. 35. Same as No. 42., *q. v*

No. 36. *Stretched Quartzite*—Three miles and a-half up the West Branch of Spanish River.

FIGURE 5.



Section of specimen 36, from three miles and a-half up the west branch of Spanish River. Stretched quartzite, showing the larger grains of quartz pulled apart in the direction of the stretching.

This is a pinkish to brownish, cryptocrystalline banded rock, which might be macroscopically designated as a banded jasper or felsite.

The microscope shows that it is a clastic, consisting of quartz which has been almost wholly recrystallized under the influence of intense pressure, and that it has thus had the parallel structure developed in it by an elongation of its grains in one direction, that is commonly known as "stretched" (Germ., gestreckte) structure.

During this recrystallization there has been a large amount of epidote developed in this rock, which appears as extremely minute granules. Felspar substance is also present in amounts which vary very much in different parts of the specimen, being most abundant in the pinkish bands. An occasional needle of hornblende may also be seen. That there has been an actual stretching of this rock during its recrystallization is proved by the fact that the larger quartz grains, which have retained their original individuality, have been broken and their fragments pulled apart, always in the direction of the banding. This may be seen from the accompanying sketch, Figure 5.

No. 37. *Extremely altered Gabbro or Diabase* (?)—Vermilion mine, shaft No. 2, Denison.

A pale grey compact even-grained rock, rich in pyrite.*

This rock now appears under the microscope as a confused mass of chlorite, biotite, epidote, sericite, quartz, pyrite, opaque iron oxide, leucoxene, calcite and apatite needles. All of these minerals except the apatite are of secondary origin, and with their production the original structure of the rock has been quite obliterated. This specimen is comparable with No. 10 from the same locality, of which it seems to represent a much more altered form.

It is of course impossible to say in such an altered rock what its original form was, but there is little doubt that it represents the remains of some basic eruptive (either diabase or gabbro). From analogy with Nos. 5 and 10 we may say that the choice is perhaps in favor of gabbro. The pyroxene of the original rock has given rise to the chlorite and biotite; the felspar, to the sericite, calcite and quartz. The iron oxide (ilmenite or titaniferous magnetite) is partly changed to sphene (leucoxene), while the apatite needles alone remain in their original form.

No. 38. Rock from Nachvak, Labrador. *See* end of list.

No. 39. Rock from Ottawa Islet, Hudson Bay. *See* end of list.

No. 40. *Amphibolite or Hornblende Schist.*—Murray mine.

A fine-grained very dark green or nearly black foliated rock, containing a much coarser felspathic or granitic vein.

This is a closely interwoven aggregate of green hornblende and brown biotite. The foliation is produced by the approximate parallel-

*The pyrite is thickly scattered through the rock in very fine grains.—R. B.

ism in the cleavage directions of these minerals. The only other constituents visible under the microscope are quartz, and ilmenite surrounded by veins of sphene (leucoxene). Of the origin of this rock we can say nothing now with certainty. It may well have resulted from the extreme metamorphism of some basic eruptive, but from a small specimen like this it is unsafe to draw any such conclusion. The felspathic vein is a much coarser aggregate of quartz, orthoclase and plagioclase with a little green hornblende. The felspar has many minute hornblende needles secondarily developed in it, but otherwise the rock appears like a fresh granite.

No. 41. *Recrystallized Arkose.*—Quarter of a mile north-west of Copper Cliff mine.

A grey rock enclosing large and small fragments of a highly felspathic granite or coarse gneiss.

The microscope shows plainly the clastic nature of this rock, in spite of the fact that extensive recrystallization has gone on in its matrix. This is a mixture of minute quartz and felspar grains, in which biotite and epidote have been extensively developed *in situ*. Some of the smaller areas included in this matrix seem to have been entirely recrystallized and now consist of an interlocking mosaic of limpid striated felspar (albite) and quartz grains. The largest fragments in this rock have, as far as can be determined by the microscope, the normal structure and composition of a hornblende-biotite granite.

Nos. 35 and 42. *Vitrophyre Tuff**.—Lowest falls of the Onaping River.

This dark compact rock is crowded with lighter-colored patches, which at first glance seem to resemble porphyritic crystals. A closer examination, however, shows that they possess extremely irregular outlines which are inconsistent with such an hypothesis.

Under the microscope the real character of this unusual rock is at once apparent. It consists of volcanic ejectamenta in the form of glass fragments of all shapes and sizes, associated with some crystals or crystal fragments (Fig 6). Some of the glass is, or was, a pumice, although most of it was compact, and exhibits in a beautiful manner the fluidal structure often observable in recent acid glasses. These sharply angular fragments grade down to those of microscopic dimensions, and all are imbedded in a dark matrix consisting of still finer fragments of a globulitic glass. This specimen is therefore a consolidated volcanic ash in which a great amount of chemical change (mainly silicification) has gone on without materially disguising the

* This rock has been mentioned by Prof. Bonney in his paper on the Sudbury rocks. (*l. c.* p. 40.)

original form of the rock. In spite of the rock having once been principally composed of glass it now contains none of this material. It has been replaced almost entirely by finely crystalline chalcedonic quartz. The cavities in the pumice have been filled with the same substance. Some of the crystals are rounded grains of limpid quartz without any impurity or composite character. In one of the specimens there is a large crystal of fresh felspar, presenting glistening cleavage surfaces, but this mineral is exceptional and does not appear in either of the thin sections.

In an appendix to a paper by Dr. Bell, read before the Geological Society of America, 31st December, 1890, the present writer says: "In a hand specimen this rock presents a nearly black felsitic matrix, in which are embedded sharply angular or slightly rounded fragments, varying from $1\frac{1}{2}$ cm. in diameter downwards to ultra-microscopic dimensions. These fragments are lighter in color than the matrix, but differ considerably among themselves in their tint, structure and composition. The majority resemble chalcedony in appearance, others are greenish, while some of the largest fragments are now replaced by a single calcite individual. Occasional small grains of clear vitreous quartz may also be detected, while specks of magnetic pyrites (pyrrhotite) are everywhere abundant, Many of the angular fragments show distinctly under the lens a flow or vesicular structure, which is still more apparent in a thin section of the rock when seen under the microscope.

FIGURE 6.

Section of silicified Glass-Breccia or Vitrophyre Tuff. No. 42.

"The appearance of this rock when viewed with a low magnifying power (× 20 diameters) is shown in the accompanying figure 6, for which I am indebted to the skill of Mr. Charles R. Keyes, Fellow in Geology at the Johns Hopkins University.

"The fragments, even down to those of the smallest dimensions, have the angular form characteristic of glass sherds produced by explosive eruptions. The larger fragment in the lower part of the figure is finely vesicular, while the one above is more coarsely so. The flow structure is as perfectly marked by sinuous lines of globulites and microlites, which terminate abruptly against the broken edge of the glass particle, as in the most recent vitrophyre. Minute spots of opaque pyrrhotite are scattered throughout the section. The ground-mass is of a dark color, owing to the massing in it of minute black globulites, to whose nature the highest magnifying power gives no clue.

"Unfortunately, no* analysis of this interesting rock has as yet been made. Between crossed Nicols it is seen to be made up largely of chalcedonic quartz, which has changed the easily destructible glass into a sort of jasper. Chlorite is also abundant, frequently arranged as a border of radiating scales around the edges of the fragments, so as to coat them green in the hand specimen. The larger grains are always a fine mosaic of interlocking quartz, but some of the smaller ones are composed of a unit individual of clear vitreous quartz. The only other minerals which could be identified in the section are calcite and a few grains of a glassy, striated feldspar. The presence of this latter mineral is very noteworthy, as we should expect it to have disappeared during the vicissitudes through which this rock has passed.

"After a careful study of this rock I find it possible only to interpret it as a remarkable instance of a very ancient volcanic glass-breccia, preserved through the lucky accident of silicification. Nor did this process go on, as is usual, through devitrification and loss of structure, but rather like the gradual replacement of many silicified woods, whose every minute detail of structure is preserved. The rarity of such rocks in the earth's oldest formations is readily intelligible, but for this very reason the exceptional preservation of a rock like this is all the more welcome proof that explosive volcanic activity took place at the surface, then as now, and on a scale, if possible, even greater than that with which we are familiar."

No. 43. Rock from near Skynner's Cove, Nachvak, Labrador. *See* end of list.

---

*Since the above was written, Mr. Hoffmann has made an analysis of a specimen of this rock from the High Falls of Onaping River and found it to contain 60.23 per cent. of silica.

No. 44. *Garnetiferous Hornblende Schist.*—Vermilion mine. Roadside, one-third of a mile south-west of boarding house.

A fine-grained dark green hornblende schist, acting as the matrix for huge rounded crystals of reddish garnet, two inches or less in diameter.

The thin section of this specimen shows little except the garnet. This is quite normal, being reddish in color and isotropic in optical behavior. It is much cracked and slightly seamed with green chlorite which has resulted from its incipient alteration. It is also stained with iron hydroxide, and contains numerous inclusions of magnetite and quartz.

There is a very little of the hornblende schist also included in this section. It is an irregular aggregate of short and stout hornblende fibres mingled with more or less quartz.

No. 45. *Crushed and re-crystallized Granite.*—Canadian Pacific Railway, south-east of Murray mine.

Pale grey granitic rock.

This rock appears, under the microscope, like a granite which has been subjected to great crushing action. Its constituents are quartz, orthoclase, plagioclase, biotite, very little green hornblende, magnetite and zircon. The structure is irregular, the grains being of very unequal size with considerable fine mosaic. They, however, all interlock and appear to have been much broken by a crushing action. Many large felspar grains are fractured and the fragments separated. They are also granulated into a fine-grained mosaic around their edges. It is not possible to assert positively that this rock is not a wholly recrystallized arkose, composed of granitic debris, but there is now nothing in its composition or structure to indicate a clastic origin.

No. 46. *Quartz Hypersthene Gabbro with accessory Biotite.* Dyke, Dominion mine, township of Blezard.

A medium-grained massive brown trap, quite full of mica.

The microscope shows this to be an eruptive rock of quite exceptional character and interest. It belongs to the general type of gabbros, but has traces of a diabase-like structure in its long idiomorphic felspars; is related to the norites by the abundance of its hypersthene, and contains what is exceptional for all of these rock types—an abundance of original quartz. The rock is quite fresh, but shows the effect of dynamic action in the bending of felspar crystals and in the uralitization of the pyroxene.

The felspar is in stout lath-shaped crystals of good size, which produce a coarse ophitic or diabasic structure, as in many of the well known Scandinavian gabbros. They present a brownish color in the thin section, from an abundance of ultra-microscopic dust-like inclusions. They exhibit, in a beautiful manner, the effect of strain, in the bending

of the crystals and the production of secondary twinning lamellæ, similar to those described and figured by the writer from the Norites of the Cortlandt Series, near Peekskill, N. Y. (Am. Jour. Sci. (III) 33, p. 140, Feb., 1887.)

The pyroxene is both monoclinic (diallage) and orthorhombic (hypersthene) in about equal amounts. Both are undergoing alteration into compact green hornblende. The mica is an intensely pleochroic biotite. It is abundantly present in large flakes of irregular size and has all the properties of an original constituent. Quartz is also quite abundant in large clear grains of irregular shape, and was apparently the last mineral to crystallize. Apatite, zircon and magnetite are also present in considerable amount. This rock, although a typical gabbro, is unusually acid, and approaches in its quartz and zircon to the augite granites.

No. 47. *Granite (Micropegmatite).*—Eagle Rock Lake ("Moose Lake"), near west end; township of Levack.

A dark rock of medium grain with reddish felspar.

The microscope shows this to be a biotite granite or granitite whose quartz and felspar are minutely intergrown as they are in graphic granite, thus producing the structure called micropegmatite or granophyre. This structure exists in this specimen in an unusual degree of perfection. It composes most of the rock-mass, and is usually developed as a delicate network surrounding and radiating from a central rectangular orthoclase crystal (generally a Carlsbad twin). The quartz exists for the most part intergrown with the felspar, but a few separate and individual grains may also be found. The ferro-magnesian silicate is biotite, now considerably altered. A little light green hornblende is also present, but this, like the chlorite, seems to be of secondary origin. Apatite is abundant in sharp acicular crystals, some of which have attained an extraordinary length.

No. 48. *Olivine Diabase.*—Great Dyke, 5th Portage, Spanish River.

A medium grained grey rock whose diabase structure is macroscopically apparent.

The microscope shows this specimen to be a fresh aggregate of olivine, reddish augite, plagioclase and ilmenite, with accessory apatite and biotite. Its diabase or ophitic structure is very typical. The olivine in this rock is remarkly fresh. It is in small pale yellow grains, which rarely show external crystal boundaries. It has a very high refractive index, no pleochroism, and contains glass inclusions. The augite is of the reddish and slightly pleochroic variety common in diabase. It not uncommonly shows zones of growth, having different shades of color. In form the augite is allotriomorphic, filling the interstices between the laths of plagioclase. The felspar (probably

labradorite) is idiomorphic and forms an interlacing network of lath-shaped crystals. It is the only constituent that shows any alteration, and this is comparatively slight. The opaque iron oxide is probably ilmenite. It is without distinctive form or alteration, and is sometimes surrounded by a narrow rim of biotite. Apatite is abundant.

No. 49. *Diabase.*—Bruce Mines, north shore of Lake Huron.

A dark brown granular rock, containing vein quartz and disseminated chalcopyrite.

The microscope shows this specimen to be a diabase, free from olivine and in rather an advanced stage of alteration. Its structure is quite normal. The stout and somewhat rounded laths of plagioclase are but little altered. The place of the pyroxene, on the other hand, is entirely taken by a granular aggregate of brownish crystalloids with a weak double refraction and high extinction. These may represent originally polysomatic augite (cf. Lawson, Rainy Lake Report), but they now occupy areas of the irregular form characteristic of diabase pyroxene. The common change of the pyroxene to hornblende or chlorite has hardly more than commenced in this rock. There is little secondary quartz present.

No. 50. *Felsite.*—Cliff on Colonization Road, half a mile north-west of Sudbury.

Pale grey compact felsite.

The microscope shows this rock to be a medium grained mosaic of interlocking quartz and felspar individuals, with which are associated a small amount of biotite, magnetite and minute highly refractive epidote (?) granules. All the constituents are quite fresh, although the felspar shows an incipient stage of kaolinization. The grain is not entirely even, nor are there any distinctly porphyritic crystals present. It is not impossible that the rock may be of clastic origin, but if it is, recrystallization has progressed so far as to obliterate all certain traces of its original structure.

No. 38. *Porphyritic Diabase or Diabase-Poryhyrite.*—(Dyke) Nachvak, Labrador.

A dark green compact and massive rock, in which minute crystals may be detected with the unaided eye. One side of this specimen represents the edge of the dyke, and from this the grain can be distinctly seen to grow coarser as we pass to the opposite side of the specimen.

The miscroscope shows that, in spite of considerable alteration, the original composition and structure of this rock are still plainly recognizable. Good sized lath-shaped crystals, of an almost colorless augite, are imbedded in a fine-grained but holocrystalline ground-mass, composed of minute lath-shaped felspars and green hornblende. The

only other noticeable constituent is titanic iron (ilmenite) in minute grains, which is largely altered to grey leucoxene.

The alteration to which this rock has been subjected, consists principally in uralitization of the pyroxene, *i.e.*, its change into more or less fibrous, secondary green hornblende. This change is only partial in the case of the larger porphyritic pyroxene crystals, so that a large core of unaltered mineral remains at the centre (Fig. 7). In the case

FIGURE 7.

Section of specimen 38, from a dyke at Nachvak, Labrador. Porphyritic diabase or diabase porphyrite, showing an unaltered core of pyroxene in a crystal which has been peripherally changed to hornblende.

of the finer pyroxene of the ground-mass, however, the change to hornblende has been complete. Accompanying this development of secondary hornblende, there has been some little biotite also formed. The felspar has itself suffered little alteration, although very delicate hornblende needles have also been developed in it. The opaque iron ore (ilmenite) is extremely changed to leucoxene, which surrounds it as a border, when the grain of the original mineral has not been entirely replaced. Twinning parallel to the orthopinacoid is a very common feature in the original augite of this rock.

No. 39. *Variolite* (*Spherulitic Diabase.*)—Ottawa Islet, Hudson Bay.

A compact greenish-grey rock, with round or oval spots of a paler color distributed somewhat irregularly through it.

The microscope shows this specimen to be, in spite of its greatly altered condition, a rock of unusual interest. It represents a peripheral facies of a diabase, called variolite (cf. Rosenbusch: Mass. Gest., 2nd Ed., p. 227), which, although well known from many localities in Europe, has not, as far as I am aware, ever yet been described from any part of America. This specimen came in all probability from near the edge of a mass of diabase, and was once a very fine grained (possibly partly glassy) and porphyritic variety of this rock. The round or oval spots represent former spherulites, which are characteristic of rocks

whose solidification has been rapid. Such spherulitic aggregations, while universally distributed through the acid rocks, are exceptional in those of basic composition. Nevertheless, they have been described from the edge of diabase areas in Bavaria, Saxony, Savoy, Piedmont, Russia and Great Britain.

This specimen of variolite from Hudson Bay has suffered total alteration of all its original mineral components, and yet enough of its original structure has been preserved to place its true character beyond reasonable doubt. The main mass of this rock is now a matted aggregate of secondary hornblende flakes and fibres, together with epidote, chlorite and a little quartz. There are, however, still recognizable traces of the former structure, for the narrow laths of felspar have frequently left their outlines where their substance has wholly disappeared. The outlines of the former porphyritic crystals are in the main quite sharp. From their shape they appear to have been largely olivine, although they are now all replaced by an aggregate of serpentine, chlorite and epidote. The oval patches of a lighter color appear in the thin section as cloudy and almost opaque areas. They are also composed largely of secondary hornblende, chlorite and epidote, but through them run the lighter, more or less radiating lines representing the former felspar crystals, whose arrangement is quite characteristic of the spherulites or "varioles" of the European varieties.

No. 43. *Hornblendic Pyroxenite*, in process of alteration to talc (steatite). Near Skynner's Coye, Nachvak, Labrador.

A dark massive rock of trappean aspect, but noticeably soft and easily scarred white by even a slight scratch.

This specimen is of very exceptional interest, both on account of its original petrographical character, and also because of its alteration, the process of which is admirably shown in the thin section. The rock was once an evenly granular aggregate of enstatite, diallage, hornblende and magnetite.* The first named of these constituents is by far the most abundant and it has succumbed to an extensive alteration into a finely matted aggregate of talc scales. This same alteration has also gone on, although to a much less extent in the hornblende and also to a still smaller extent in the diallage (Fig. 8). It is analogous to the alteration of the enstatite from Bamle, Norway, to talc, so fully figured and described by vom Rath and Brögger (Monatsber. Berl. Akad. Wiss., Oct., 1876, and Zeitschrift. für Kryst. I. p. 18.)

The enstatite has very pale colors in the thin section, but has its characteristic pleochroism; a. reddish; b. yellowish to colorless; c.

* It is, therefore, a hornblendic variety of the rock-type for which the writer has suggested the name Websterite. Am. Geologist, July, 1890.

pale greenish. It also shows parallel extinction and all the other properties of an orthorhombic mineral, together with the rectangular cleavage of pyroxene in cross sections. It no longer has its original form, but now exists only as irregularly shaped cores in the midst of the talc which has taken its place.

FIGURE 8.

Section of specimen 43, from near Skynner's Cove, Nachvak, Labrador. Hornblendic pyroxenite in process of alteration to talc. *a*. Hypersthene or enstatite. *b*. Hornblende. *c*. Talc. *d*. Magnetite. *e*. Diallage.

The hornblende is next to the enstatite in abundance. It has all the properties of an original component. It is compact and with its usual optical orientation and pleochroism: $\mathfrak{a}$. and $\mathfrak{b}$. pale yellow; $\mathfrak{c}$. green. Its alteration to talc is as yet comparatively slight. The monoclinic pyroxene, recognized by its high extinctive angle, is nearly colorless and devoid of all pleochroism. Its amount is relatively small and it is the best preserved of all the constituents. The opaque iron ore in this rock occupies a very prominent place. It is in irregular grains, sometimes of rounded form, and is either compact or porous. The magnet shows it to be magnetite. The talc scales are usually arranged radially about these grains. The rounded contours of the largest and least solid of the magnetite areas, suggest that they may represent a replacement of olivine, but no certain traces of this mineral now exist in this rock.

APPENDIX II.

LEVELS OF LAKES ABOVE THE SEA.

The following are the approximate elevations above the sea, of the more important lakes shown on the map accompanying this report. In the case of lakes lying close to the Canadian Pacific Railway, the levels have been ascertained by direct comparison with some point on the line, but where the distance was considerable, the altitude of the lake was determined by barometric readings relatively to the railway, except, that of Onaping Lake, which was derived from a comparison of the mean of twelve barometric readings with the average reading at the sea level in the same month. The heights of the lakes in the north-eastern part of the sheet are deduced from the observations of the late Mr. Alex. Murray and myself, checked by the level of the railway at Wahnapitæ station. The names of the lakes are given in alphabetical order.

	Feet above sea level.
Bannerman Lake	1,270
Barlow (near W. end of Lake Nipissing)	650
Campbell do	645
Crooked or Crab (near Cartier Station)	1,348
Elbow (in Township 45)	678
Fairbank, or Washaigamog	867
Geneva	1,345
Koo-ka-gaming	879
Maskinongé-wagaming	800
Matta-gama-shing	866
Ma-zin-in-waning, or Vermilion	786
Murray (W. of Sturgeon River)	774
Nipissing	639
Ni-ta-wa-gami or Whitewater	835
Onaping	1,417
Onaping, Lower Lake	1,410
Panache	772
Pogamasing	1,181
Ramsay	820
Red Deer	685
Round	780
Straight	1,335
Vermilion, or Ma-zin-in-waning	786
Wahnapitæ	845
Washaigamog, or Fairbank	867
Wash-ki-gamog	788
White-water, or Ni-ta-wa-gami	835
Windy, or Ma-ko-ping	1,060

List of Elevations on the Canadian Pacific Railway from a point Fifty-two (52) miles west of Callander, which is 343·9 miles from Montreal.

These elevations were obtained from the profiles of the Canadian Pacific Railway corrected by comparison with the recently perfected levels of the United States lake surveys, as published by Mr. L. Y. Schermerhorn in the American Journal of Science, April, 1887, and the level of Lake Nipissing, as ascertained by William Murdoch, C.E., for the Department of Railways and Canals, Canada. The mean level of Lake Huron is given as $518\frac{3}{10}$ feet above mean sea level, while the level of Lake Nipissing, according to Mr. Murdoch, is 639 feet. Assuming these elevations as correct, the height of Sudbury Junction was fixed at 840 feet by the mean of the levels as brought up from Lakes Huron and Nipissing.

MAIN LINE CANADIAN PACIFIC RAILWAY.

Miles West of Callander.	Elevation above Sea.	Miles West of Callander.	Elevation above Sea.	Miles West of Callander.	Elevation above Sea.
52	653	87	784	120	960
53	655	88	812	121	996
54	657	89	812	122	1037
55	661	90	796	Onaping St.	1050
56	657	91	810	123	1075
57	657	Romford St.	835	124	1097
58	660	92	831	125	1145
59	671	93	853	126	1202
60	672	94	833	127	1219
61	675	95	838	128	1257
62	670	96	838	129	1292
63	668	97	882	130	1349
64	663	98	842	131	1360
65	664	Sudbury St.	840	132	1370
66	662	99	856	133	1351
67	662	100	906	Cartier St.	1356
68	662	101	954	134	1364
69	663	102	976	135	1345
70	665	Murray Mine.	975	136	1349
71	667	103	949	137	1359
72	670	104	895	138	1364
73	669	105	871	139	1343
74	670	106	875	140	1289
Markstay.	673	107	879	141	1258
Veuve River B'dge.	674	108	878	142	1261
75	693	109	881	143	1292
76	699	110	876	144	1340
77	714	Chelmsford St.	876	Straight Lake St.	1335
78	729	111	883	145	1336
79	740	112	877	146	1311
80	766	113	872	147	1259
81	823	114	865	148	1206
82	847	115	865	149	1202
83	847	116	858	150	1156
84	818	Bridge across Vermilion River.		151	1150
85	788		858	152	1145
86	777	Larchwood St.	860	153	1144
Wahnapitæ St.	776	117	867	Pogamasing St.	1144
Bridge across Wahnapitæ River.	776	118	884	154	1140
		119	931	155	1156

Sault Ste. Marie Branch.

Miles West of Sudbury.	Elevation above Sea.	Miles West of Sudbury.	Elevation above Sea.	Miles West of Sudbury.	Elevation above Sea.
Sudbury St.	840	17	777	35	690
1	834	18	794	36	646
2	829	Whitefish St.	791	37	620
3	828	19	785	Bridge across Spanish River.	620
Copper Cliff St.	832	20	810	38	671
4	836	21	822	39	677
5	848	22	803	40	671
6	857	23	795	Stanley St.	669
7	848	24	761	41	669
8	843	Worthington St.	756	42	663
9	792	25	756	43	663
10	783	26	738	44	682
11	786	27	710	45	667
Naughton St.	786	28	685	46	679
12	779	29	705	47	666
13	787	30	671	48	642
14	775	31	700	Webbwood St.	643
15	765	32	718	49	622
16	770	Nelson St.	702	50	646
Bridge across Vermilion River.	771	33	705		
		34	704		

APPENDIX III.

REPORT BY H. H. LYMAN, M.A., OF MONTREAL, ON LEPIDOPTERA COLLECTED BY DR. R. BELL IN THE COUNTRY NORTHWARD OF LAKE HURON.

These specimens were taken in different years by Dr. Bell and embrace seventy-three (73) species of the order. Most of them were unfortunately in poor condition, and hence several species could not be determined with certainty, while some of the specimens were quite undeterminable. Having been collected for the purpose of identification only, few of them were preserved in such a way as to be of value for museum purposes.

The species of most interest is *Cœnonympha Inornata*, Edw., described from the neighbourhood of Lake Winnipeg. This species was not previously known from so far east except that Mr. Wm. H. Edwards, from drawings by Gosse, believes that it occurs in Newfoundland. The form represented in this collection is a very dark one and was thought by Mr. Henry Edwards of New York, to be a new species, but Mr. W. H. Edwards, of Coalburgh, W. Va., pronounced it to be *Inornata*. The other species represented are chiefly those which might naturally be looked for in the Lake Huron region. One of them, however, *Thecla strigosa*, Harris, was not before known to occur so far north in this longitude, though, further west, it is said to have been taken as far north as Manitoba. One of the most interesting specimens is a hermaphrodite of *Argynnis Atlantis*, Edw., in which the right side is male and the left female. The abdomen is unfortunately in too poor a condition to admit of an examination of the genital organs.

For the determination of some of the specimens I am indebted to Mr. Wm. H. Edwards, Professor J. B. Smith, of New Jersey, and the Reverend Geo. D. Hulst, of Brooklyn, N.Y. The following is a list of the species with the localities and the dates of capture. The number of specimens taken at each place is indicated by the numbers in brackets. Where no number is given, one is to be understood.

Pieris Protodice, Bd.—Lec. Sault Ste. Marie, July 16th.

P. Oleracea, Harris. Sault Ste. Marie, La Cloche, Montreal River. June, July and August.

P. Rapæ, Linn. Lake Temiscaming. September.

Colias Philodice, Godt. Sault Ste. Marie, Lake Temagami, Lake Temiscaming, La Cloche, Sudbury. July, August and September.

C. Interior, Scudder. (4) Spanish River, Lake Temagami. August.
Danais Archippus, Fab. Georgian Bay. July.
Argynnis Cybele, Fab. (3) Georgian Bay, La Cloche. July and August.
A. Aphrodite, Fab. (3) Lake Temiscaming, (3) Spanish River, Montreal River. July and August.
A. Atlantis, Edw. Sault Ste. Marie. June, July and August. One specimen is a hermaphrodite.
A. Myrina, Cram. (4) Sault Ste. Marie. July and August.
A. Chariclea, Schneid. (4) Spanish River. July.
A. Bellona, Fab. Lake Temiscaming. July.
Phyciodes Nycteis, Doub.–Hew. (2). Sault Ste. Marie. July.
P. Tharos, Drury. (8) Sault Ste. Marie, Spanish River. July.
Grapta Faunus, Edw. Montreal River. (2) Lake Temagami. (4) Vermilion River. August and September.
G. Progne, Cram. Vermilion Lake. July.
Vanessa Antiopa, Linn. (2) Lake Temagami, Vermilion River. August and September.
Vanessa J. Album, Bd.–Lec. Lake Temagami. (3) Vermilion River. (4) Echo Lake (2) Montreal River. July, August and September.
V. Milberti, Godt. (3) Sault St. Marie. July.
Pyrameis Atalanta, Linn. (2) Sault Ste. Marie, July.
P. Cardui, Linn. (2) Sault Ste. Marit. July.
P. Huntera, Fab. Sault Ste. Marie. July.
Limenitis Arthemis, Drury. (2) Lake Temiscaming. July. (2) Sault Ste. Marie. June and July.
Neonympha Canthus, Bd.–Lec. Sault Ste. Marie. July.
Cœnonympha Inornata, Edw. (4) Sault Ste. Marie. June 28th, July 8th.
Satyrus Nephele, Kirby. Georgian Bay. (2) La Cloche. August.
Thecla Strigosa, Harris. Wahnapitæ Lake. August 17th.
Chrysophanus Thoe, Bd.–Lec. Sault Ste. Marie. July.
C. Hypophleas, Bd. (2) Lake Temiscaming. Little Current. (3) Sault Ste. Marie. July, August and September.
Lycœna —— ? Sp. undeterminable. Sault Ste. Marie. June 28th.
Pamphila Peckius, Kirby. Sault Ste. Marie. June.
Pamphila——? Sp. undeterminable. Sault Ste. Marie. End of August.
P. Mystic, Edw. (2) Sault Ste. Marie. June and July.
P. Cerues, Bd.–Lec. (2) Sault Ste. Marie. July.
Nisoniades——? Sp. undeterminable. La Cloche. August.
Deilephila Lineata, F. (2) Michipicoten. August.

Ctenucha Virginica, Charp. Sault Ste. Marie. June 30th.
Lithosia Bicolor, Grote. Wahnapitæ River. August 16th.
Euphanessa Mendica, Walk. (2) Sault Ste. Marie. July.
Crocota——? Mattawa. July 14th.
C. Rubicundaria, Hubn. Sault Ste. Marie. July.
Arctia Saundersii, Grote. Georgian Bay. August.
A. Phyllira, Drury. Near Bruce Mines. August 6th.
Agrotis Normaniana, Grote. Mattawa, July.
A. Haruspica, Grote. Mattawa. July 14th.
A. Ypsilon, Rott. Sault Ste. Marie. July.
A. Saucia, Hubn. Sault Ste. Marie. June 14th.
Mamestra Vicina, Grote. Mattawa. July.
Scoliopteryx Libatrix, Linn. Lake Temiscaming. July.
Lithophane Pexata, Grote. Upper Ottawa River, September.
Aletia Argillacea, Hubn. (5) Upper Ottawa River. September.
Plusia Balluca, Gey. Mattawa. July.
P. Bimaculata, Steph. (2) Lake Temiscaming. July.
P. Mortuorum, Guen. (2) Montreal River. August 2nd.
P. Viridisignata, Grote. Montreal River, August 9th.
Heliothis Armiger, Hubn. Vermilion River. September.
Catocala Concumbens, Walk. Sault Ste. Marie. August.
Pseudaglossa Lubricalis, Gey. Mattawa. July 14th.
Epizeuxis Æmula, Hubn. Vermilion River. August.
E. Americalis, Guen. Mattawa. July.
Eutrapela Transversata, Drury. Montreal River and Trout River to the north of it. August.
E. Transversata, Drury, Var. Vermilion River. September.
Therina Fervidaria, Hubn. (2) Montreal River. August 9th.
Sicya Macularia, Harris. La Cloche. July.
Angerona Crocataria, Fab. Sault Ste. Marie. July.
Corycia Vestuliata, Guen. Sault Ste. Marie. July 2nd.
C. Semiclarata, Walk. Sault Ste. Marie. June 30th.
Semiothisa Granitata, Guen. Vermilion River. August.
Cleora Pulchraria, Minot. Montreal River, August 9th; (2) Onaping Lake, September 11th.
Triphosa Dubitata, Steph. Near Onaping Lake, September Township of Levack, October.
Rheumaptera Unangulata, Haw. Sault Ste. Marie. July.
R. Hastata, Linn. (2) Sault Ste. Marie. July.
Hydriomena Sordidata, Fab. Var. *Glaucata*, Pack. Sault Ste. Marie. July.
Salebria Fusca, Haw. Sault Ste. Marie. July.

APPENDIX IV.

MEANINGS OF INDIAN GEOGRAPHICAL NAMES IN THE COUNTRY AROUND SUDBURY.

During the progress of our surveys and explorations, care was taken to obain from the local Indians the meanings of their geographical names as far as they were able to give them. My own knowledge of the Ojibwé or Otchipwai language enabled me to verify these in most cases. But all the translations in the following list have been submitted to Mr. Robert Ross, of Naughton, and Professor John Galbraith, C.E., of Toronto, both of whom have a knowledge of this language. Some of these names have the Cree rather than the Ojibwé form, from which it appears probable that the Crees, who now inhabit the country around James' Bay, may have at one time extended further south. The meanings of these Indian names are often obscured by contractions, which are very common in the Ojibwé dialect, and also by corruptions that have crept in by carelessness and have been adopted by the Indians themselves. The spelling in common use is given with the addition, in some cases, of what is believed to be the correct form. In the pronunciation, it is to be understood that the value of the letters is the same as in French, which gives the sound much more correctly than by using the English pronunciation. Most of the Indian geographical names are in the locative form, so that *at* or *the place of* is to be understood in addition to the interpretation given in this list. The names are in alphabetical order.

Ashigan-ipoon-sap-agaming—The lake where nets are set for bass in winter.—A lake just south of Koo-ka-gaming Lake.

Ka-bi (or pi)-to-ti-twi-a—The stream having the same course as (or continuing the course of) another stream ; or it might, in other cases, mean the stream parallel to another stream.—A branch of Sturgeon River from the west in townships 25 and 23, which has the same course as the stretch of the latter just below it.

Ka-kake-shi-wish-ta-gwa-ning—The cormorant's head.—A rock forming part of the cliffs on the west side of Onaping Lake, a short distance north of Proudfoot's line.

Ka-min-i-tik-wia-kwuk—River having many islands.—A stream in the township of Morgan.

Ka-si-sé-gan-da-ga-wonk—Where there are spruces.—A lake west of upper Vermilion River and near Proudfoot's east-and-west line.

Ka-wa-wi-ai-gama—The round lake.—Situated east of the outlet of Onaping Lake.

Ka-wa-sa-ski (or hi)-gama—The lake of bays.—A lake on a small river of the same name which flows into the upper Vermilion from the west.

Ka-wak-won-é-ka-gama—Lake where *tripe de roche* is plentiful.—Situated a short distance west of Upper Vermilion River.

Kin-ni-wabik—(Golden) eagle's rock.—A lake in the south-eastern part of Levack, which the surveyors have called "Moose Lake."

Kitchi-mish-kwis—Big grass.—A branch of Vermilion River from the north.

Kino-gami—Long lake.—Between Lake Panache and Wahnapitæ Station on the Canadian Pacific Railway.

Koo-ka-gaming—Owl lake.—A lake nine miles long, situated a short distance east of Wahnapitæ Lake.

Ma-ko-ping—Contraction for bear lake—literally, bear's water.—The aboriginal name for the sheet of water which has been re-named "Windy Lake," on the line of the Canadian Pacific Railway north-west of Sudbury.

Mat-ta-ga-ma-shing—A contraction for Mat-ta-wa-ga-ma-shing—The meeting of the waters—literally, the place where the lakes meet together.—At this sheet of water two arms meet and into each of them a canoe-route falls. A lake laying just east of Wahnapitæ Lake.

Maskin-ongé-wa-gaming—Big pike lake.—Between Sturgeon River and Wahnapitæ Lake.

Maz-in-in-waning—The pictured water.—So called from the reflection of the landscape on the calm water in the summer evenings. Situated in the township of Fairbank. The surveyors re-named it "Vermilion Lake."

Ministik (Sa-kuh-i-kun)—Island lake (Cree).—A lake on the town-line between Ermatinger and Cascaden.

Miska-wi-ko-bang—Place of the rushes.—A lake about ten miles north of the township of Lumsden.

Muck-a-tai-wa-gaming—Black lake.—On the east side of the Whitefish Indian reserve.

Na-mai-gus (or goos)—Trout (the large grey or lake trout).—A lake east of Onaping River.

Ni-nips-ka-gaming (or Ni-bish-i-ka-gaming)—Leafy lake—The source of Vermilion River.—Situated a short distance east of Onaping Lake.

Nipissing—A contraction for A-nib (or nip)-i-sing—The place of elms. Or, possibly, it may mean the little lake—as compared with Lake Huron.—Lake at the head of French River.

Nita-wa-gami—Lake where the stream is born—A lake in the northern part of Snider. Re-named Whitewater Lake by the surveyors.

O-na-ping.—May be a contraction for O (or wun)-num-un-a-ning —Cree for red paint or "vermilion" place. Perhaps the reason why the river from the junction of this stream with what the Indians call the Onwatin, has received the name of Vermilion River, is to be traced to this meaning. Onaping might also be a contraction for Oo-na-min-a-ping—place of gooseberries, Oo-na-min being the word for the fruit we call gooseberries in the dialect of the Crees around James' Bay, although shabomin is the name of these berries in the Ojibwé dialect.

On-wa-tin—Calm or smooth—literally no wind.—A lake on the Vermilion River, regarded by the Indians as the source of the main river, which is known among them by the same name.

Pawa-tik, or Pow-a-tik—Rapid.—A small river which flows through township 66.

Pay-pun-aka-mas-kik—Probably a contraction for Pay-i-pa-pun-aka-mas-kik. Where the sun shines out upon the other side, or there is a glint of sunshine over on the other side of the water.—A lake between the Onaping and upper Vermilion River. Its northern extremity touches Proudfoot's east-and-west line.

Pi-mitchi-wan-ga (or ka)—Probably for Pi-midgi-i-wan-ka—Place of running water.—A lake on the upper Vermilion River.

Ping-wi-i-min-ka-ni-wi (sipi)—Sand-cherry river with the two branches.—A small river flowing into the township of Morgan.

Po (or pa)-gama-sing—A contraction for either Opa-gama-sing, Lake-of-the-narrows or Pa-gwa-gama-sing, shallow lake. Lake of the Shallow Norrows would be an appropriate name.—A lake ten miles long, situated just west of Spanish River, opposite the station of the same name on the Canadian Pacific Railway.

Sa-ga-mook—The Peninsula.—The name of an Indian village situated at a peninsula on the north shore of Lake Huron a few miles west of La Cloche.

Sagitchi-wai-a-ga-mog—Lake with the hills where the water goes out. Sagitchi is a single particle and means out of, or out from, and wai is a contraction for wai-tchu, a hill.—A lake situated just north of the township of Lumsden.

Schkow-a-na-ning (for Wa-ska-wa-naning).—The place of the turn (in the canoe-route). A lake east of Onaping River.

Shi-ba-o-na-ning—The channel.—The original and proper name of a place on the north shore of Lake Huron. Called also "Killarney."

Shing-wak—White pine.—A lake a short distance east of Onaping River.

Temagami—Deep lake (in the Ojibwé or Otchipwai dialect).—A lake thirty miles long between the Montreal and Sturgeon Rivers and sending a stream into each.

Temiscaming—Deep lake (in the Cree dialect).—On the Ottawa River, where it changes its general course from west to east.

Wab-a-gi-(or ki)-zhik—Clear or white sky.—A lake in the southern part of Nairn.

Wah-na-pit-æ—More ocrrectly Wa-na-pit-é-(ping), the final syllable being merely locative, as it was formerly spelled upon the maps. The change to the present incorrect form was introduced by the late Mr. Alexander Murray when he surveyed the lake in 1856, and arose from a misapprehension of the proper pronunciation of the diphthong æ and which, moreover, does not occur at all in the Cree or Ojibwé language. The accent is on the final é. The h is the first syllable is unnecessary, as the a alone is sufficient, being always prounced soft and long in the Ojibwé language. A return to the proper and simpler spelling would be welcomed by everyone who has occasion to write this name often. The word means hollow (molar) tooth and was probably suggested to the Indians, who are good map-makers, by the fact that the outline of the lake resembles that of a side view of a molar tooth. It is the largest lake on the river of the same name.

Wa-na-tanga-(sa-gai-(hi)-gan)-Hollowed-rock lake.—Situated east of Onaping River and north of the township of Levack.

Was-ka-gaming, for Oja-wask-ka-gaming—Green or blue lake, these colours having only one adjective to denote them. Called Lake Panache, (Antler Lake) on the maps.

Wa-shai-ga-mog—Clear lake.—A lake in the south-west corner of the township of Fairbank. Re-named, contrary to the wishes of the natives, "Fairbank Lake." A similar name with the prefix ka belongs to a lake in township 66.

Was-ki-ga-mog—the lake that curves round.—A hook-shaped lake on the Maskinongé River, not far west of Sturgeon River.

We-quet-(sa-gai) (hi)-gan)—Bay lake.—In the township of Ermatinger.

Wenge-kis-i-naw—Why is it cold?—The name of an Indian, after whom a stream north-west of Morgan, and passing through his hunting ground, is called.

Wia-shai-ga-mog—Clear lake.—The same as Wa-sha-ga-mog.

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

THE GEOLOGY OF

HUNTERS ISLAND

AND ADJACENT COUNTRY

BY

W. H. C. SMITH, C.E.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1892.

To A. R. C. Selwyn, C.M.G., LL.D., F.R.S.,
Director and Deputy Head of the
Geological Survey of Canada.

Sir,—I herewith submit to you my report upon the physical and geological features and economic resources of Hunters Island and adjacent country, lying principally in the Rainy River district of the province of Ontario, but extending eastward five miles and a half across the eastern boundary of this district into Thunder Bay district; also a geological map of the same on a scale of four miles to the inch. The sheet, No. 7, Ontario, embraces an area of eighty-seven and a half by forty-eight miles. The usual size of the sheets of this series is seventy-two by forty-eight miles, but fifteen and a half miles are added to this sheet to the west, in order to show on the one sheet that small portion of Canadian territory lying south of the eastern part of the area embraced in the Rainy River sheet, already published, and thus avoid the publication of a second seventy-two by forty-eight mile sheet, only a very small proportion in the north-east corner of which would be Canadian territory. Only about one-third of the area depicted on this map is in Canada, the boundary line between Canada and the United States extending in a sinuous line completely across the sheet.

All the topography north of this line is from our own surveys, checked and in some cases supplemented by township surveys, mining location surveys, timber limit surveys, and the survey of the boundary line between the districts of Rainy River and Thunder Bay by the Provincial Crown Lands Department.

All the topography on the American side is compiled from the best American maps extant.

The examination of the area was originally under the direction of Dr. A. C. Lawson, who, however, resigned before the work was completed. As his assistant, my work was for the most part topographical. The geological notes, taken in conjunction with those for the topography, were only intended to be supplementary, and in many places where surveys were not required, the writer took no geological notes. With a few unimportant and isolated exceptions, the main geological boundaries were, however, laid down by Dr. Lawson on the map, prior to his departure. These boundaries he determined partly from his own observations and partly from those of the writer, but he

had not indicated on the map the subdivisions of the Keewatin series, therefore the report is brief and incomplete.

The area of Canadian territory on this sheet being small comparatively, and the publication of the map having been already much delayed, it is deemed advisable to publish it at once, rather than to wait another year in order to acquire information for the minuter subdivision of the rocks of the Keewatin series.

I have the honour to be, sir,

Your obedient servant,

W. H. C. SMITH.

OTTAWA, 3rd May, 1892.

NOTE.—All bearings have reference to the true meridian.

REPORT

ON

THE GEOLOGY OF

HUNTERS ISLAND

AND ADJACENT COUNTRY.

INTRODUCTION.

This report, with its accompanying map, is a continuation of the work commenced by Dr. A. C. Lawson in 1883, in the Lake of the Woods region. Since then his reports on the Lake of the Woods, Rainy River and Rainy Lake together with three sheets of the map have been published.

Position of shee

This sheet, lying to the south and east of the Rainy Lake sheet, is the fourth of the series published, although it is numbered "7," in accordance with a systematic numeration of the sheets of this series, which it is intended to publish.

Period of field investigation.

The present report and map embody surveys and geological investigations made in the latter part of the summer of 1887, during the summer of 1888 and part of the summer of 1889, during which time I was acting as topographer and assistant to Dr. Lawson.

Work of season 1887.

In the summer of 1887, I was assisted by Mr. William Lawson. The early part of the summer was occupied in finishing the topography required for the Rainy Lake sheet. We left Fort Frances on the 5th of August and commenced work on the area covered by this sheet on the 9th of August. Micrometer and compass surveys were made of all the lakes and streams north of the international boundary shown on this map west of Lac la Croix, with the exception of Little Vermilion and Loon lakes and the intervening stream; thence from the eastern boundary of Indian Reserve "D," we surveyed the Maligne River, carried a micrometer and compass line along the south side of Sturgeon Lake, and continued this line through Russell and Chatterton lakes to

Keat's Lake, which we surveyed, with the river stretches and lacustrine expansions to Kahnipiminanikok Lake, through which we carried the line; thence up the Kahnipiminanikok River to Saganagons Lake, where the system of surveys was connected with the mining locations which approach within a few chains of the south-west arm of this lake, and which had already been connected with the American township surveys.

Boundaries of Hunters Island.

The lakes and rivers above enumerated form the north-western, north-eastern and eastern boundaries of that area to which the name of Hunters Island has been given. The south-eastern boundary is formed by the northerly shores of Saganaga and Swamp lakes, by the Swamp Portage, by the north-western shores of Cypress, Big Knife, Carp and Birch lakes, with their connecting streams. Basswood Lake forms the southern boundary, while Crooked Lake, with the stream which pours into it the waters of Basswood Lake, and that which carries the waters of both into Lac la Croix, form the south-western boundary.

The work on the northern boundary of Hunters Island was finished on the 30th of September, and the season's work brought to a close at Silver Mountain on the 7th of October.

Work of season 1888.

In the summer of 1888 Mr. Wm. Lawson again assisted me, and from the 29th of June to the 24th of August, we were continuously engaged in surveying, by means of the compass and Massey patent boat log, the lakes bordering Hunters Island to the north-east, and those in the interior of the island east of, and including, the lakes and streams forming the route from Shelley Lake through Keefer to Kashapiwigamak Lake. In addition to these, Ross, Beaver and McKenzie lakes were surveyed during this period.

From the 24th of August to the 12th of September, we were engaged on work in the area included in the sheet north of this, the Seine River sheet (No. 6 of the series.)

Between the 15th and the 19th of September we surveyed Wink and Pooh-Bah lakes, with the creek and portage connections between these and Sturgeon Lake and River. The next week was spent in the Seine River sheet, but the remainder of the season, from the 27th of August till the 18th of October, was spent in the south-western and northern Laurentian areas of Hunters Island, during which time nearly all the lakes shown in these portions were surveyed wholly or in part.

Work of season 1889.

In the summer of 1889 I was again assisted by Mr. Wm. Lawson. Work was commenced at Savanne on the 6th of June, and continued until the 12th of August, on surveys in connection with the Seine River sheet. From the 14th till the 25th of August, while Mr. Lawson continued working in this sheet, I was employed in Hunters

Island, completing some unfinished surveys arnund Wicksteed, Brent, William, Conmee, McIntyre and Sarah lakes, and in investigating more closely some geological questions there, and on the south-east arm of Sturgeon Lake. The remainder of the season was spent on the Seine River sheet, with the exception of a week in October devoted to topographical work in the neighbourhood of Port Arthur and Fort William.

Much of the area embraced in the Hunters Island sheet had been surveyed for various purposes, with a considerable degree of accuracy, and for this reason it was deemed expedient to use, for the most part, the more rapid method of surveying with the prismatic compass, for determination of bearings, and the Massey patent boat log, for the measurement of distances. This log, carefully used, gives very satisfactory results and permits great rapidity of work, but it does not allow close continuous examination of the lake shores for rock exposures, as it is necessary to hold a straight course with the canoe from point to point.

Instruments used in surveys.

The southern shores of the lakes and rivers along the international boundary line were accurately defined by the Minnesota township surveys, which afforded an excellent base line for our work. The whole of Hunters Island had been traversed with the transit and micrometer for timber limit purposes, and this survey fixed with much accuracy many prominent points on all sides. The boundary line survey, between the districts of Thunder Bay and Rainy River, the Indian Reserve surveys, and the mining location surveys, all contributed considerably to the topographical detail, and to the accuracy of delineation of the geography of the field. Some of the outlines of the northerly shores of the lakes and rivers along the international boundary were taken from Mr. David Thompson's survey under the Boundary Commission. This work, when corrected by the American township surveys, has been found to be sufficiently accurate between points thus fixed. Little Vermilion and Loon lakes, the eastern part of Lac la Croix, Crooked and Basswood lakes are the principal places where this survey was made use of.

Older surveys made use of.

Minnesota township surveys.

Canadian surveys.

Boundary Commission survey.

That Man's and This Man's lakes were surveyed by Mr. McDougall of Port Arthur, and a map of them kindly given me by him. The position of The Other Man's Lake was fixed by Mr. McDougall with reference to those above mentioned, and the traverse of the shore line and island was made by Dr. Lawson.

Mr. McDougall's surveys.

With the above exceptions, all the topographical work of this sheet on the Canadian side of the boundary was performed by the writer and Mr. Wm. Lawson.

Original surveys.

I may take this opportunity of expressing my appreciation, not only of the cheerful manner in which this gentleman has endured the hardships and undertaken all the tasks incidental to our explorations, but also to the readiness and ability with which he mastered the requirements of the work and to the rapidity, care and accuracy which invariably characterized his performance of it. He not only assisted me throughout the seasons during which I was engaged in the topography of this sheet, but has been working under my direction for the last two seasons, five summers in all, during three of which he has, for the most part, been engaged in making independent surveys.

Acknowledgments.

I may here also take the opportunity of acknowledging my indebtedness to all the members of the engineering firm of Russell, McDougall & Russell, of Port Arthur, for maps, sketches and information; to the Messrs. McKellar, Mr. McIntyre and Mr. John McLaurin, of Fort William, for information, and for assisting me to secure suitable men; to Mr. Geo. McLaurin, of Savanne, and to Mr. Alex. Matheson, of Rat Portage, for similar favours. To Messrs. Thos. Marks & Co. of Port Arthur, I am especially indebted for courtesies and favours extending over several years.

Bibliography.

The geological literature of this field is very cursory. Half a century ago the two main routes from Lake Superior to the north-west, were the Pigeon River route and the route by Lac des Mille Lacs. The former which now forms the boundary line between British America and the United States, from Lake Superior to the Lake of the Woods, is represented on this sheet between Saganaga and Namakan lakes; the latter route joins this one at Lac la Croix. On these two routes only, therefore, do we find some brief references to the geology of the country in the earliest scientific records of the West.

Bigsby.

The earliest reference that I can find, is in Dr. J. J. Bigsby's delightful book of travels, entitled "The Shoe and Canoe," published in 1850.

In the Quarterly Journal of Geological Science, for 1851, the same author, in a paper entitled the "Erratics of Canada," has a brief reference, on p. 218, to the lakes in the sheet.

Owen.

In the report of the Geological Survey of Wisconsin, Iowa and Minnesota, by Dr. Dale Owen, 1852, are references to the rocks of Little Vermilion, Sand Point and Namakan Lakes, on pages 317 and 318.

Hector.

In Captain Palliser's report of an exploration of part of British North America, Dr. James Hector under date 1857, gives a few geological notes, and a sketch map and section geologically coloured, of part of this region.

evine.

On a map, by Mr. Devine, of the north-west part of Canada, published by the Crown Lands Department of Upper Canada, in 1857, the

part of the area shown on this sheet south-east of Sturgeon Lake and Maligne River is geologically coloured as belonging to the Silurian system.

Prof. H. Y. Hind in his report on the Assiniboine and Saskatchewan district, 1859, has a reference, on page 165, to the glacial groovings on the gneissoid rocks of Sturgeon Lake. Hind.

In the Quarterly Journal of Geological Science, vol. XVII., 1861, page 438, Hector refers to the rocks of Sturgeon, Saganaga and intermediate lakes. Hector.

Dr. Bell, in his report on the country between Lake Superior and Lake Winnipeg, published in the report of this department for 1872–73, and also in his report published in the succeeding volume, 1873–74, on the country between the Red River and the Saskatchewan, with notes on the geology between Lake Superior and Red River, briefly records some of the geological features of the eastern part of this region. Bell.

Prof. N. H. Winchell, in the 15th, 16th and 17th Annual Reports of the Geological and Natural History Survey of Minnesota, makes occasional references to the geology of all the lakes on the American northern boundary. Winchell.

Brief references to the geology of this region have been made in the annual summary reports of this department for the years 1887, 1888 and 1889.

N. H. and H.V. Winchell, in their joint report on the Iron Ores of Minnesota, 1890, refer to the rocks of Saganaga Lake. N. H. and H. V. Winchell.

Mr. H.V. Winchell, in the "American Journal of Science," for May, 1891, publishes an article on the same rocks. H. V. Winchell.

In the same journal, for April, 1892, Dr. A. R. C. Selwyn publishes an article on the "Geological Age of the Saganaga Syenites." Dr. Selwyn.

Physical Features.

The whole of the area, comprised in this sheet, is of the "*rocky lake*" character described by Dr. Lawson* and presents, particularly in the schistose areas, the same intimate dependence of lake and river shore lines upon the direction of the strike, cleavage or lamination of the rocks.

The surface features of the country present a rough hummocky succession of low-rounded hills, with irregular depressions occupied by lakes and their connecting streams. Surface features. A few well marked continuous ridges, roughly parallel to each other, occur in the eastern part of Hunters Ridges.

*Geological Survey of Canada, Annual Report, vol. III., 1887-88, Part I., p. 11 F.

Island, the most important and regular of which is that running north-west of Knife and Cypress lakes and which consists largely of greenstones, with which are associated the jaspilyte and iron ores. These ridges run in a general north north-east direction. They follow closely the strike of the rocks, and continue with occasional depressions for from ten to twenty miles These hills are particularly high and precipitous in the schistose area, rising to a height of about 300 feet above the level of the neighbouring lakes. The shores of Emerald and Big Rock lakes are especially high and rugged, the ridge between them probably marking the line of greatest elevation in the area comprised in this sheet.

Arctic and Atlantic divide Branch watershed.

The watershed between the Arctic and Atlantic slopes passes between North Lake and South Lake, sixteen miles east of this sheet, in a west south-west direction, and a branch of this divide crosses the Swamp Portage, and thence in a sinuous line, but general westerly direction, across Hunters Island, separating the waters that flow around the north-east and north-west sides of the island from those that flow around the south-east and south-west sides to meet again in Lac la Croix ; whence they flow down the Namakan River through Namakan Lake to Rainy Lake. With the exception of the narrow neck of land crossed by Swamp Portage, the area known as Hunters Island is completely surrounded by water. The whole area comprised in this sheet lies on the southern margin of the Arctic basin.

Drainage of Hunters Island region.

Elevations.

Probably the highest lakes in the region are the small lakes north of Jasper Lake and Louisa Lake, neither of which can be much below the level of North and South Lakes at the main divide.

Assuming the level of Rainy Lake, as estimated by Dr. Lawson,* to be 1,182 feet above the sea, the elevation of Cypress Lake would be somewhere in the neighbourhood of 1,400 feet. The elevation of Lac des Mille Lacs, as determined by the Canadian Pacific Railway levels, is 1,500 feet above the sea, which is probably higher than any lake in this area. All the estimates of the earlier explorers, of the elevation of the lakes at the height of land, seem to have been considerably too low, while Prof. N. H. Winchell's† estimate of the elevation of Saganaga Lake (1,518 feet) would seem to be a little too high, the highest land, however, in the area, can hardly be less than 1,800 feet, attained not only by the ridge north of Knife Lake, but also in all probability by that skirting the south-east shores of Louisa, Glacier and McEwen lakes.

Previous estimated elevation.

*Geological Survey of Canada, Annual Report, vol. III., 1887-88, Part I., p. 14 F.

†Geological and Natural History Survey of Minnesota, 1872-1882.

The greatest depth found, *280 feet, was in Agnes Lake, two miles from its southern extremity. Depth of water in lake

The following short list of soundings will convey a good general idea of the maximum depth of water usually found in these lakes, which would seem to bear about the same proportion to the height of the hills surrounding them, that the area of lake surface bears to that of the land.

SOUNDINGS OF LAKES IN THE HUNTERS ISLAND REGION. List of soundings.

	Feet.
Namakan Lake, western part	48
Namakan River, expansion, south-west of Captain Tom Lake	34
Sand Point Lake, bay on east side near southern end	70
do southern expansion	43
Pooh-Bah Lake, north side	50
do south-west bay	50
Chatterton Lake, central part	27
McDougall Lake, northern part	30
Keefer Lake, centre	72
Lake north of Keefer Lake	70
do do north-western part	50
Kashapiwigamak Lake, two miles from southern extremity	130
Hulburt Lake, one mile from southern extremity	33
Lake south of Hulburt Lake, western part	25
Williams Lake, northern arm	33
do middle of south-west part	75
Kahnipiminanikok Lake, two miles from northern end	80
do three do	62
do four and one-half miles from northern end	108
Murdoch Lake, southern part	14
Western outlet of Agnes Lake	13
Agnes Lake, eastern arm	94
do four miles from southern end	35
do three do	102
do two do	*280
Robin Lake, southern part	18

The whole country is, as a rule, very thickly clothed with forest. Most of the trees are, however, evergreens, and no hardwood trees, with the exception of a very few elms *(Ulmus Americana)*, soft maple *(Acer rubrum)* and, very rarely, small ironwoods *(Ostrya Virginica)* were anywhere seen. In parts of the country that have not been more or less recently swept by fire, the principal trees are white pine *(Pinus strobus)*, red or Norway pine *(Pinus resinosa)*, jack pine, called by some pitch pine *(Pinus Banksiana)*, and spruce, probably of the two varieties, white and black *(Picea alba* and *P. nigra)*; these are, as a rule, somewhat small in size. Canoe birch *(Betula papyrifera)* is also a very common tree, but, usually, it does not in this part of the Forests. Variety of trees found.

country grow to a sufficient size to furnish good bark for canoes. Very rarely the silver or yellow birch *(Betula lutea)* is seen of small size. The aspen poplar *(Populus tremuloides)* is very abundant, growing to large size in unburnt forests, and forming the sturdiest and quickest second-growth in portions that have been swept by fire. White cedar *(Thuya occidentalis)* is sometimes seen where the soil is deeper than usual, generally in somewhat marshy places and lining the banks of streams; it rarely attains to any very large size and, although widely, is sparsely, distributed. Tamarack *(Larix Americana)*, sometimes of considerable size, is generally found in the more extensive marshes. The balsam or fir *(Abies balsamea)* is a very common tree, but is usually smaller and less abundant than the spruce. Basswood Lake is supposed to have been named after the tree of that name, but I have seen no basswood in this part of the country, and Dr. Bell* reports that there is none, and that the name was probably taken from the whitewood or balm of Gilead *(Populus balsamifera)* which is abundant on the shores of the lake. Basswood is erroneously called whitewood by some. The Indian name of the lake is Bassmenani Sakahagun, and the first French name for it is Lac des Bois Blancs. From this it may be conjectured how the present name has been evolved.

Basswood.

Comparatively a great part of the country embraced in the area mapped has been ravaged by fire within the last half century. These devastating fires, which do so much to mar the beauty of the scenery and destroy the timber, are too often caused by the carelessness of explorers, prospectors and hunters; the Indians are very careful to extinguish their fires during the dry season; but it is to be regretted that the fatal carelessness of others cannot be checked; the amount of valuable timber thus destroyed is mutely but strongly attested by the gigantic half-burned dead pines which, towering in the air, add so much to the wildness and desolation of the scene. Where sufficient time has elapsed a dense second-growth has sprung up, consisting, in places, almost entirely of jack pine, thickly clustered, sometimes of more thinly scattered, birches and poplars, but generally of all three with the addition of spruce. Frequent clumps of Norway pine often break the monotony of the burnt country. These trees remain unscathed, and where they are thickly clustered have often arrested the progress of the fires in that direction.

Forest fires.

From the character of the woods noted on the lake shores, a general idea of the extent of these fires can be gathered.

Extent of forest fires.

*Geol. Sur. of Can., Rep. of Progress, 1872-73, pp. 87-111.

Below is a list of the lake shores which, in 1888, were observed to have been at different periods swept by forest fires which have destroyed the best timber :—

List of localities where traces of fires were observed in 1888.

Namakan Lake, isolated small areas.
Lac la Croix, west shore of western part.
Tanner's Lake, all the north shore.
Sturgeon Lake, nearly all the north shore.
McDougall Lake, eastern half.
Chatterton Lake, eastern part.
Keat's Lake, all the shores.
Shelley Lake do
Kahnipiminanikok Lake, western side of northern part at intervals for seven miles along the channel to Williams Lake.
Long narrow lake, north of Agnes Lake, western outlet.
Agnes Lake, northern part.
do western shore for nine miles to within one mile of southern extremity.
do north-west shore of bay to north-east, and on eastern shore of main lake for one mile and a half north of the mouth of this bay.
Sunday Lake, northern shore.
Burk Lake, all except one mile of southern shore.
Basswood Lake, north-eastern half of north-eastern part.
Shade Lake and lake north-west of it, and small lake south of it, all shores.
Noon Lake.
Lake Silence, southern three-quarters.
McNiece Lake, eastern shore.
Kashapiwigamak Lake, both shores for four miles from southern extremities.
Wicksteed Lake, western shore.
Lake south of above, all the shores.
William Lake, eastern part.
Conmee Lake, west shore and south-eastern bay.
Pooh-Bah Lake, all except north-western arm and north shore.
Brent Lake, north shore of eastern part and both shores for one and a half miles from eastern extremity.
McIntyre Lake, all except northern bay.
Sarah Lake, all shores.
Small lake south of Sarah Lake.
McKenzie Lake, southern part, and northern shore of arm of Kahnipiminanikok Lake for two miles west of it.
Kahnipiminanikok Lake, south-east shore of arm, for two and one-half miles from mouth of Kahwawiagamak River.
Bird Lake, and southern part of bay of Kahnipiminanikok Lake east of it.
Robin Lake, and small lake tributary to Agnes Lake south of it.
McEwen Lake, eastern side, and portions of western side.
Wet Lake, all shores.
Glacier Lake do
Louisa Lake, all shores except at southern extremity.
Cross Lake, all shores.

Saganagons Lake, Deadman Point and shore south of it to eastern extremity of lake, and north shore for three miles west of this extremity.
Ross Lake, all shores.
Beaver Lake, all shores.

Probable extent of these fires.

Without exploration, the distance to which these fires have penetrated into the interior from the lake shores, is a matter of conjecture; in many cases it is known not to be far, and probably owing to the increasing dampness of the woods in the more sheltered interiors, as the lake shores are receded from, the fires could not spread to any great distance except by repeated burnings in successive seasons; on the other hand, from the close contiguity of some of the lake shores which betray the evidence of forest fires, and from the contemporaneity of these fires on different lakes, as indicated by the second-growth timber, it is to be feared that in many cases the fires have swept over the whole intervening country from lake to lake.

A proportional estimate of the country which has thus suffered is somewhat difficult to arrive at, but in the field I concluded that not less than one-sixth of the whole area of this region had been ravaged by fire.

Periods of fires.

The second-growth timber would seem to indicate three main periods of conflagration. The first period would seem to have been about the year 1870, and the second about the year 1879 or 1880. Professor Macoun states that no extensive fires had occurred in the vicinity of Port Arthur and along the line of the Dawson route prior to 1869, and that, in 1870, fires were very general and destructive owing to the carelessness of the troops who passed over the Dawson route in that year. It is certain, however, that fires were prevalent along the line of the Pigeon River route (international boundary) long before this date, as Dr. Bigsby, in his "Shoe and Canoe," quoted above, refers to the bare hills of Saganaga Lake, and in one of his scenic sketches of Lac la Croix, the country is represented very much as it is now in that respect.

The last period of fires seems to have been quite recent, and to have affected for the most part those districts already burnt.

Pine.

There is much good pine timber in the unburnt areas, but the largest trees do not grow on the lake shores. The distribution of white pine is very general, although it bears but a small proportion to the forest timber. The finest pines were seen on Trout and Darkey lakes, the western part of Brent Lake, the south-east part of Sturgeon Lake, at several places on Kahnipiminanikok Lake, and in the northern part of Silence Lake. Isolated groves of medium-sized white pine are seen on the western side of McEwen Lake and on the north-

western shore of Russell Lake. Some fine trees were seen on Williams and Hulburt lakes, and around the south part of Brent Lake.

Regarding the character of the canoe routes traversing the district, a few words may be said for the guidance of future travellers. All the portages known are indicated on the map, the length being usually given in chains. The word "portage" is printed, where space is available on the map, on that side of the watercourse on which the path is to be found. Canoe route.

Those routes, which on the map are seen to be the shortest and to have the fewest portages, are not always the best, and are sometimes impracticable, from the number of rapids and shallows.

Of the two main routes from Lake Superior to the North-west, above referred to, *viâ* Rainy Lake, the one by Lac des Mille Lacs and the Dawson route through Sturgeon Lake to Lac la Croix, is, in the opinion of the writer, decidedly the easiest to travel, though much the less interesting to the geologist or explorer. Dawson route to the North-west.

The Pigeon River, or Grand Portage, or International boundary route, traverses the whole of this sheet. Between Saganaga Lake and Lac la Croix, the watercourse around the northern side of Hunters Island affords an alternative route. The distance between these two lakes by either route is about the same. There are fewer portages on the southern or boundary route, and there are no lengthy rapid streams which are dangerous to descend and difficult to ascend. By this route also the portages are better cut out and more easily found, but the lakes are larger and more intricate, and it is difficult for a stranger to detect at once the shortest way through them. Pigeon River route.

The old Dawson route led by one portage, four miles long, from Lac la Croix to Sand Point Lake; this portage is now overgrown with thick bushes and is impassable, and the traveller has the alternative of going round by the boundary line (the original route) which is undoubtedly the best, or of taking the Namakan River from Lac la Croix to Namakan Lake. This river is very rapid and turbulent: it is unsafe for the traveller without a guide who is thoroughly conversant with its many treacherous rapids and falls, and it is extremely laborious to force a canoe against its strong current. With small canoes and when the water is high a much better passage is afforded by the watercourse shown south of this river and north of David and Thompson lakes. Nequaquin Portage. Namakan River.

A route exists between Lac des Mille Lacs and Kahnipiminanikok Lake, by Kashabowie and Shebandowan lakes, and Kawawiagamak Lake and River. I am told there are twelve portages on this route, Kawawaigamak River route.

some of which are about a mile long, but that otherwise the route is a good one.

Means of access to Keewatin belt of rocks.

From Port Arthur the readiest access is obtained to the Keewatin belt of rocks in the south-eastern part of Hunters Island, by the railway to Whitefish Lake, thence by Whitefish and Arrow Lakes to the Pigeon River or boundary line route. From Cypress Lake, the upper series of these rocks is reached by Jasper Lake to Saganagons Lake, northward, and by Big Rock and Emerald lakes to Carp Lake southwestward. The portages are short and well cut out, having been prepared for the passage of testing machinery to the iron ore locations on Jasper Lake.

Routes between Sturgeon and Basswood Lakes. Agnes Lake route.

The best route between Sturgeon and Basswood lakes is that by Russell, Chatterton, Kahnipiminanikok, Agnes and Sunday lakes. An alternative, doubtfully preferable, is offered between Agnes and Basswood lakes, by Silence, Sultry, Noon and Shade lakes. This was the old route of the Hudson Bay Company.

From Sunday Lake to Basswood Lake the traveller may pass directly by the North Portage, or by Burk Lake and three short portages, as best serves the object of his journey. Agnes Lake has two outlets into Kahnipiminanikok Lake, of which the eastern one, by Bird and Robin lakes, affords much the best route.

Kashapiwigamak Lake route.

A shorter route between Sturgeon and Basswood lakes, is afforded by Keefer, Kashapiwigamak and Yum Yum lakes, but the portages between Kashapiwigamak and Basswood lakes more than counterbalance this advantage. The alternative route between Shelly and Kashapiwigamak lakes, by Kahnipiminanikok, Williams and Hulburt lakes is in no respect to be preferred.

Darkey Lake route.

The best of the more direct routes between the western part of Sturgeon Lake and Basswood Lake, is afforded by Tanner's, Darkey, Trout and Crooked lakes. Three of the portages are rather long, but the footing on them is good, and with lightly laden canoes time could probably be saved by going this way rather than by making the long detour by Lac la Croix ; in any case it requires less time and labour to traverse the western than the eastern side of Hunters Island.

Winter route.

The most direct route through Hunters Island crosses from the southwest end of Sturgeon Lake, at the Maligne dam, across Pooh Bah, Conmee, Brent, McIntyre and Sarah lakes to Basswood Lake. On account of its directness, and the absence of steep hills on the portages, this is a favourite route with the Indians and the traders in the winter with dogs and toboggans, but it is never travelled during the summer ; of the twenty-two miles, from the Maligne Dam to Basswood Lake, nearly six are taken up by portages.

From Sarah Lake to Basswood Lake there is a route by a chain of lakes, indicated in dotted outlines on the map; of the five lakes on the route, two are reported by my Indian guide to be comparatively large, and of the seven portages, the one into Basswood Lake is said to be a long one. Between Brent and Sarah lakes there is a chain of lakes, indicated in dotted outlines on the map, which affords an alternative route over four portages, only two of which are said to be of any great length. Lakes not surveyed.

These constitute all the canoe routes in this area, which the explorer is likely to have occasion to travel.

ARCHÆAN ROCKS.

The rocks to which this report refers are divisible into the same groups as those established and described by Dr. Lawson* in the Lake of the Woods and the Rainy Lake districts. They are: A, Laurentian; B, Huronian; b-1, Coutchiching; b-2, Keewatin. The upper series consists of micaceous and hornblendic schistose rocks, for the most part fine-grained. The field evidence fails to determine satisfactorily whether any of these rocks are of sedimentary origin, but they exhibit abundant evidence of having been subjected to great thermo-mechanical metamorphism. Upper group of Archæan rocks.

This series is divisible into two minor series, named by Dr. Lawson the Coutchiching and Keewatin, the former of which is essentially micaceous and felspathic in its character, and possibly derived from original bedded gneisses. The upper division is more varied in character and includes hornblende schists, micaceous hornblende schists, hydromica schists, quartz porphyries, grauwackes, felsitic schists, conglomerates and agglomerates, with which are associated more or less altered volcanic rocks, and volcanic ashes. Of these minuter subdivisions, I am unable in all cases to delineate the distribution from my notes, as this work was to be done by Dr. Lawson; and no uniformity of sequence appears to be discoverable in them, so that they are all included in the one colour, the localities where I am familiar with them being indicated by letters in red, referring to notes on the margin of the map. Coutchiching and Keewatin series. Rocks of Keewatin series.

The lower division of rocks, of the granitic and syenitic type of mineral composition, is in this field, for the most part, granitoid in character, and present many phenomena suggestive of the igneous irruptive origin of their present attitude with regard to the schistose series. Laurentian rocks.

* Geol. Survey of Canada, Annual Rep. vol. I., 1885, 29 C. C., and vol. III., 1887-88, p. 21 F.

Subdivision of Laurentian rocks.

It might be possible to map the distribution of the different lithological phases of the Laurentian, but my notes are unfortunately too incomplete to do this satisfactorily. From minuter observations made elsewhere since this work was performed, I think that this subdivision is more important than it has hitherto been considered, and that we may have in the hornblendic and in the micaceous phases of these granites, rocks of different ages, the relative age of which is determinable, and the discovery of which may throw much light, not only on the genesis of the Laurentian, but on its relations to the overlying Coutchiching and Keewatin groups.

A. Laurentian.

Designation of areas.

For convenience of description and for future reference, a name will be given to each geographically separated important area of Laurentian rocks. While a broad general similarity of character and of mode of occurrence obtains between the rocks of these distinct areas, each possesses individual characteristics which demand attention, and they are all separated by intervening belts of upper Archæan Huronian rocks.

Kawagansikok area.

I. The granitic rocks on Sturgeon Lake and the lakes to the east as far as Shelley Lake, belong to a very large Laurentian area, the western part of which is closely defined. Its general outline forms an elongated oval, with a rounded excrescence on the south side. It is known to be over twenty-two miles wide, north of the western part of Sturgeon Lake, to the east of which the extension south of Russell Lake adds eleven miles. The longest axis has a general direction of 10° N. of E. and S. of W., and cannot be much less than one hundred miles in length. The largest portion of the area, that north of the limit of this sheet, is characterized by the great abundance and persistence of bands of mica schist.

This area will be referred to as the "Kawagansikok Area" from the largest and best known lake in its central portion.

Pooh-Bah area.

II. The rocks surrounding Pooh-Bah Lake are lithologically distinct from those of all the other areas, and from this fact and from a certain doubt entertained as to their relative age, they require a separate designation, and the area will be referred to as the "Pooh-Bah Area."

Hunters Island area.

III. The broad belt of granitic rocks which extends all across the area embraced in this sheet, also for more than sixty miles to the west of its western boundary, and for about forty-five miles E. N. E. of its north-east corner, will be referred to as "Hunters Island Area." The rocks of this area are, in lithological character, typical generally of all the Laurentian rocks of north-western Ontario and northern

Minnesota, so far as these are known; but the shape of the area in its irregularity of outline and great length (over two hundred miles) compared with its breadth (nowhere over twenty-five miles and rapidly tapering from the centre each way to extend in long narrow tongues) presents a marked contrast to the usual oval or egg-shaped areas of the granite gneisses in this country.

Saganaga area.

IV. A portion of a granitic area is exposed around Saganaga Lake which, so far as its outlines have been determined, would seem to be of comparatively regular ovoid form; about sixteen miles in extreme width; and about sixty miles long, in a direction N. 60° E. of which forty-five miles will be mapped on the sheet east of this. This area will be called the "Saganaga Area," from the name of the best known and most important lake within it.

Lithological peculiarities of each area.

The rocks of this area present some lithological peculiarities, and differences of opinion prevail as to their age, which will be briefly alluded to in a later part of this report.

I. KAWAGANSIKOK AREA.

Limits of area.

The limits of this area have been already defined as far as they encroach upon the district under consideration. This portion of the area so far from presenting the feature of containing bands of mica schist, so characteristic of the area to the north, appears to be unusually free from them, even in close proximity to the occurrence of these rocks to the south. A few localities in which these bands occur have, however, been already noted.

Sturgeon Lake portion.

Description of rocks.

The rocks north of Sturgeon Lake are of typical pink-gray granite gneiss, usually distinctly foliated on the islands and on the more southerly points of the north-west shore, but appearing less distinctly so, as the distance from the line of contact increases. A hard, red, fine-grained granite, almost devoid of mica, hornblende or any of their decomposition products, occurs on the north side of the narrows at the east end of the western portion of Sturgeon Lake. Here a feature, very common, particularly in these felsitic granites of the Laurentian, is seen, viz., a parallel system of jointing planes a few inches apart. The constituent minerals of the rock do not show any parallelism of arrangement.

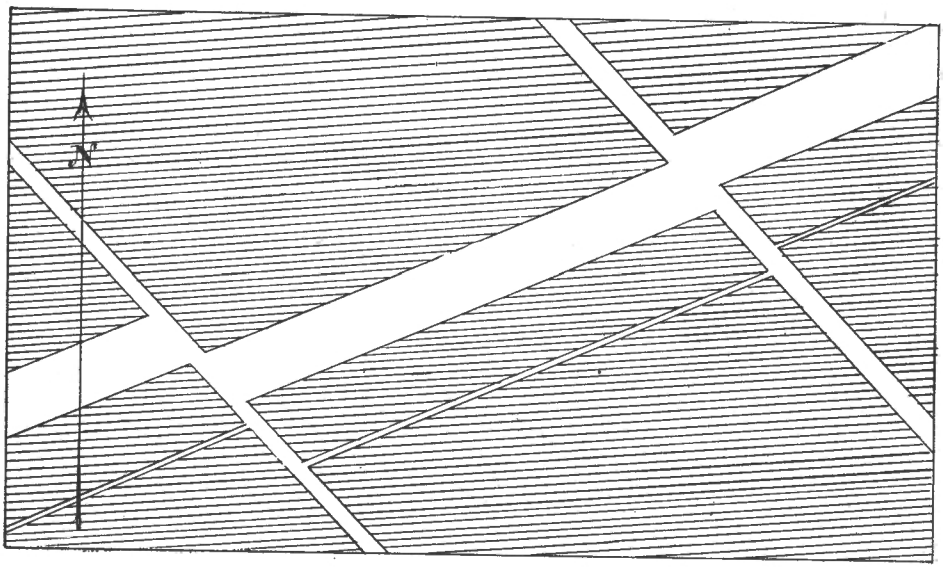
Jointing planes.

Pegmatite.

On the north-west shore of Sturgeon Lake, the rocks are also characterized by the presence of small irregular areas of very coarsely crystalline rock, or pegmatite; sometimes these areas are irregularly circular in form and sometimes gradually merge, by diminution in the size of the crystals, into the ordinary medium-grained granite, but as a rule there is a more or less sharp line of demarcation. Very frequently

the pegmatite occurs in distinct and uniform veins. A most excellent example of such veins is figured below, from an occurrence on the point between the two bays close together. and running north from the centre of this part of the lake.

Fig 1



The unshaded portions represent the veins of coarsely crystalline quartz, orthoclase and bleached mica. The figure is correctly drawn to a scale of eight feet to an inch, and the veins are as regular and straight as represented. As a rule however the veins are not so straight and uniform. The shading lines represent the direction of the foliation planes of the inclosing gneiss. From the "faulted" occurrence

Faulted veins.

of the veins, it would seem that they have been filled in, probably by infiltration from the inclosing rocks, after the gneisses had been cracked and faulted, as the age of the veins running in both direc-

Muscovite.

tions is evidently the same. The rocks of that portion of this area, in which are Russell, Chatterton, and the smaller lakes to the south, are characterized for the most part by the presence of muscovite, sometimes associated with, sometimes replacing, the biotite constituent of the granites. The presence of muscovite does not appear to have any

Garnets

especial significance, but it is observed that the presence of garnets in the granite gneiss, which in this part of the area is a notable feature, appears to be, in a measure, a function of the presence of muscovite.

Muscovite granites are particularly noted on the western part of Russell Lake and a little muscovite occurs in all the red granites around the shores of the south-eastern extension of Sturgeon Lake and of the lakes to the east tributary to this, and on the west side of Chatterton Lake where the granites are a dull whitish colour. Muscovite is the only micaceous mineral in the rocks of the south-east bay of McDougall Lake. Muscovite as well as biotite occurs in the rocks of the east side of Chatterton Lake. Localities of muscovite granite.

Garnetiferous granite gneisses are characteristic of the shores of the eastern or rather central expansion of Sturgeon Lake (a large expansion north of the northernmost point of Hunters Island is locally called this), particularly on the southern shores, and on the south side of the channel to the north-eastern part of the lake above referred to. Garnetiferous rocks of Sturgeon Lake.

Pegmatitic granite is of such frequent occurrence around this portion of the lake as to form a large proportion of the rock exposures. It occurs principally in irregular patches, often 100 feet or more across; sometimes a gradual differentiation of the pegmatite into the medium-grained granite is observed, but as a rule a more or less distinct line of demarcation is noticeable. Occurrence of pegmatite.

South-east of this, in the extreme south-eastern expansion of the lake, some straight uniform veins of pegmatite, only two or three inches wide were observed, cutting the red granite, which is here devoid of structure and contains a very little muscovite mica. The veins have weathered more than the inclosing granites, and form shallow channels or troughs in the surface of the rock.

It has been observed that, speaking generally, this aggregation of coarse crystals in veins and irregular areas, usually consists of orthoclase quartz and mica in the granitic rocks, and as a rule, almost wholly of white orthoclase with a small proportion of quartz, but with little or no mica in the Coutchiching and Keewatin rocks; and that in these latter the orthoclase crystals do not attain to so large a size. A much more frequent exception to this rule is found in the felspar rock, as distinct from pegmatite, associated with the granites, than in pegmatite associated with the newer rocks. Distribution of pegmatite and felspar rock.

At the north-east end of the main body of Sturgeon Lake, a bedded structure is apparent in the rocks. This, however, is probably a series of jointing planes simulating this structure. Bedded structure.

II. THE POOH-BAH AREA.

Limits of Area, Character of Contact and Lithological Characters.

The rocks of this area may be generally described as very coarsely crystalline aggregations of hornblende and felspar, generally ortho- Description of rocks.

clase. The felspar crystals are often twined, but they seldom exhibit the fine striation due to multiple twining, characteristic of plagioclase. While individual felspars attain to sizes larger than neighbouring crystals, the rock is not a true porphyry. On an island one-third of a mile south of the prominent point on the west side, felspar crystals were measured three inches in length; here the rock is intersected by jointing planes, but with no uniformity of direction. In places, particularly on the west side of the lake, a rough parallelism of arrangement among the constituent minerals is barely discernible on the surface, and sometimes the rock shows an inclination to cleave in parallel directions under the hammer, but it cannot be described as being foliated.

Hornblende granite.

In some localities the hornblende syenite merges into a finer-grained hornblende granite, by the addition of a little quartz, and on the western part of the large island, in the northern part of Pooh-Bah Lake, the rock becomes quite fine-grained. In some localities, associated with the hornblende syenite, is a finer-grained, decomposed, greenish-black felspathic hornblende rock, containing sometimes a pyroxenic constituent, and generally many disseminated scales of black mica.

Decomposed felspathic hornblende rock.

These are probably local phases, where the felspar has become subordinate and the hornblende partly changed to chlorite, with the biotite developed as an accessory mineral.

Localities where this rock occurs.

Occurrences of this rock were observed at the south-west end of Pooh-Bah Lake, near the portage; on the north-west shore, one mile north-east of the portage; and at several points along the south-east shore, to the eastern end; but none were observed in the more central portions of the area.

At the point on the south shore, near the east end of the lake, associated with this decomposed rock, is a hard black coarsely crystalline hornblende felspar rock, the felspar apparently one of the triclinic varieties (diorite).

Limits of Pooh-Bah area.

Wink Lake.

The Coutchiching rocks of Wink Lake are represented by fine-grained light gray evenly laminated biotite gneisses; on the south shore merging into felspathic mica schists, elsewhere, particularly on the northern end of the lake, sometimes containing siliceous nodules. The syenites are represented on this lake apparently only by a red medium-grained hornblende granite, containing some large crystals of felspar perhaps porphyritically developed. This rock is lithologically the same as the dark gray medium-grained rock found associated with the hornblende syenites of Pooh-Bah Lake, on an island near the south shore one mile and a quarter east by north of the portage from Wink Lake.

Hornblende granite is seen in various exposures for three-quarters of a mile on the north-east side of Wink Lake, where indicated, and on the adjacent islands. Its contact with the mica schist is concealed under the waters of the lake or under the boulders and marshy land of the shore.

North side Pooh-Bah Lake.

The outlet of Pooh-Bah Lake is eroded entirely out of the mica schists and on the west shore of this lake south of the outlet, the contact line can be very closely located by the proximity of adjacent exposures of each variety, although the actual junction is concealed. The whole of the north shore of Pooh-Bah Lake is occupied by mica schist, becoming in places, particularly near the syenites, very hard, compact and fine in texture, and hornblendic in composition.

On an island near the north shore, forty-five chains east of the portage to Hoffmann Lake, is an almost aphanitic, hard grayish-black rock, containing very much iron pyrites, very slightly schistose and resembling a fine diabase; it is, however, close to the line of junction and strictly parallel with it. A continuation of the band is seen on an island to the north-east and on the main shore, where it is more schistose and less fine-grained. In this band, where schistosity is visible on the last island mentioned, the planes of schistosity are much contorted, and the rock is cut by bands of granite and felspar rock.

The contact line can be traced with considerable accuracy through the islands and between them and the main shore, and although it cannot be seen exactly in the north-east bay, it can be located within the limits of accuracy definable on the scale of the map.

The whole of the eastern and southern shores of the lake, as far as can be judged from the comparatively few exposures they afford, is occupied by the hornblende syenites, with their local varieties.

Contact in south-west end of lake.

A single exposure of mica schist on the extreme south-west shore, with several exposures of very coarse-grained hornblende syenite a few chains east of it on the north shore, define the contact with the mica schists, which are exposed at intervals across the portage to Wink Lake.

Metamorphism of schists near contact.

It is here observed that the mica schists become less massive and compact as the distance from the syenites increases.

Contact south of Pooh-Bah Lake.

The contact can be again located with considerable accuracy on the first lake south of Pooh-Bah Lake, on the winter route to Conmee Lake, and the contact line from here to the last determined point is probably closely approximate as laid down.

Limits of area east of Pooh Bah Lake.

East of this the line of junction is conjectural, and is inferred to be approximately located as indicated on the map, from the convergence

of the strike of the mica schists in their most easterly exposures, to the north and to the south of Pooh-Bah Lake. It has been found that the line of contact is conformable with the strike of the rocks, and from the rapid convergence of these strikes it would seem evident that the syenites do not extend very far east. The ovoid termination given to the area is representative of the usual form assumed by these small areas, wherever they have been worked out accurately. The country between Pooh-Bah Lake and the eastern part of Sturgeon Lake is very rugged and affords no means of access by canoes, and very few exposures of rock certainly *in situ* are revealed.

Possible continuation of granites south-east of Sturgeon Lake.

It is possible that this area connects geographically with, and is a western extension of, the granite area south-east of Sturgeon Lake; but this is very unlikely, in consideration of the probable and revealed directions of structural planes already detailed, and from the great dissimilarity, in general characters, between the rocks of the two areas and from a well-founded doubt as to their being of one age.

General character of contact.

From the foregoing, it will be seen that the syenites and mica schists were nowhere observed in actual contact, but from the close proximity of adjacent exposures of the two classes of rock, from the absence of bands of mica schist in the syenites and of the syenites in the mica schists, the brecciated aspect of the contact so characteristic of the granites elsewhere, seems to be here entirely wanting.

Outcrops of felspathic hornblende rock.

Several outcrops of the greenish-black micaceous hornblende rock described as associated with the syenites are found in very small areas among the mica schists, particularly at the south-east end of Wink Lake.

Reasons for correlation of rocks of William Lake with those of Pooh-Bah Lake.

The small area of rocks mapped in the same colour as the Pooh-Bah area, extending from William Lake to form the tongue of land in the western part of Brent Lake, are assumed to be of the same origin and age as the Pooh-Bah syenites, from the strong similarity between them and the associated greenish-black felspathic hornblende rocks of the latter.

Character of hornblende rocks of William and Brent Lakes.

They may generally be described as coarsely crystalline, hornblende rocks, frequently containing a felspathic constituent and occasionally having some scales of black mica, probably secondary, associated with them. The felspar cannot be determined macroscopically, but appears to be orthoclase. The structure in the field has been very closely worked out, and the map exhibits their relations to the mica schists and granites with all the accuracy possible to the scale. These

Surrounded by mica schist.

rocks are observed to be nowhere in direct contact with the granites, but to be surrounded on all sides by mica schist strictly conformable in its strike to the outline of the hornblende rocks. The band of mica schists intervening between them and the granites to the east is only a few chains wide.

The aspect of the hornblende rock in its relations to the mica schist, is that of an eruptive boss. On the south-east side of William Lake, about thirty chains north-east of the portage into Brent Lake, and in the west bay of the latter, the mica schist is seen to be very much contorted and crumpled. In William Lake, associated with the crumpled mica schist, are bands of granitic rock very similar to the bands found usually in the contact zone between the Laurentian and the Coutchiching rocks, and these bands, quite conformable with the schist with which they are intercalated, have suffered the same contortions. They may be later segregations, but it is difficult in the field to avoid the conclusion that the structure is due to a later intrusion of the hornblende rocks through the contact zone between the Laurentian and Coutchiching rocks. In that case, as the date of folding of the Coutchiching and Keewatin rocks was in all probability the same, these hornblende rocks would be Keewatin or post-Keewatin in age. Eruptive character.

This may or may not involve the age of the Pooh-Bah syenites, as the correlation of the two is a doubtful one; but as the question involves broad and general issues, it will be discussed later under "Theoretical Considerations."

III. "THE HUNTERS ISLAND AREA."

As before stated, the rocks of this area are typical of the Laurentian series in this part of the country, and a general description of them applies also to the Kawagansikok area partially exposed in the area of this sheet. Typical rocks.

The rocks vary in colour from white through shades of gray and pink to dark gray and deep red. In texture, they vary from almost aphanitic, in the unmicaceous varieties, to such extreme coarseness of crystallization, as to characterize them as pegmatites, nor can any general law be as yet formulated which the rocks seem to follow in this particular. Description of rocks.

Sometimes large crystals of orthoclase developed porphyritically in a finer-grained ground-mass, are observed, but no deduction with regard to any stratigraphical significance of these occurrences could be drawn from such observations as were made in this connection. Porphyritic structure.

The foliation of the granites has been observed with some care, and while it may be stated as a general rule, that in the neighbourhood of upper Archæan areas the granites are more or less distinctly foliated, and that in the central portion of granitic areas the rocks show very faint traces, if any, of this foliation, still, the rule is by no means without exceptions to both statements. The localities where the rock exhibits very few or no traces of parallelism in the arrangement of its constituents, are indicated on the map by short red lines drawn Foliation.

in all directions, and can be considered as reliable only on the shores of the lakes; those localities where the rocks are more or less distinctly laminated are indicated by a parallelism and continuity in the direction of these red lines; again these give reliable information only on the lake shores, where they have been observed, and where corroborated by the strikes shown; however, it is probable that the structure thus indicated is the true one.

Composition. In composition, the rocks are usually biotite granites in which the orthoclase and quartz are very constantly present; but the biotite is often replaced by, or associated with, muscovite or hornblende, and in many places these bi-silicates are changed to chlorite. It is probable that a minute proportion of plagioclase is a more or less common constituent, but in the Kawagansikok and Hunters Island areas it can seldom be detected by the unaided eye.

Limits of area. The limits of the Hunters Island area, in so far as it occurs in Canadian territory on this sheet, have been already described in defining the limits of the Huronian, or upper Archæan, rocks.

Namakan Lake. The Laurentian rocks of Namakan Lake are massive reddish granite, for the most part not foliated, although in places faint structural lines are visible. This granite holds in places bands of mica schist, which would appear to be large included fragments broken off from the main series.

Sand Point Lake felsites. On the east side of Sand Point Lake at, and on the prominent point north of, the narrows in the southern part, the granite changes into a very fine-grained hard red rock, containing very little if any bi-silicate, and is more truly a felsite than a granite. No foliation of the constituent minerals is observable, but it is intersected by well marked sharp cleavage or jointing planes in three directions: One horizontal, the other two vertical and nearly at right angles to each other; these planes cut the rock into small rhomboidal blocks, often less than a foot in largest measurement, although in places the blocks are very large. This is a very common feature, particularly in the felsitic granites. The change from this phase of the granite to the more micaceous and coarser variety, appears to be somewhat gradual, and there is little doubt that the felsites are merely local phases.

Jointing planes.

Localities of felsites. This felsitic phase of the granite is not at all uncommon, and is seen in many places, among others:—

Kahnipiminanikok Lake. On Kahnipiminanikok Lake, on the west side of the two large islands extending from the second to the fifth mile from the northern end, and on the main shore opposite.

On the lake south of Hulburt Lake.

On the south part of Agnes Lake. Here a gradual transition from the felsites (by the introduction first of chlorite, then of biotite, accompanied by a gradually increasing coarseness of texture) into the ordinary biotite granites, is seen, not only in the direction of the structural planes, which are almost indiscernible in the felsites, but also across this direction. Agnes Lake.

Felsites are seen north-west of Louisa Lake, where in places they are quite aphanitic and become a felstone.

About the narrows between Sand Point and Vermilion Lakes the granites have a porphyritic structure. The rock is massive and granitoid. Sand Point Lake.

On the boundary route from Lac la Croix to Basswood Lake many varieties of typical Laurentian granite and granite gneiss are seen; but the rocks are generally faintly foliated, pink, biotite granite gneisses. Lac la Croix to Basswood Lake.

Dr. Bell* describes the rocks of Basswood Lake, east of the Hudson's Bay Company's post, as "rather fine-grained, bright, light gray and reddish-gray syenite, consisting of crystalline white or red felspar and black hornblende, with more or less quartz in some parts." Basswood Lake rocks.

In Wicksteed Lake the rock is very coarse-grained, in many localities pegmatized, particularly on the south shore; is usually light pink and not foliated, and is characteristically a muscovite granite. On the northern shores it becomes a medium-grained muscovite biotite granite gneiss, somewhat distinctly foliated. Wicksteed Lake.

On the lake south of this, and west of Darkey Lake, the muscovite granite is deeper in colour, finer in texture and contains a little biotite.

It has been thought advisable to indicate on the map the localities where muscovite occurs as a more or less prominent constituent of the granites, and this has been done by placing the letter *(a)* in red in such places. Similarly the occurrence of garnets is indicated by the letter *(b)* in red on the face of the map. Muscovite localities.

The eastern shore of the southern part of Darkey Lake is occupied by coarse-grained reddish biotite gneiss, associated with some subordinate bands of mica schist. On the west shore almost continuously, is exposed a dark reddish-gray micaceous gneiss, quite distinctly foliated in bands, with more massive phases intervening. Darkey Lake.

The rocks of Conmee Lake, and the western part of Brent Lake, have been already described. In the north-westerly bend of the latter, between the eastern and western parts, the granites on the west side Brent Lake.

*Rep. of Progress Geol. Survey of Canada, 1872-73. Report on the country between Lake Superior and Lake Winnipeg, p. 94.

present high precipitous cliffs, due to vertical jointing planes. In the eastern part the rocks are pink biotite muscovite granites, rather distinctly foliated. A very light gray gneiss is seen on the north side near the portage on the route to Pooh-Bah Lake, in which the alternate bands of white and dark gray rock are uniform, and the laminæ much distorted; the bands in which the biotite predominates are comparatively far apart and give the rock a streaked aspect.

McIntyre Lake.

On McIntyre Lake the granites are rather fine-grained, deep pink, and indistinctly foliated; the same rock is seen on Sarah Lake. On an island at the east end of the latter the granite is darker in colour, and affords macroscopically distinct evidence of having been sheared.

Graphic quartz.

A peculiar graphic granite is seen at an exposure at the north end of the small lake south of Sarah Lake, where a red felspar, in medium sized crystals, is associated with irregular grains of quartz; this is intersected by veins and stringers, less than half an inch in thickness, of pure quartz; these little veins as a rule are roughly parallel in a general north and south direction, but sometimes veins intersecting these at various angles are seen.

Keefer Lake route.

The rocks of the second lake north of Keefer Lake, south of Shelley Lake, are in places doubtfully biotite granite, the bi-silicate now existing as a chloritic mineral which may have been derived from hornblende. Comparatively large imbedded crystals of orthoclase give the rock a porphyritic aspect.

Most of the rocks of this route are reddish biotite granites somewhat obscurely foliated.

Chloritic granites.

Chloritic granites are associated with the biotite granites of the first lake north of Keefer Lake, and on the west side of Keefer Lake, about the middle; here the rocks show crushing and shearing phenomena, and it is probable that the chloritic mineral has been derived in this way from mica.

The shores of Kahshapiwigamak Lake are rather high and abrupt, and present continuous exposures of granite, reddish in colour, and fine-grained, containing, as a rule, but a small proportion of mica, and none at all in several places in the southern part. In the rocks of the north-eastern arm the bi-silicate is now a chlorite, and they contain some porphyritic twinned crystals of felspar. The rock is deep red in colour. On an island near the west shore, north of the centre of the lake, the granite contains a little muscovite, probably secondary, as the rock exhibits crushing and shearing phenomena. The chloritic phase of the granite is seen on the west side of the most easterly of the two bays at the south end. Pegmatite with muscovite is seen in the northern part of the lake.

The shores of Hulburt and Williams lakes, with those of the other lakes forming this route, are high, rugged and precipitous, presenting bold, sometimes perpendicular, cliffs, seen to be composed of granite, containing as a rule a small proportion of mica. The rocks are gray or reddish-gray in colour and coarse in texture. The lamination is very indistinct, often indescernible in the hand specimen, though foliation is often quite apparent in the field. Biotite pegmatite occurs about the middle of the lake south of Kahnipiminanikok Lake. Hulburt Lake route.

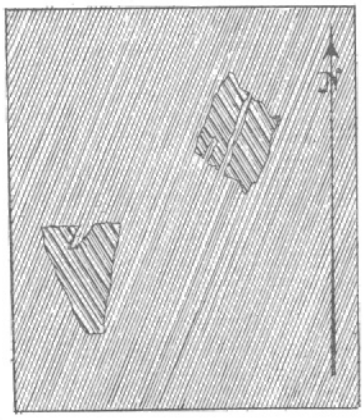
The granitic rocks of Kahnipiminanikok Lake may be generally described as light pinkish-gray, medium-grained biotite granites, usually somewhat distinctly foliated. Their character is comparatively uniform in all parts of the lake, and presents no novel features beyond those already referred to. In the bay on the north side of the lake one mile west of McKenzie Inlet, some of the largest crystals of orthoclase known in this country, occur, some of them measuring four inches in length. Iron pyrites occurs in the granites of the north end of the lake. Muscovite-biotite-pegmatite occurs on the north side near the mouth of McKenzie Inlet. Rocks of Kahnipiminanikok Lake.

The granites of the northern part of Agnes Lake, are on the whole a pinkish-white or light gray biotite-granite-gneiss generally quite distinctly foliated. Agnes Lake.

A curious example of patches of foreign rock included in the granite, is seen on the bare hill on the east side of the little bay forming the southward extension, behind the spur running north of the large bay running north-east from about the middle of the lake. Inclusions in granite.

The country rock is a pink foliated granite gneiss, dipping S. 70° E., angle 45°. There is a faint appearance of bedding in planes parallel to this. Imbedded in this are the fragments, figured here, which consist of a dark gray micaceous gneiss or mica schist, with a greenish tinge, probably due to a partial decomposition of the mica into chlorite.

Fig. 2



The lamination of the gneiss abuts sharply upon the outlines of the fragments, and continues into the little dikes which cut into the fragments, as shown. These dikes are parallel to the direction of the lamination.

The surfaces of the inclusions have a regular ribbed or fluted appearance, the ribs being two or three inches apart and standing nearly an inch above the trough-like depressions. These ribs are parallel to each other, and their direction in different inclusions are also roughly parallel; they also mark the direction of the planes of schistosity of the mica schist (which is not, however, very fissile), cross that of the lamination of the inclosing gneiss, at an angle of about 50°.

Synclinal axis.

It will be observed that a line drawn from this locality, north-east, parallel to the lines of strike shown on the map, would strike the schistose band of McEwen Lake, and the inference is strong that these inclusions mark a synclinal axis in the once overlying Coutchiching rocks, which, save only these fragments, have been entirely denuded.

The rocks on the south part of Agnes Lake, for the most part obscurely foliated red granites and felsites, have nearly all been incidentally described in previous pages.

Pegmatite.

A pegmatite, containing no mica, is seen on an island in the northern part of the lake, thirty chains south of the mouth of the narrows through which the eastern outlet passes. A little iron pyrites is here associated with it.

Agnes Lake to Basswood Lake.

The rocks exposed on the route from the middle of the west side of Agnes Lake, are for the most part reddish medium-grained biotite gneisses. Near Basswood Lake, they usually contain a little bi-silicate, which is now principally changed to chlorite. The foliation is generally apparent, but rarely distinct. In some places they are lighter in colour and are banded with dark gray varieties.

Remaining portion of area.

All the rocks east of this, comprising the Hunters Island area, may be generally described as pink gray, medium-grained biotite granite gneisses, usually foliated with more or less distinctness; they present no varieties which require special mention.

Hornblende Granites.

Stratigraphical relations.

As yet no specific mention has been made of the hornblendic variety of granites occurring in this area. The writer has not studied the relations of these to the mica granites sufficiently closely, or extensively to enable him to formulate any general observations thereon; while it is probable that they are but phases of Laurentian rocks, and that they possess no stratigraphical importance, it is on the other hand possible that some general law giving them a distinct significance may be deduced and that they may be shown to differ both in origin and age from the ordinary biotite

granites. For the present, only some of the localities where they are found in the Hunters Island area can be indicated.

A small area of hornblende granite or syenite is seen on the portage at the south-east end of Brent Lake. The same rock is exposed on the south portage at the west end of Conmee Lake. The area is here a small one and would seem to be an inclusion in the biotite granite. Similar rocks are seen on the west shore of the lake, south of the Coutchiching belt of rocks. Brent Lake. Conmee Lake.

Hornblendic granite is associated with the biotite granites of the lake north of Keefer Lake.

A band of red coarse-grained hornblende granite, containing porphyritic crystals of felspar, perhaps triclinic, occurs on the east shore of the north-east arm of the lake south of Hulburt Lake, a quarter of a mile south of the portage into that lake; it is again seen half a mile S.S.W. on the south-east bay of the same lake. It has here a direction of S. 35° W., indicated by its foliation, which is in some places quite apparent. A probable southward extension of this band, is represented by a band of very similar rock occurring a mile S.S.W. of this, skirting the east side of the north-east arm of Kashapiwigamak Lake, near the portage between the two lakes. The strike is here S. 40° W., dip N.W., angle 75° A still further south-westerly extension may be represented by an occurrence of a similar rock, containing, however, a smaller proportion of hornblende, seen on the small island at the mouth of this arm; here the direction of the foliation planes is uncertain but appears to be about S. 10°W. A narrow band not over two chains wide, of a rock which answers to the same description, but which contains a mica constituent, is seen cutting the red indistinctly foliated biotite granite, starting from the west shore of the lake south of Hulburt Lake, due west of the first granite band referred to, on this lake, and is traced through the narrows, and, then with a more northerly trend it crosses in a north-westerly direction, the north-west arm of the lake. These two bands converging on the same point are suggestive of dikes emanating from a central mass, and may be altered post-Laurentian eruptives. Associated with both these diverging bands are narrow bands of fine-grained dark gray siliceous, micaceous, hornblende schist. Hulburt Lake. Diverging bands.

On the south-west bay of Agnes Lake, a considerable proportion of hornblende granite is associated with the foliated biotite granites. The whole of the southern part of the bay is occupied by these rocks, while a small area, probably a comparatively narrow band, is seen on the west side, just opposite the point dividing this bay from the main lake; here the rock is faintly laminated, and there appears Agnes Lake.

to be a sharp line of demarcation between it and the biotite granite, although some of the associated rocks contain both hornblende and mica. In some places the hornblende granite appears to be included in the biotite granite or felsite.

Fine-grained red hornblende granite, sheared and containing some biotite, is seen on an island near the east side of Agnes Lake, two miles and a half S.S.E. of the point above referred to, and south of this on the west shore similar rocks are occasionally seen.

Farquier Lake.

In the north-west bay of Farquier Lake, the granite is massive and very dark, and exhibits in the fresh fracture small inclosed masses of hornblende.

Murdoch Lake. Kahnipiminanikok Lake.

Gray medium-grained hornblende granite occurs on an island in the north end of Murdoch Lake, and in Kahnipiminanikok Lake, at the entrance to the bay north of Murdoch Lake.

McKenzie Inlet.

On the south side of the eastern end of McKenzie Inlet, the prominent points consist of large flat blocks of medium-grained hornblende granite; west of this on the north side of the narrows, a similar rock, but finer grained, occurs *in situ*, being apparently a band a few chains wide; the same rock is exposed at three or four localities due west of this, on the west shore. On the extremity of the prominent point on the south side of this inlet, a mile and three-quarters north north-east of the entrance, a local occurrence of coarse-grained sheared hornblende granite is seen, in which the hornblende has been largely changed to chlorite in the shearing planes.

Kahwawiagamak Inlet.

On the arm south-east of this, at the narrow part halfway between the main lake and the Indian reserve, a local occurrence of fine-grained hornblende granite is seen on an island in the centre; on the north shore opposite this a little biotite is associated with it.

South-east part of lake.

On the south-east part of this lake, on the north side, about the middle, is an irregular band of fine-grained hornblende granite, which, in the most westerly exposure examined, becomes a fine-grained, felspathic, dark gray hornblende schist, containing apparently a pyroxenic constituent.

Wet Lake.

At the outlet of Wet Lake, on the north side, the rock consists mainly of hornblende, considerable mica, a little flesh-red felspar and perhaps a little quartz; on the north side of the lake, about the middle, a narrow band having the aspect of a dike of hornblende syenite occurs.

McEwen Lake.

On the northern extremity of the island in the east bay of McEwen Lake, and opposite it on the north shore, a medium-grained dark red micaceous hornblende granite occurs; the same rock occurs on the

point at the extreme south end of the lake. These occurrences would seem to mark a continuous band or dike of these rocks. Continuous band of hornblende granite

At rare intervals a bedded structure in the granite is discernible. The beds are usually not much less than a foot thick, and seldom more than three feet thick, and are generally parallel to the foliation planes of the rock. From later observations made elsewhere, it may be stated as a general rule, that the hornblende granites exhibit this feature much more commonly, in proportion to their development, than the biotite granites do; but in hornblende granites the writer has nowhere seen a distinct lamination of the mineral constituents, associated with this structure. Bedded structures. Hornblende granite.

Some of the localities where this apparent bedded structure was observed may be briefly enumerated:— Localities of bedded structure.

On Kahnipiminanikok Lake, on the north side of the bay on the south side of McKenzie Inlet, beds from a few inches to a foot thick inclined to the south-west at angles varying from zero to 15° are seen. Kahnipiminanikok Lake.

On Agnes Lake, on the east side, near the north end, the planes dip to the north angle 10° to 15°, foliation planes which strike N. 30° E and are nearly vertical intersect these beds. Agnes Lake.

On the east side of Agnes Lake, near the entrance of the north-east bay, the beds dip N. 60° W., angle 30°. On the opposite side, near the north end of the bay, the beds are parallel with the lamination planes.

Two localities in the red granite of the east shore of the lake, about the middle of the southern part.

On the south-west end of Farquier Lake are rough irregular beds in red granite, inclined N. 70° W., angle 50°. Farquier Lake.

On Sunday Lake, south part, beds inclined S., angle 60°.

IV. SAGANAGA AREA.

The rocks of Saganaga Lake and vicinity were not examined by the writer who is, therefore, unable to make any definite statements regarding their character, or to do more than state the grounds on which they have been tentatively represented on the map as Laurentian. These reasons will be given later.

On the geological map of the Dominion of Canada, published in 1882, the granitic rocks of Saganaga Lake are represented as igneous granites breaking through Huronian strata. On the "Geological map of the Iron Regions of Minnesota," published by N. H. & H. V. Winchell in 1890, they are represented as Laurentian. The rocks are Previous correlations.

Winchell's description of rocks.

described by the above authors in the accompanying report as "receiving a distinctive character from the large grains of quartz. These grains are large, angular and numerous, and on weathered surfaces stand out prominently. The felspar exists in sub-angular patches, imbedded with the quartz in a ground-mass, which is mostly chloritic and in places develops chloritic spots, while in other places hornblende forms merge into visibility." Again they say: "The rock itself is not of course a characteristic syenite. All hornblende has disappeared; a felspathic matrix remains, with some green specks and spots, and the quartz is imbedded in it. Some of the broken surfaces of the rock have a sericitic lustre. The formation as a whole is roughly bedded." From this they would appear to be allied to the quartz porphyries.

H. V. Winchell's later description.

H. V. Winchell,* in a later paper on the subject, dated December 20th, 1890, says that "the rock is conglomeritic in places, and contains pebbles which are strikingly similar to each other in composition and appearance. A majority of the pebbles are composed of lamellar augite, with or without apparent small grains of felspar."

V. ISOLATED GRANITIC AREAS.

Breaking through the Coutchiching rocks of the region, are isolated areas of granite, which cannot certainly be said to be of Laurentian age, but it would seem that the balance of evidence favours that view.

Granite area north of Namakan Lake.

By the Soldiers' Portage route, above referred to, between Namakan and Rainy Lakes, there are two portages; on the south-easterly one felspathic mica schist is frequently exposed; on the slough and on the other portage (Soldiers' Portage) massive granite is exposed, as well as on several points of the southern extension of Hale Bay, and on the island in the angle of it. These exposures indicate the existence of what is probably an isolated local area, similar to those shown on Hale Bay and on the southern shore of the eastern arm of Rainy Lake, west of Kettle Falls (see Rainy Lake sheet). This granite is deep red in colour and not at all foliated; it would appear to be a distinct intrusive mass.

Thompson Lake granite.

The granite of Thompson Lake is an isolated area, being cut off from the main mass to the south by the band of mica schist indicated by the almost continuous exposures along the south shore of the lake. The exposures in the eastern and western extremities of the lake, and along the canoe route north, prove this area to be surrounded on all sides by mica schist. The contact is brecciated, and is typical in character of that of the large Hunters Island area to the south. On the north-west,

*Am. Jour. Sc., vol. XLI., No. 245, p. 386. 1891.

north and east sides, the schists, wherever observed, were found to dip away from the granite nucleus at angles varying from 40° to 60°, but there is no evidence of a synclinal structure between this and the granite apophysis to the south.

Wolseley Lake granite.

The granite boss on Wolseley Lake is inferred from a few exposures on the peninsula and adjacent islands. Its limits could not be exactly defined, nor its contact with the schists observed, owing to the drift covering by which it is concealed.

Small outcrops of granite in mica schist.

Small outcrops of granite in rocks of presumably earlier age, are seen in many localities, particularly in proximity to the large granitic areas, and as these areas are approached the increasing abundance of granitic bands marks the contact zone. Such small areas and isolated bands, more or less distant from this zone, and too insignificant to be shown on the scale of the map are found in the following localities :—

Captain Tom Lake.

Captain Tom Lake, about the middle of the north side.

South of Tanners Lake.

On the creek east of the portage south from Tanners Lake, reddish fine-grained evenly foliated biotite gneiss.

North-west of Darkey Lake.

On the outlet of Darkey Lake. Several small outcrops perhaps marking an anticlinal axis. Medium to coarse-grained and pegmatitic muscovite granite. Biotite is sometimes associated, and in one exposure, garnets are seen.

Near the mouth of the stream forming the outlet of Pooh-Bah and Wink lakes.

Conmee Lake.

On the portage north of Conmee Lake.

On the small lake, north of Conmee Lake, at the west end. This same band apparently occurs on the south side, near the north-east end ; but here it is very coarse-grained, the larger crystals of the felspar are twinned, and a little hornblende is perhaps present.

William Lake.

A small area of muscovite granite is seen associated with the mica schists of the west end of William Lake.

General Theoretical Considerations.

In the foregoing pages, doubts have been expressed as to the age of some of the so-called Laurentian areas, notably the Pooh-Bah syenites, the Saganaga granites, and the small areas of eruptive granitic rocks.

Any attempt to reconcile the various diverging theories regarding the Archæan rocks, is perhaps premature and can only be suggestive. The Laurentian rocks of the eastern part of the Dominion, as described by the older Canadian geologists, and corroborated by the observations of later workers, point to the conclusion that many at least of these granite gneisses are sedimentary in their origin.

Sedimentary gneisses of the eastern part of the Dominion.

Eruptive granites of the western portion.

In this western portion, the work of Dr. Lawson, in the Lake of the Woods and Rainy Lake regions, the observations recorded in this report, and the observations made by other workers in contiguous fields, indicate, with equal strength, that here the granites are eruptive in their attitude and relationship to the overlying rocks.*

Theory accounting for brecciated contact.

Objections to the theory.

It has been argued that while the Laurentian rocks as a whole may have been sedimentary in their origin, the brecciated character of the contact with overlying series may have been caused by later granitic eruptions along this line, which would be emphatically the line of weakness. This is a possible, though not probable, explanation of the facts; not probable, because no distinction can be drawn between the granites at the contact and those in the central portions of the great granitic areas, save that of a gradual change from a gneissoid character at the contact to a granitoid one in the centre, as a rule, and this is not the change that would be expected between a sedimentary nucleus however metamorphosed and a granitic periphery however foliated by flowing movements while in a liquid or viscid state. Again no line of demarcation between the supposed sedimentary rocks of the interior and the assumed newer granites of the periphery, which also cut the upper Archæan schists, has, within the writer's knowledge, ever been described. It must be acknowledged, however, that in such old and changed rocks, negative evidence is especially inconclusive.

Irruptive origin not certain.

The question of the irruptive origin of all the granites of this Lake Superior region cannot yet be answered with absolute certainty. It would be rash to state from the comparatively local examinations that have yet been made, that the contact is always of an irruptive character, although in many cases it must undoubtedly be so regarded. It would be equally rash to state that the nature of the contact is nowhere compatible with a sedimentary origin for the granite gneisses; minute and irregular interbanding is not an uncommon feature in the transition zone between contiguous formations of rock unquestionably sedimentary.

*Having personally examined both the eastern and the western Laurentian areas at intervals, from the Straits of Belle Isle to Ottawa, and thence to the Lake of the Woods and Lake Winnipeg, I am convinced that whatever theory of origin may be correct, it is equally applicable to the whole of the great Archæan area of Canada. The local greater or lesser development of some special lithological character, as limestone, quartzite, etc., or physical structure, as gneiss, granite, mica, schist, etc., has no more bearing on the question of age, than have the similar local peculiarities which are more or less characteristic of all the younger geological systems, as for instance, the Cretaceous of Britain and of Canada; the lower palæozoic of Canada, and of Southern Australia; and even within the limits of the Dominion, the upper palæozoic rocks are both lithologically and physically more unlike each other than are any of those of the great Archæan area from Labrador to Winnipeg, and thence to the mouth of the Mackenzie in the Arctic Ocean. A. R. C. SELWYN.

In the previous pages localities have been cited where an apparent bedded structure in the granite gneisses is more or less marked. This feature occurs at very rare intervals, and is extremely local in extent, wherever observed; the inclination of the bedding planes are generally, though not always, parallel to the lamination planes, where these are discernible; and the rock at the planes of parting does not present any of those changes in composition which so frequently mark the bedding planes of sedimentary rocks; from these facts it seems highly improbable that this apparent bedded structure indicates a sedimentary origin. It is probably caused by the accidental yielding of the rock in parallel planes under the various strains to which it has been subjected. Nor can the foliation and lamination discernible in these gneisses be regarded as indicative necessarily of sedimentary deposition. Bedded structure.

Between the Laurentians of the Ottawa Valley and of Western Ontario, there is one marked difference, the presence of a series of limestones in the former, and its comparative absence in the latter; but the absence of a lithological member of a series, as limestone or quartzite, does not militate against the correlation of the members occurring in different districts, and future investigation may prove the Coutchiching series to be the stratigraphical equivalent of the Upper Laurentian series of the east, to which as far as may be gathered from published descriptions of the latter the mica schists would seem to bear a marked resemblance in stratigraphical relationship. But whatever conclusion may be eventually arrived at regarding the origin of Laurentian rocks, or whatever subdivisions of, or rearrangement of certain members of this system future investigation may justify, the separate areas of granitic rocks referred to in this report present no individual characteristics sufficiently significant to justify the belief that any great difference exists between their respective ages, and the same theory of origin that applies to one applies to all. The smaller granitic areas of this region present no difference in lithological characters or in stratigraphical relations from those of the large areas which have been called Laurentian, such as to justify us in regarding them as of later date; and it seems most probable that they are subordinate developments of the same fused rocks, marking the crests of anticlinal domes or folds in the intensely and minutely folded crust. Laurentian limestones. Small granite areas.

H. V. Winchell regards the Saganaga Lake granitic rocks as of Keewatin age from their lithological character, from his discovery of a small band of chalcedonic silica in the syenites, and from their frequent alternation in bands with Keewatin schists. From the title to his photographs given by Dr. Lawson, he evidently regards these rocks as Laurentian. As before stated, the writer is not in a position Saganaga area.

to express any opinion on the subject, but he has mapped them as Laurentian in accordance with Dr. Lawson's opinion, and from the character of the contact as shown by his photographs and reproduced in plates I., II. and III., which seems to be typical of the contact of lower and upper Archæan rocks elsewhere in this region; and also because they seem to form an integral part of a granitic area, which, from what is known of its more eastern development, would seem to be more undoubtedly of Laurentian age. The portion of this area in this sheet is trifling in extent, and in working up the region embraced in the sheet east of this, the rocks will receive closer and more conclusive study. In the meantime it would seem safer to map them as Laurentian.

Pooh-Bah area.

The Pooh-Bah syenites differ in lithological character and in the nature of their contact, so far as can be determined, from the typical Laurentian biotite granites, but these differences are neither so marked nor so important as to offer any serious obstacle to the correlation of them with the Laurentian. In mineral composition they are typical of the quartzless hornblende syenites, which have always been regarded as a species, although a rare one, of Laurentian rocks; and they are not more coarsely crystalline than the pegmatitic phases of these rocks.

In comparison with the whole length of the periphery of the area, so little of it has been available for study, that it is hazardous to make any statement concerning the general nature of the contact, and though where the rocks are revealed sufficiently near the line of contact to allow its nature to be guessed at, it would seem to be unusually sharp and clear, this fact, in itself, has little significance. The mica schists appear to have suffered more than usual contact metamorphism; but on the other hand, the syenites reveal no differentiation from a coarse texture on the central portions to a fine one at the contact, indicating that they were intruded into cool consolidated rocks; and they would seem to have cooled very slowly and uniformly, such as deep seated subcrustal irruptions would be expected to cool.

The correlation of the hornblende rocks, between William and Brent lakes with these is at best a doubtful one, and while the field appearance of the former suggests that they were erupted at a later date, it by no means proves it.

In the absence of conclusive field evidence, we are again thrown back upon their lithological affinities with certain phases of Laurentian rocks to decide, for the present, the question of their age.

COUTCHICHING SERIES.

Limits of area and conditions of contact with lower rocks.

The Coutchiching series of rocks, which is so largely developed in the south-eastern part of the Rainy Lake sheet, extends into the north-west part of this sheet in a broad tapering area, whose outline will be now briefly defined.

Namakan Lake.

Passing up the channel above Kettle Falls (see Rainy Lake sheet) into Namakan Lake, where the channel bends sharply to the south, evidences of an approach to a granitic area is seen in the banded intrusions of granite into the mica schist; these intruded bands become more and more numerous and important as we proceed southwards, until when we reach the long narrow island, three-quarters of a mile south of the expansion of the channel into Namakan Lake, we find on the southern part of this island that the granitic rocks are decidedly the most abundant, while on the north part of the island the mica schists still seem to maintain their predominance, for this reason the line of contact is placed across that part of the island where the two rock species appear to be most equally developed. East of this island, along the north shore of the lake, the exposures are sufficiently numerous to admit of an approximate delineation of this line of equal development, as indicated on the map. The brecciated contact zone appears to become a little narrower. North of this conventional line the predominating rocks are medium grained felspathic mica schists, gray in colour; south of it massive pink granites, doubtfully if at all foliated, form the material of the widest and most numerous bands.

Soldiers' Portage route.

From the bay south of Hale Bay (see Rainy Lake sheet) to the middle of the north side of Namakan Lake, there once existed, probably but a short time since, a subordinate channel between these two sheets of water; it has become choked with boulders and drift and exists now as a narrow slough, between the north-western end of which and the bay south of Hale Bay the Soldiers' Portage is cut, while a shorter portage connects the south-east end of the slough with Namakan Lake.

American side.

Less than half a mile south south-west of this latter portage, the line of contact of the mica schists and granites can be fixed with great accuracy, from the close proximity of adjacent exposures of the two rock varieties and from the comparatively unbroken character of the two series each side of this line. From here the contact line sweeps to the south-east and passing through the centre of the lake crosses in an east south-east direction over to the American islands, and cuts across the

small peninsula to the south-west of the boundary line at the Narrows into Sand Point Lake, and appears again in Canadian territory on the south side of the bay north-west of David Lake.

Minnesota band of granite.

The contact thus far traced, marks the northern limit of the great development of granite gneisses shown on the geological maps of Minnesota.

Sand Point Lake.

David Lake.

In the bay of Sand Point Lake, north-west of David Lake, the junction can be seen on a narrow point forming a shallow bay of the south-east shore of this arm. The contact is next located in the south-west corner of David Lake; it cannot be placed here within a few chains. On the west shore of the lake the granites are frequently exposed, containing thin bands and irregular patches of mica schist. A single exposure of granitoid gneiss on the north-east shore of the lake, one-quarter of a mile north-east of the point about the middle of this part of the shore, probably marks the eastern limit of the granites. The point is occupied by a soft light gray evenly laminated gneiss, doubtless Coutchiching; the same rock is exposed near the outlet on the south shore; these exposures probably belong to a transition zone between the granitoid gneiss of the west shore, which, near the outlet, is distinctly foliated, and the mica schist exposed on the extreme eastern shore of the lake in one locality. The line of contact, therefore, would appear to strike from the north-west corner of the lake to touch the north-east shore, at the granite locality indicated above, then to turn sharply to the south and south-west under the waters of the lake and pass through the channel forming the outlet into Sand Point Lake, between the foliated granites, containing thin bands and patches of mica schist exposed on the north side of the channel, and the mica schist and fissile light gray gneiss frequently revealed on the south side. This location of the line of contact is supported by the strikes which are everywhere observed to be in conformity with such a line. The contact is seen on the point of the south shore, just west of the outlet of David Lake, and must pass very close to the north-west shore of the bay south of this point, as the rocks here consist of alternating bands of granites and mica schists, the former predominating, while there are several exposures of uninterrupted mica schist on the east side of the bay. The strike of the rocks on both sides of this bay are parallel to the shore line.

Contact curving to south-west.

Sand Point Lake.

From here the line of junction evidently strikes south-west, in conformity with the strike of the rocks, to the north-east shore of the southern expansion of Sand Point Lake. Although it can be here approximately located, the actual contact is concealed under the marshy shore. On the shore to the south and on the islands the mica schists

are frequently exposed, and from the curvature of their strike, and from the occurrence of granitoid gneiss on the American side of the channel, it is evident that the junction line sweeps to the south and then to the south-east, under the waters of the lake. Contact curves again to south-east.

The schists, in this part of the lake, dip away from the granite at unusually low angles, in one locality as low as 17°. From Sand Point Lake, the contact line has a still more easterly trend, and is located with considerable accuracy in the northern bay of Little Vermilion Lake. Low dips. Little Vermilion Lake.

From here it must strike generally east, then north-east to the south side of the bay of Lac la Croix, out of which the old Nequaquon portage leads. The mica schists of this bay are much invaded by granites, and the point on the south side of its narrow inlet is entirely occupied by the massive granite, indicating either a sharp twist in the line of contact, or an invasion of the granites across the strike of the schists, as the contact west of this point and east of it on the opposite side of the bay can be located with much precision. Lac la Croix.

The schists show considerable variation in their strike, but dip away from the granites at angles varying from 35° to 45°, in a northerly direction. In the northern extremity of this bay, is an exposure of massive granite which would appear to belong to the same mass as that exposed in the first portage going north from Lac la Croix to Thompson Lake, and on the long portage, further east, leading directly between these two lakes; and this granite appears to be an apophysis from the main mass of granite exposed on the adjacent islands and on the American shore. There is no evidence that the band of schists, above described, continues sufficiently far east to separate this tongue of granite from the main mass, although the granite on the islands to the south, includes narrow bands of schist. The dip of this band of schists is uniformly to the north at a fairly constant angle, viz., 45°, and there is no convergence of dip to indicate a possible synclinal structure in this band. Granitic apophysis.

From the north-west corner of the bay, in which on the map is shown the line of junction of the northern edge of the apophysis, the contact line appears to bend sharply to the south south-east, and then to strike a little south of east through the islands, and to skirt the American shore, until it is seen again in Canadian territory on the northern part of Roland Island; in this distance, the brecciated contact zone seems to be unusually broad, alternating bands of mica schist and granite being exposed on all the American islands, along the Minnesota shore. Roland Island

Through the south-eastern part of Lac la Croix, the topography was taken from the surveys of Mr. David Thompson, and the geological boundary was determined by Dr. Lawson.

Between here and Wicksteed Lake the contact was not actually traced, but it lies between the extreme north end of McAree Lake, and the southernmost outlet of Maligne River, and it is drawn in conformity with the strike of the rocks. On the north-eastern side of Wicksteed Lake, the contact is marked by a zone of alternating bands of granite and mica schist, which is here somewhat narrow, being about three or four chains in width.

Wicksteed Lake

Darkey Lake.

The numerous exposures on the shores and islands of Darkey Lake, enable the distribution of the rocks to be mapped with considerable precision. All along the northern shore, fine grained, brownish-gray mica schists are exposed, invaded by some bands of pink muscovite granite gneiss; going south down the east shore, there is a broad zone of alternating bands of mica schist and gneiss, and along the north shore of the outlet of Brent Lake, the granites preponderate, and on the south shore of this inlet they are almost entirely unbroken by schistose bands. These granites (fine-grained muscovite biotite) can be traced on the shore of Darkey Lake south. This would appear to be an apophysis of granite, as it is divided from the main mass by an unbroken band of dark gray felspathic mica schist exposed further south on the east side of the lake. The probable eastern extension of this band is exposed on the south-west shore of Brent Lake as a somewhat narrower band. This band has no extension westward, but on the portage into the small lake lying west of Darkey Lake, is an exposure of mica schist striking about N. 30° W., with a comparatively low north-easterly dip, which probably marks its western termination, as no considerable isolated band of mica schist occurs on the shores of Wicksteed Lake. The strike above given probably indicates a sharp horizontal fold in the mica schists lying between the main granitic mass to the south and the apophysis to the north.

Granite apophysis.

Band of mica schist.

Brent Lake.

The tongue of granite frequently exposed in the channel forming the outlet of Brent Lake, is not seen to extend further east than the west shore of Brent lake, where a single granite exposure is found a few chains south of the outlet. Along the south-west shore, for half a mile, the mica schists of the band described as terminating in Darkey Lake are exposed. They dip northerly at a low angle. The point forming south of it the small bay in the extreme southern part of this part of the lake, is composed of granite; this indicates the existence of another small granite apophysis, as the south and east shores of this bay afford numerous exposures of mica schist, somewhat hornblendic in character.

Granite apophysis.

On the portage, and in the little lake south of this bay, however, massive red granite, containing very little bi-silicate, is exposed. On the north-east shore of the bay the same mica schists are exposed, in-

vaded by narrow bands of granite; these occur all along the south shore of this south-western portion of Brent Lake. The little bay to the east affords one exposure of granite, on the south shore; which probably marks the northern limit of the large granitic area. The eastern end of the bay is marshy, but on the north shore and through the main channel to the north, massive gneiss, reddish in colour, and somewhat distinctly foliated, occurs.

Eastern extension of band of mica schist.

The band of mica schist to the south, therefore, is about ten chains wide where it is last seen on this lake; its continuation to connect with the band, probably about the same width, of brownish and dark gray siliceous felspathic mica schist, seen on the north side of McIntyre Lake, is conjectural, as also is the continuation of this band south-eastward; but whether continuous or not, the band shown on the map probably indicates the position of the axis of a synclinal fold, of which these exposures are the pinched in remnants.

McIntyre Lake.

The band on McIntyre Lake contains intermediate bands of granite, and dips N. by E., angle 40° to 45°, over the granites on the south and under them to the north. The granites are deep pink in colour, faintly foliated for the most part, and contain chlorite.

Brent Lake.

Returning to the south-western part of Brent Lake to trace the northern boundary of this band, we find exposures of mica schist at the two points at the entrance to the most easterly of the two bays running north, and again striking along the western shore of this bay, while the eastern shore is occupied by granites. Along the eastern shore the bare hillside slopes about 35° to the west; on the surface are seen many flat scaly inclusions of crumpled micaceous schist. This would seem to be a surface of contact between the underlying granites and overlying Coutchiching rocks, and the appearance is strongly suggestive of the irruptive character of the former. The line of contact appears, therefore, to sweep sharply to the north up this bay. The contact in the northern end of the bay is concealed by drift; but on the south side of William Lake, it can be closely located, and by the few exposures of schist on the north side of the east end of this lake, and the few granite exposures on the south side, is determined as lying under the waters of the east end of William Lake; thence it can be again somewhat closely located, on the west shore of Conmee Lake, by the exposures occasionally outcropping along the low marshy shore.

Surface of contact.

William Lake.

Conmee Lake.

Through Conmee Lake, the contact is determined as lying between the brownish-gray mica schist exposed all along the north shore, and the off-lying islands, which consist of medium-grained, dark gray granite, containing hornblende and biotite, and banded with subordinate bands of mica schist.

Bands of mica schist.

On the south side of the lake, is a series of narrow but persistent bands of mica schist, striking generally about S. 80° W. and dipping northerly at angles varying from 30° to 45.° On the bay running to the south, at the east end of the lake, is a band occupying the whole of the island, at the mouth of the expansion and traced on both shores; the band curves from S. 30° E., on the west, to S. 60° E. towards the east, with a north-easterly dip of 30° to 40.° This band appears to taper off to the south-east, but its extension to the north-west cannot be seen on the south-east shore of the main lake, and it would appear to be a comparatively large isolated lenticular band.

Possible unconformity.

The general strike of the foliated granitic rocks on the south-east side of the lake, gradually changes from S. 80° E. near the west end, to S. 20° E. near the east end; while the strike of the mica schists on the north side, varies between N. 65° E., and N. 85° E. This would appear to indicate a structural unconformity between the two series. One or two strikes obtained near the contact, indicate that the strike of the gneisses bends sharply round, in conformity with the structural planes of the schists, but as the line of contact is mainly concealed under the water, there is not sufficient evidence to establish whether there is here an unconformity or not. While the varying directions of the structural planes of the Laurentian and Coutchiching rocks may be explained by assuming the existence of a fault, there is no independent evidence at hand in support of this assumption.

The most easterly point where the contact is determined is on the south-eastern shore near the eastern end of Conmee Lake.

Distribution east of Conmee Lake.

The distribution of mica schists in the area between Conmee and Keefer lakes, owing to the inaccessibility of the country is conjectural, but is based on facts which will be given below.

Lake north of Keefer Lake.

A band of fine-grained, dark gray siliceous, hornblendic mica schist is seen on the lake north of Keefer Lake, on the bay running to the north-west. From the exposures on this bay, the band must be over half a mile wide, but its western boundary was not determined; it is interrupted by parallel granitic bands, of subordinate width. Presumably, the northern extension of the same band, is seen on the stream forming the outlet of these lakes, and is traced closely and accurately to the north end of Kahnipiminanikok Lake, where it is about half a mile wide. These schists contain so much hornblende, as to leave some doubt as to whether they are not Keewatin in age, but lithologically they are perhaps more closely allied to the Coutchiching hornblendic mica schists, than to the Keewatin micaceous hornblende schists. The presence of hornblende, even in predominant quantity, cannot be taken as conclusive evidence of age, in the face of opposing stratigraphical pro-

Kahnipiminanikok Lake. Hornblendic schist.

babilities, and for this reason I have mapped them as Coutchiching, considering the presence of hornblende to be a local and not significant facies.

Influences guiding the mapping.

The mapping of this band of rocks in continuation with the mica schists north of Conmee Lake, is inferred from the structure of the granites on the lakes surrounding this area. An examination of the strikes and dips of the foliated portions shown on the map, will show that with local variations the general strike of the rocks is rudely parallel with the general trend of the watercourse, from the small lake south of Keats Lake to the ultimate outlet of these lakes into Sturgeon Lake, viz., from south-west with a north-west dip south of Keats Lake, to north-west with a north-easterly dip on the south-east arm of Sturgeon Lake. On Brent, McIntyre and Sarah lakes, particularly the two latter, the rocks are granitoid and exhibit very little foliated structure, which, however, may be regarded as parallel to the general trend of the watercourse, which curves from E. by S. on Brent Lake, to S. by E. on McIntyre and Sarah lakes.

The general trend of Keefer and Kashapiwigamak lakes indicates roughly the direction of the structural planes of the surrounding rocks, which is S.S.W. or S.W. by S.

Triangular synclinal trough.

Such dips as are observable, are northerly, at a high angle, on the lakes south-east of Sturgeon Lake; north-easterly, at a comparatively low angle, on Brent, McIntyre and Sarah lakes, and westerly, at a comparatively low angle, in Keefer and Kashapiwigamak lakes, viz., if we regard the high inclination of the rocks on the north as representing overturned dips, all inward towards a triangular central area, which represents probably a triangular trough in the Laurentian rocks, in which would very likely lie the south-eastward extension of the rocks north of Conmee Lake, and the south-westerly extension of the micaceous schists seen on the lake north of Keefer Lake.

Southerly extension of the trough.

A southerly tapering extension of the trough would probably be involved by the folding above assumed which would extend roughly parallel to Kashapiwigamak Lake.

Attenuated anastomosing bands of upper Archæan rocks, surrounding nuclear areas of granite are so common a feature in these azoic rocks, that coupled with the suggestion offered by the structure of the surrounding granites, the general correctness of this mapping would seem highly probable.

South-western limit of central northern granite area.

The south-western boundary of the northern central area of granites, probably swings round from the north-western edge of the band of mica schists, revealed in the lake north of Keefer Lake, in general conformity with the trend of the watercourse of the lakes draining into the

south-eastern part of Sturgeon Lake; first westerly, then north-westerly, thence northerly and north-easterly, to the point where it is again accurately determined in the narrow channel between the eastern and south-eastern expansions of Sturgeon Lake, where the usual brecciated contact zone is seen between the fine grained gray muscovite biotite granite and the mica schist. The contact is placed where the included bands of mica schist become predominant in quantity. From here on the west shore to the mouth of the small creek half way to the point at the narrows between the eastern expansion and the main body of the lake south-west, the mica schists, though broken by bands of pegmatite and coarse grained granite, form the principal rock. This band of mica schist is nearly half a mile wide; the strike on the north side is N. 80° E. and in the south side N. 65° E. with a uniform southerly dip of about 70°. Opposite this on the eastern shore this converging band of mica schists appears to have almost entirely died out, and is represented only by two or three narrow bands only a few feet wide, which bend sharply to the N. N. E. with a lower southerly dip, and are flanked by massive red coarse grained muscovite granite, containing numerous small garnets. The above distribution is graphically represented on the map by the two long narrow tongues of Coutchiching rocks.

Contact on Sturgeon Lake.

South-western part of Sturgeon Lake.

The northern part of the peninsula forming the narrows at the north-east end of the main body of the lake, consists of pink muscovite granite, very coarse grained, pegmatitic in places, and often containing biotite as well as muscovite, and sometimes garnetiferous. The contact with the mica schists to the south is seen about half way down the western shore of the peninsula, south of this the mica schists are invaded by a few granitic bands. From here the contact must lie between the fine grained brownish-gray felspathic mica schist of the south-eastern shore of the lake and the pink, usually, distinctly foliated granite gneiss of the large off-lying islands. Neither the schists to the south nor the gneisses on the north contain bands of foreign rock, although some felspathic veins, probably segregated, occur in the former.

The contact line passes north of the islands, lying off the mouth of the deep bay of the south-eastern shore, as these islands are composed of mica schist, a narrow granitic band being seen on only one of them, and a single exposure of granitic rock is noted on the north shore of the bay.

Western shore of Sturgeon Lake.

The line of contact after passing under the waters of the lake, is again closely located on the west shore, as passing between adjacent exposures of the two varieties of rock. On the bay to the west, there are a few

exposures of felspathic mica schist, but on the north-western extremity two or three exposures of massive pink granite, taken in connection with the observed strikes, determine approximately the location of the line of contact. From here westward the line probably curves to the north-west to the contact of the Laurentian granite gneisses and Coutchiching mica schists, located on the Quetico route from Namakan River to Kawagansikok Lake.

General distribution of mica schist.

The limits of the area of Coutchiching rocks have thus been traced, and the data from which they are laid down, given. The very numerous exposures of mica schists on all the lakes and river shores shown in this area, leave no doubt as to their general distribution and render highly improbable the existence of any considerable area of older or newer rocks, except in the unexplored portion north of Wolsely Lake and Namakan River.

Character of the Rocks of the Coutchiching Area.

General characteristics.

The rocks in this area are singularly uniform in character. They vary in colour, from a light gray to a dark gray, sometimes with a tinge of brown, probably due to a bleaching of the biotite constituent, possibly in some instances due to the presence of iron-bearing minerals. They vary in texture from a medium-grained rock, in which the size of the mica scales is prominent, to a very fine-grained rock. Only occasionally in this area are they observed to be coarsely crystalline. They contain generally biotite, black, brown or bleached, or muscovite, with felspar (orthoclase) and quartz. The two latter are seldom or never absent, and sometimes these minerals are such important constituents, as to characterize the rock rather as a micaceous gneiss than a mica schist. These micaceous gneisses are always fine-grained, light gray, and finely and evenly laminated.

Hornblende is occasionally found as a more or less important constituent, and small garnets have been often observed.

Coarse grained schist in Namakan Lake.

In Namakan Lake, due north of the channel to Sand Point Lake, the schists are extremely coarse-grained, the mica, which appears to be a bleached biotite, or muscovite, occurring in large scales.

Sand Point Lake.

Hornblendic schist.

In some localities on the east shore of Sand Point Lake, particularly on the island at the mouth of the bay, leading to Nequaquon portage, the schist is coarse grained and black, from the abundance of hornblende contained in it in this locality characterizing it rather as a hornblende than a mica schist. The schists here dip away from the granite gneiss at unusually low angles, in one place as low as 17°.

Lac la Croix.

In Lac la Croix, on a small island north of Roland Island, is an exposure of rather coarse-grained hornblende schist, consisting almost entirely of hornblende in parallel crystals and needles; this may be a small outlier of hornblende schist, but it does not appear to be an eruptive rock. In the channel, south of the eastern line of the Indian Reserve, at the mouth of the Maligne River, the schist is hornblendic and fine-grained, and there are also some light green chloritic schists one-half mile E. N. E. of the Dam Island portage; these, in connection with the hornblende schist in Lac la Croix, above mentioned, may represent a band of basal Keewatin rocks, but if so, it is of insignificant development.

Possible pinched in-fold of Keewatin rocks.

Maligne River.

On the Dam Island portage, up the river as far as Tanner's Lake, and at some localities on this lake, the mica schists, or gray evenly laminated gneisses, contain siliceous portions which resist weathering, and give to the weathered surface of the rock a knobby appearance and on the fresh fracture present oval or lenticular areas of lighter colour than the more micaceous and felspathic surrounding material.

Siliceous lenses.

The occurrence of these siliceous lenses is also noted on a small lake one and a-half miles north-east of Darkey Lake. The fine-grained grey felspathic mica schists of Wink Lake also present this feature.

Wink Lake.

On the stream forming the outlet of Darkey Lake, the mica schists are dark grey in colour and fine-grained. They dip to the N. N.E. at very low angles from 10° to 25°.

Pegmatite.

Small irregular areas of coarsely crystalline pegmatite, of which the mica is white in colour, occur. These patches are possibly segregations from the surrounding mica schist. The mica schists are also intersected by thin stringers of quartz and felspar, which are at times curiously contorted. Thin stringers or veins of felspar rock are noted on Sturgeon and Namakan Lakes, and are of very common occurrence in mica schists. The vein material seems to consist almost entirely of orthoclase. Most generally the veins cross, more or less obliquely, the strike of the schists. Sometimes two or more veins, having different directions, will join together or intersect each other. They rarely exceed three or four feet in width, but are very irregular in their outline. They are most probably segregations.

Felspar rock.

All the rest of the rocks in this area fall under the general description given above.

Isolated Bands and Areas of Mica Schist.

Narrow isolated bands of mica schist, which may represent the remnants of pinched in folds, and, therefore, synclinal troughs of Coutchiching rocks, are noted in the granite areas more or less remote from the main Coutchiching area, in the following localities :—

North of the extreme north bays of the main western portion of Sturgeon Lake, several bands of mica schist were observed. Their direction is parallel to the line of contact and their inclination to the north at rather high angles. One is seen to be a lenticular band only 30 or 40 feet long, the others are bands about a chain or so in width. Sturgeon Lake.

On the south-east arm of Sturgeon Lake, near the mouth of the stream draining the lakes east of it, is a band of uncertain width of soft, friable, brownish weathering mica schist. It strikes N.E. by E. and dips about 60° N.W. This is probably the eastern representative of the bands seen in the granites, south of the small lake, one mile and a half west south-west of this, which strike N. 75° E. and dip N. $<$ 70°.

On the fourth lake from this south-east arm, and draining into it, is a band two chains wide, apparently underlying the gneiss on the north-west shore.

On Chatterton Lake, on the south side of the large island opposite the portage into McDougall Lake, is a band apparently interbedded with the granitoid gneiss. Dip N. 10° W. $<$ 15°. Chatterton Lake.

On the north-east shore, north-east of this island, is a band of brownish medium-grained mica schist, with a band of pegmatitic granite. Dip S. 75° E. $<$ 49°. Perhaps the same band as above.

On Kahnipiminanikok Lake, on the north side of the large island in the north end, a narrow band of brownish-gray medium-grained mica schist occurs. Kahnipiminanikok Lake.

On the east side of the lake, at the mouth of the bay north-west of McKenzie Inlet, is a narrow band of black mica schist, dipping S. 80° E. $<$ 75°.

On McKenzie Inlet are exposures of dark gray hornblendic mica schist and brownish-gray felspathic mica schist in the localities indicated in the Coutchiching area on the map. On the small lake between this inlet and the Kawawiagamak Inlet, a gray siliceous mica schist occupies a considerable area, which reappears as a dark gray compact fine-grained siliceous mica schist, skirting the south shore of the bay into which this lake drains. Opposite this, granite gneisses are exposed. On Kawawiagamak Inlet, mica schists are seen in considerable development; on the shallow bay on the north side near the mouth there is a fine-grained felspathic mica schist, which passes into an evenly laminated biotite gneiss. These exposures, with the observed strike, render it highly probable that the area exists as mapped. A subordinate southern extension of the south fork of this area is indicated by narrow bands of mica schist on the channel to Agnes Lake. McKenzie Inlet. Kawawiagamak Inlet.

This area is probably a pinched infold of Coutchiching rocks invaded by an apophysis of granite. No synclinal structure is, however, shown by the dips.

South-east part of Kahnipiminanikok Lake.

At the narrows, near the south-east end of the lake, and on the bay north of McEwen Lake, are exposures of fine-grained hornblendic mica schists, which by their localities and the strike of the rocks indicate the presence of a crescent-shaped area, of probably Coutchiching rocks, as shown on the map.

Broad band of Coutchiching rocks.

On the south-east shore of the small lake, south-east of Kahnipiminanikok Lake, and on the stream flowing into it from the south-east, is a well-defined band of fine-grained felspathic mica schist striking E. N.E. and dipping north-westerly from 60° to 70°. This band is here about three-eighths of a mile wide, and is doubtless a north-eastern extension

McEwen Lake.

of the band, well defined in McEwen Lake, of very fine-grained evenly laminated gray biotite gneiss, merging into coarser-grained, darker and more fissile felspathic mica schists. Here the band curves a little more to the south and has a somewhat lower north-westerly declination.

The reasons for mapping the eastern extension of this band in continuation with the Keewatin rocks, will be given later.

Slate Lake.

On the south-west end of Slate Lake, the exposures of a mica schist, in which the mica is smoky-white in colour, apparently muscovite, but possibly a bleached biotite, indicate the existence of an area of Coutchiching rocks sufficiently extensive to be shown on the map. An

Saganagons Lake.

exposure of this rock at the bottom of the bay of Saganagons Lake, north-east, indicates a north-eastern extension of the band at least that far. Along the north-east shore of this bay the granites contain narrow bands of mica schist, which are, however, subordinate in quantity. The westward extension of this area is not determined, but is judged to be short on account of the rapid convergence in the direction of the strikes; on the north side of Slate Lake (S. 70° W.) and on the south side (N. 70° W.)

The lamination on the north side is vertical, and that on the south side dips to the south at a very high angle.

Agnes Lake band of mica schist.

On the north shore of Agnes Lake, between its two outlets, is a series of mica schists interbanded with the foliated granites in such abundance as to become a prominent constituent of the whole rock mass. The strikes vary from N. 50° E. on the east to N. 20° E.

Apparent sedimentary interbedding.

on the west. The manner of their occurrence is very suggestive of sedimentary interbedding. To the east the dip is S.W. $< 16°$ rapidly increasing in declination to 45°. On the most prominent point of this shore, the mica schists have a low easterly dip of 5°, and west of this

the dip is again reversed, dipping westerly at an angle of 35°. This would indicate an eastern synclinal and western anticlinal fold, but no indication of a syncline still further west is observed. The island south-west of the western outlet is composed of foliated granite, holding brecciated angular fragments of mica schist. Low dips. Areas of folding.

On the east side of Basswood Lake, east of the large island in the northern part, some small bands of mica schist occur, and further north-east is some fissile light gray micaceous gneiss, closely allied to the Coutchiching gneissic rocks. Basswood Lake.

On the point at the west end of Yum-Yum Lake, a local narrow band of siliceous hornblendic mica schist occurs. Yum-Yum Lake.

On this lake, as well as on McNiece Lake, and on the east side of Shade Lake, bands of this hornblendic micaceous schist are associated with the red foliated chloritic granites. McNiece Lake.

Thickness of Coutchiching series.

Any attempt to arrive at the probable thickness of the Coutchiching series is confronted with many difficulties, and the result must be accepted with hesitation, as being very uncertain, owing to the many possibilities involved in the structure, which cannot all be duly regarded. Difficulties of determination.

Dr. Lawson's estimate* of the thickness of the series in the Rainy Lake district is based on very evident and significant facts, and it will be interesting to see how far the facts of this field, similarly interpreted, corroborate his estimate. Lawson's estimate.

Dr. Lawson considers the whole volume of mica schists, south of the Keewatin area, to represent a threefold repetition of the series folded over a northern anticlinal and under a southern synclinal axis. The portion between the Keewatin schists and the anticline, he estimates to have a thickness of 4·50 miles. The portion between the axes he estimates at 4·588 miles, and the southern third at 5·44 miles thick, which, allowing for uncertainties of data, would indicate a much greater thickness for the series to the south than to the north.

The northern anticlinal axis, described as striking the shore of Rainy Lake between Rat River and Vague Point, crosses the Pipestone River about one mile and a quarter from its mouth, where diverging dips are seen ; thence its eastern extension marks the centre line of an ovoid area of Laurentian rocks, the southern edge of which is exposed on the north shore of Sturgeon Lake ; so that in the Hunters Island district only the southern synclinal basin is seen in its extension eastward from Rainy Lake. Granite area on line of anticline in Rainy Lake.

*Geol. Survey of Canada, Annual Report, vol. III., 1887-88, p. 100 F.

Eastern extension of Rainy Lake syncline.

The axis of this basin, along which the dips converge, can be traced from Kettle Falls, with a course east by south, north of Namakan Lake, south of Captain Tom Lake, touching the northern bend of Namakan River, whence it sweeps to the south of Wolseley Lake; from here it curves more to the east, encroaching, probably, on the north-east part of Indian Reserve "D," skirting to the north of Maligne River to cross it at the dam at the outlet of Sturgeon Lake, and passes between Sturgeon and Hoffmann lakes.

Thickness north of Sand Point Lake.

From the contact of the Coutchiching and Laurentian on Sand Point Lake, to the axis above described, the distance is about 5½ miles. The angle of dip varies between 25° and 70°, and for the first three-quarters of a mile north of the Sand Point Lake granite, may be taken to average 60°; for the next three-quarters of a mile, 30°; for the next mile and a half, 60°; for the next mile, 40°; for the next mile, 65°; and for the last half-mile, 80°. Making the corrections for these angles of declination, these measurements would give a thickness of 4·367 miles, considerably less than that found for this portion of the trough further west; but here the series might be expected to be thinner, and the calculation is based on a position of the synclinal axis determined from data obtained since Dr. Lawson's report was written.

Thickness of northern half of basin.

For a calculation of the northern half of this fold, there are no data sufficiently accurate to give satisfactory results. The distance between the synclinal and anticlinal axes on a line of section continuous with the above would be probably between five and a half and six miles, and if we assume the dips to be the same as for this part of the fold on Rainy Lake, viz., about 75°, the thickness would appear to be about 5,000 feet greater than that deduced by Dr. Lawson there. No reliance can, however, be placed on this calculation.

Thickness east of Thompson Lake.

From where the axis of convergence can be located as striking the Namakan River at the mouth of the Quetico River (the northern bend), south to the granites, can hardly be less than seven miles. The rocks have, however, a more uniform and a lower dip, averaging for the northern four miles about 60°, and for the southern three miles, 45°, which would give a thickness of 5·548 miles, greater than that calculated by Dr. Lawson. The series here, however, may have been thickened by the intrusion of the granites of Thompson Lake.

Thickness of northern fold.

North of the synclinal axis the contact with the mica schists and the granite area, seen in part on this sheet on the north side of Sturgeon Lake, cannot be accurately defined, owing to the very broad zone of alternate bands of granite and schist, but the granites first appear decidedly to predominate along a line rudely parallel with this axis and distant from it about 5½ miles. For a mile and a half north

of the axis the schists dip to the south, and north of this they dip constantly to the north under the northern granites. This indicates another anticlinal axis, probably due to an intermediate local disturbance, for such an axis is not seen on Rainy Lake. Ignoring this and assuming the average dip for the whole five miles and a half to be 65°, a thickness of 4·985 miles would be indicated.

Thickness north of Roland Island

The axis of convergence of dip can be only approximately laid down north of Lac la Croix, but it probably lies about four miles and a half north of the contact on Roland Island. For the first three miles north of the contact the dips are low, ranging from 30° to 45°, and averaging about 40°. The dips for the next mile would have an average of about 65°, and for the last half mile about 80°, giving a total thickness of 3·327 miles, which indicates a thinning of the series towards the east.

Thickness across Tanners Lake.

Neither the axis north of Tanner's Lake, nor the contact north of Wicksteed Lake, can be very accurately placed, but the distance between them would be about four miles. From the dips observed on the stream draining Darkey Lake, they would appear to be very low, averaging not over 25° for the southern mile and a half of this distance. The average for the next two miles, as revealed on Tanner's Lake, and on the portage south of it, would appear to be about 50°, and for the last half mile we may assume an average of 80°, giving a total thickness of 2·658 miles, indicating a still greater attenuation of the series.

Thickness across Pooh Bah Lake.

Still further east the series seems to have been split and wedged apart by the syenites of Pooh-Bah Lake. South of the syenites, the most reliable measurements would give a width of two miles to the schists, which have here an average dip of 45°, or a thickness of 1·389 miles, underlying the syenites. From the northern edge of the syenites to the axis of convergence of dip at the Maligne dam, the distance is 1·6 miles, the schists have an average dip of about 60°, which would give them a thickness of 1·386 miles, overlying the syenites. The total thickness would thus be 2·775 miles, somewhat greater than the last, but it is uncertain what effect the intrusion of the syenites would have upon the thickness of the series, at the present level of denudation, by the introduction of intermediate folds.

Thickness under the syenite.

Thickness over the syenite.

Thickness revealed in Sturgeon Lake.

The only place where satisfactory evidence of the thickness of the northern upward fold of the series is afforded, is on the west shore of Sturgeon Lake, where the horizontal distance across the fold is under two miles and the declination averages 75°, giving a thickness of 1·932 miles. A rapid thinning of the series would be expected so near the eastern end of the trough.

Allowing for local variations in the thickness of the series, and for inaccuracy and incompleteness of data, it is thus seen that in the Hunters Island region the enormous thickness revealed in Rainy Lake is maintained, and the calculations based on the same interpretation of the structure, give practically the same results.

Reasons for regarding the thickness as too great.

There are, however, weighty reasons for doubting the results of these calculations. In the report on the Rainy Lake region,* it is pointed out that the intervention of the mica schists between the granites and the rocks of the Keewatin series, has preserved the latter from the intense metamorphism which they exhibit when in direct contact with the former. It is, therefore, surprising to find that these mica schists, which would here seem to have been deposited in such enormous thickness, should exhibit comparatively little difference in degree of metamorphism, between its upper and lower members. Again, it is surprising to find here a development of a singularly uniform series, unparalleled by any other series of upper Archæan rocks, particularly in view of the fact that in no other part of the whole field between the Lake of the Woods and Lake Superior, is anything more than a comparatively subordinate development of mica schists observed.

Metamorphism.

Unusual development.

Period of folding of Coutchiching and Keewatin the same.

The contact between the Laurentian and the Coutchiching rocks, and between the former and the Keewatin presents the same characteristics; and no unconformity of structure between the two upper series has ever been observed. It is therefore highly probable that the two series were folded at the same time, and it is therefore most likely that the true original thickness of the Coutchiching rocks would be more nearly arrived at from measurements taken where these rocks are found in position between the Laurentian and Keewatin rocks, than in the main areas where the apparent thickness may have been manifolded by intense and minute plications. In the area comprised within this sheet, no such occurrence of the mica schists is seen, but one such instance is afforded on Rainy Lake, where the band of schists south of Pither's point, lying between the Keewatin belt on the south and the Laurentian area on the north, has been computed as 8,000 or 9,000 feet thick†. As pointed out in connection with this statement, the comparative thinness may be due to partial absorption of the mica schists into the magma from which the granites recrystallized, but this supposition is contradicted by the fact that the southern half of the southern synclinal basin, which would be subject to the same influence, is thicker (on the double synclinal interpretation of the structure) than any other part of the series.

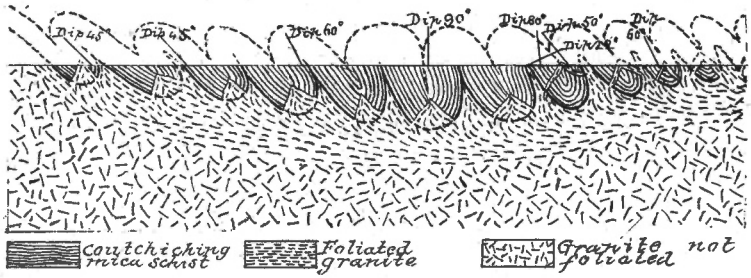
True thickness more nearly determined in intermediate bands.

*Geol. Survey of Canada, An. Rept., vol. III., 1887-88, Part I., p. 38 F.

† Geol. Survey of Canada, An. Rept. vol. III., 1887-88, Part I., p. 104 F.

A minute study of the section east of Thompson Lake reveals the following facts:—The schists at the contact on Roland Island have a northerly inclination of 45°, and this is the prevailing dip for three miles north; 60° being the average northerly dip for the remaining four miles to the axis of converging dips where the rocks are in vertical position. For one mile north of this axis the rocks have a prevailing dip to the south of 80°. One mile and a half north of the axis a dip of 22° S. was observed; at two miles north the declination is 80° to the north, lowering to 50° half a mile still further north; for the remaining three miles, to the line of predominance of the granites, the dip is uniformly to the north at angles differing little from, and averaging 55°. The section below represents what, in the writer's opinion, is the most probable structure of the rocks along this line. Section east of Thompson Lake.

Fig 3



Ideal Section across Coutchiching series East of Thompson Lake; suggesting probable manifolding of the series, the intrusive character of the gneissoid granite, and the probable cause of the brecciated contact zone.
Natural scale 4 miles = 1 inch

The alternating bands of foliated granite and mica schists, in the contact zone, may thus be accounted for not only by intrusive dikes of the granite, but by intrusions between the folds, and the shattering of the crumpled schists particularly at sharp synclinal turns and the intrusion of granites into these fissures. A comparatively thin series, thus manifolded would have a comparative uniformity of metamorphism throughout. Explanation afforded by diagrammatic section.

The low dips often observed in central portions of the basin might thus indicate proximity to the crest of an original anticline or to the trough of a syncline.

This interpretation of the structure nullifies all data from which a calculation of the original thickness can be made, and affords only a

reason for believing that the Coutchiching series is much thinner than it has previously been considered to be.

Keewatin Series.

Limits of area and conditions of contact with lower rocks.

Work done in Keewatin area.

It is unfortunate that, for reasons already given, I cannot describe these rocks with the thoroughness and minuteness that their scientific and economic importance deserves. A reference to the record of work, previously given, will show how little of the work in the area occupied by Keewatin rocks was performed by me. In 1888, I spent three days on Saganagons Lake, during which a hasty visit was paid to the most northerly of the mining locations, south-west of the lake. In July, 1888, I passed hurriedly from Basswood Lake through Birch, Carp, Emerald, Big Rock and Jasper lakes to Saganagons Lake, taking cursory notes on the way without any expectation of requiring them for future use. I surveyed the islands in Saganagons Lake. Mr. Russell had made an excellent traverse of the shores of the lake, a plat of which he kindly gave me, so that less attention was paid to the rocks of the shore than they would otherwise have received, but the notes and specimens collected at this time, form the only systematic geological work in this area that is at hand.

Contact in Basswood Lake.

The contact of the Laurentian and Keewatin rocks, shown in the north-east corner of the extreme eastern expansion of Basswood Lake, has been determined by Dr. Lawson. The contact of the granites of Meadows and Louisa lakes, with the Keewatin rocks of That Man's and This Man's lakes, must lie somewhere between them and in a line generally parallel to these chains of lakes, as the foliation of the rocks in both chains is coincident with the general trend of the shore lines. The next point north-east where Keewatin rocks were seen in contact with Laurentian, was on Glacier Lake, where a band of fine-grained black siliceous hornblende schist was found, the width of which could not be determined; it is exposed along the eastern shore for about a quarter of a mile, having a strike in the central part of this distance of N. 80° E. with a southerly dip of 45°, a single exposure opposite this on the west side of the lake has a north and south direction of strike. It is again exposed at the southern extremity of the lake, at the portage to Cross Lake; here the direction of structural planes is also north, with a low westerly dip of about 40°, the reversal of the dips and their low declination together with the sharp change in the strike indicate considerable disturbance. The contact with the distinctly laminated pink biotite gneiss of this lake was everywhere concealed by drift, the shores afford-

Glacier Lake.

ing only isolated exposures. The gneiss in the neighbourhood has a strike of N. 25° E. which would indicate probably the general direction of this band. The band is probably of insignificant width, from the fact that no certain continuance of it is seen to the north-east.

Parallel small band of hornblende schist. Louisa Lake.

South-west of this, on the portage between the two small lakes north-east of Louisa Lake, a band of precisely similar rocks to these, but so narrow in development as to be inappreciable on the scale of the map, is associated with the light gray distinctly foliated biotite gneiss, which here strikes N. 35° E., with a south-easterly dip of 80°. On the northernmost island, lying near the north-west shore of this lake, is a narrow band of similar hornblende schist, interbanded with a fine-grained red granite, in which the bi-silicate is changed to chlorite; here the hornblende schist strikes N. 45° E., and has a low north-westerly declination of only 10°. No occurrence of this band is seen between these two localities, but the rock exposures are comparatively infrequent, and the band is probably continuous. On the portage between Louisa and Agnes Lakes is another exposure of hornblende schists dipping S. 45° E., angle 80°. No intermediate occurrence of this band is seen, but where it would be expected the rocks on the shore of the lake are concealed by sand. These three exposures of hornblende schist are therefore nearly linear with each other in their localities and in the direction of their structural planes, and it would seem that they probably represent fragmentary portions of a pinched infold of Keewatin rocks, parallel to the main trough to the south-east. I have not mapped the rocks seen in Glacier Lake, although very similar in character, as continuous with this band, as the direction of the former in its most southerly occurrence seemed to suggest that it was rather an apophysis of the main mass than a greatly thickened development of the Louisa Lake band.

Band probably continuous.

Contact in Slate Lake.

The next place where the contact is seen is in Slate Lake, lying to the west of the south-west end of Saganagons Lake, on the southern bay of which massive quartzose hornblende schists are exposed. On the peninsula between the south and west bays is an important exposure of red, rather coarse-grained granite gneiss, in which the bi-silicate would seem to have been hornblende, now changed to chlorite. The actual contact, though not well exposed, presents the usual zone of interbanded granite and schist, here, however, narrow, with but few alternating bands. From the direction of the strike of the rocks here, together with the strikes observed by Dr. Lawson on The Other Man's Lake, there can be little doubt that the line of junction to the south-west is approximately as indicated on the map. The schists on the north shore of Slate Lake, north-west of the granites

above described, are mica schists, so characteristically Coutchiching as to leave little doubt as to their correlation with that series.

Contact in Saganagons Lake.

The bottom of the bay of Saganagons Lake, north-east of this, is occupied by granitoid gneiss, distinctly foliated and holding bands and lenticular inclusions of hornblende schist. On the long narrow point forming the south-western shore of this bay, the bands of hornblende schist or schistose trap become so frequent as to predominate over the foliated granites, and the contact is, therefore, placed north-west of this point. The islands at, and to the north-east of, the mouth of this bay present the same features of interbanded and foliated granites and black schistose rocks, indicative of the contact zone. The rocks here strike N. 35° E., and dip S.E., angle 80°. The large triangular island, three-quarters of a mile north-east of the above mentioned point is composed almost exclusively of hornblende schist.

The line of junction passes through the islands, and crosses the narrow neck of land, cutting off the point north of the trail which forms a winter route to Saganagons Lake. This point and the small islands to the west of it, are composed of hornblende schists, while the shore of the shallow bay to the west presents numerous exposures of deep pink obscurely foliated granitoid gneiss. The bay north and east of this point, presents no exposures, but the extreme point, one-half mile to the north-east, offers an exposure of hornblende schist.

Chloritic schists.

A single exposure of granite, probably interbanded, is seen a few chains to the north-west. Here the rocks become chloritic in composition, the rocks on the point of the shore to the east being soft, fissile, dull green, quartzose chlorite schists. The contact is again determined

Deadman's Point.

in the bay north of Deadman's Portage, which crosses the narrow part of the long tongue of land which runs north-east to the eastern boundary of Rainy River district. This tongue is called Deadman's Point, doubtless from the fact that it has, for years, been a favourite cemetery of the Indians, several of their curious elevated coffins still remaining there. The portage crosses just east of the last point described. The tongue of land is occupied by hornblendic and chloritic schists. The south-western shore of the north-western part of the lake affords many exposures of reddish, coarse-grained biotite granite gneiss, having a strike of N. 50° E. The contact lies in a grassy bay in the extreme south corner. The junction can be traced as lying between adjacent exposures of hornblende schist and foliated pink granite, on the off-lying islands skirting the south-east shore of this part of the lake ; the usual strike being about N. 50° E., with local variations to N. 70° E., the rocks being nearly in a vertical position. The contact on the north shore of the lake, west of the narrow channel

to the eastern part, cannot be very closely located, owing to the stony character of the shores of the bay, but it must lie between the reddish biotite granite, indistinctly foliated, exposed on the point between the two deep bays to the north, and the chloritic hornblende schists revealed on both sides of the narrow channel between the north shore and the long narrow island to the south-west. The rocks on both sides of the contact line have a common direction of foliation of N. 70 E. The granites do not reveal the dip clearly, but the schists are in vertical attitude. The line of junction from here would seem to sweep from the north-east to the north, then to the north-west to form the south-western edge of the band of hornblende schists, indicated by the occurrence and strike of these rocks exposed on the shores of the lake west of Ross Lake, crossed by the boundary line between the districts of Rainy River and Thunder Bay. The rocks strike in a west-north-westerly direction from this lake, and in the east end of it they strike a little north of east, and due east near the centre of it; while several exposures in the west end of the lake show a uniform strike of W.N.W. The dip is uniformly to the south and south-west, at an angle of 45°. The width of this band is uncertain, but a westerly projection of the strikes noted would indicate a width of not less than three-quarters of a mile just west of the lakes, although it probably becomes attenuated in its westerly extension. This westward extension is a matter of conjecture; but, for the following reasons, I have mapped it as in continuance with the mica schist band of McEwen Lake, as being probably representative of the facts.

Lake west of Ross Lake.

This band is seen to strike west-north-west. The McEwen Lake band of mica schist, characteristically Coutchiching, is seen in its most easterly exposures, on the shores of the chain of lakes and connecting streams forming the outlet of Saganagons Lake, to strike east north-east. The projection of these two directions would intersect. For many reasons, which need not be detailed here, it may be assumed that the periods of folding of the Keewatin and Coutchiching rocks were identical. These bands represent synclinal folds of the Laurentian rocks, and whether the latter were in a viscid or in a hard condition at this period, it is simpler and more rational to conceive of a single curved trough than of two intersecting ones. Coutchiching and Keewatin rocks are frequently found occupying the same trough, the Coutchiching being always the inferior series, and generally seen to flank the Keewatin schists on both edges of the trough, while Coutchiching rocks may be found exclusively at one end of the trough and Keewatin rocks exclusively at the other end. The mapping, therefore, represents on a small scale conditions found to obtain elsewhere on a larger scale.

Reasons for mapping McEwen Lake band in continuation with branch of Keewatin rocks of Saganagons Lake.

While this represents, therefore, the most probable distribution, it is by no means certain that these bands do not terminate before reaching the point of intersection or of union, but bands of Coutchiching and Keewatin rocks, in granites, are usually found to extend for such great distances, in proportion to their width, that this supposition is unlikely.

Rocks on Ross Lake.

On the north side of the channel into Ross Lake, there are very few exposures, but such as there are indicate a continuous band of hornblende schists on the north side, striking east and dipping at a low angle to the south. On the south shore of the channel, near where it expands into Ross Lake, are some exposures which indicate the existence of a band of granitic rocks. The hornblende schists of the north side of the channel are again seen on the small island lying close to the south shore of Ross Lake, where they strike a little south of east and have a low southerly dip of 45° from the strike here, and on the west side of Beaver Lake it is probable that the band is continuous with the main mass to the south, and locally separated from it by a lenticular band of granite exposed on the south shore of Ross Lake. These exposures may indicate only small local intruded bands of granite, but in the absence of intermediate exposures of hornblende schists, it is mapped as representing a considerable band. This affords a graphic representation of a very frequent occurrence, though usually on a much smaller scale.

Intercalated granitic band.

Beaver Lake.

The north shore of Ross Lake and both shores of the channel to Beaver Lake afford a few isolated exposures of granitic rocks. There are few exposures in Beaver Lake, but such as there are, are of granite on the north side, and of dark green hornblende schist on the south side. On the south side the strike of the schists curves round from south of east, near the west end, to N. 75° E., at a point near the middle of the lake, the dip also becomes steeper, changing from 45° S. on Ross Lake to 52° S. at the west end of Beaver Lake and to 80° S. at the point near the middle of the lake. At the narrows, three-quarters of a mile east of Beaver Lake, the granite is fine-grained and red in colour, with a little biotite; it is cut by intersecting cleavage and jointing planes, one set of which, striking N. 65° E., would seem to represent the true structural planes of the rock. There are so few exposures on this route that the line of junction cannot be laid down with great precision, or described as to its character, but there is little doubt that it is defined on the map with as much accuracy as the scale will permit.

South-eastern boundary of Keewatin area.

As to the south-eastern boundary of the Keewatin belt, it was nowhere traced or examined by myself, but it has been closely defined by Dr. Lawson and laid down by him on the map.

The question of the age of the rocks of Saganaga Lake, in contact with the Keewatin, will be discussed later.

Cache Bay.

The line of junction is seen, on the Canadian side of the international boundary, only in and on the west and north shores of Cache Bay of Saganaga Lake, and along the north-west shore of the main lake in one locality. It skirts along this shore, the mainland being occupied, for the most part, by Keewatin rocks, while the off-lying islands are composed of granites.

Conglomerates.

An interesting series of specimens, collected by Dr. Lawson from Cache Bay, reveal the presence of a felsitic conglomerate in contact with a coarse-grained hornblende granite.

The conglomerate holds well water-worn pebbles of various sizes, usually as large as a hen's egg; these pebbles are of white and bluish quartz and coarse-grained hornblende granite; the matrix is a medium grained aggregation of quartz and felspar, with a little decomposed bi-silicate. The matrix has a granitic aspect and appears to be itself a finer conglomerate, made up of many partly-rounded grains of felspar and quartz cemented together. Beds of dolomite are associated with this conglomerate. Not having myself examined the localities where this conglomerate is exposed, I can say nothing of its relations in the field or of its stratigraphical significance.

Character of contact in Cache Bay.

On the north side of Cache Bay the contact between the hornblende schist and the granite gneiss is well exposed and is very characteristic of the contact between the Laurentian and upper Archæan or Huronian rocks of this district. Three photographs showing the nature of this contact at different localities were taken by Dr. Lawson, and are here reproduced. Plate I. represents what I shall so often have occasion to describe as the interbanded structure of the gneiss and schists. These lenticular bands of hornblende schist (dark coloured portions in the plate), included in the hornblende granite gneiss (light coloured portion), are not always so abruptly terminated, and often maintain a comparative uniformity for hundreds of yards. The appearance is frequently suggestive of an interbedding of the two series at the contact, and but for the brevity of these beds, and their sometimes rounded ends, such as shown in this plate, one would be apt to regard them as true interbedded depositions.

Lenticular bands of hornblende schist.

Angular fragments of schist in granite.

In plate II. is seen a common feature along the junction between the granites and the Coutchiching and Keewatin rocks, viz., the inclusion in the granites of scattered angular fragments of schistose rocks. These angular fragments usually have the appearance of having been broken and torn apart by longitudinal stretching. The longer axes of the fragments are nearly always parallel with the contact planes, and

sometimes would seem to have been moved but little from their original position as parts of the massive schistose series. Again, these scattered sharply angular fragments are often seen many yards from the contact, and isolated occurrences of them embedded in the granite have been noted a mile or more from any important development of similar rocks.

Granite dike.

Plate III. represents a bifurcated dike of hornblende granite (the lighter portion) striking from the main mass of these rocks into the hornblende schists across their planes of stratification.

Phenomena figured characteristic.

These plates afford very strong evidence of the intrusive character of these hornblende granites, and the phenomena here shown are of such frequent occurrence all along the line of contact of the Laurentian and the upper Archæan rocks, as to characterize the general nature of the junction and to strongly support the supposition that the Laurentian rocks of this region are as a whole irruptive in their relations to the overlying series.

Character of some of the rocks of the Keewatin belt.

Rocks in Birch Lake.

On Birch Lake the rocks exposed are coarsely crystalline hornblendic rocks, not very schistose. With these are associated very fine-grained fissile dark gray slates, apparently little altered clay slates. On Carp Portage, at the west end, these slates strike N. 58° E., and have a south-easterly declination of 84°. These schists or slates are almost continuously exposed on the south shore of Carp Lake, becoming more greenish in colour and softer, but less finely fissile, as we cross the series to the south, where they are exposed on the bare hills as soft chloritic schists.

Between Carp and Emerald Lakes, is a small lake surrounded by bold hills of massive "greenstone." These rocks are dull dark greenish-gray in colour, very hard, and they have as a rule very little schistose structure.

Emerald Lake.

The shores of Emerald Lake are very steep, presenting high, rugged cliffs of this same massive greenstone. At the east end of the lake, on the north shore, the rock is black in colour, compact and fine-grained, and appears to contain a small percentage of iron.

Big Rock Lake.

The rocks exposed in Big Rock Lake are fine grained, light greenish-gray altered trap or "greenstone." It is sometimes cut by jointing planes, but no true schistose structure is discernible. The rock is often

Iron staining

deeply stained with iron rust. This appearance of iron oxide staining is often closely simulated by an orange coloured lichen, which adheres very closely to the surface of the rocks, and at a distance is quite indistinguishable from the orange-brown stains caused by the deposition

of scales of iron oxide left on the surface by percolating waters. Prof. Macoun states that this lichen is the species *Placodium elegans*.

Cypress Lake seems to lie entirely in this greenstone horizon, these rocks being exposed almost continuously along the shores, which are high, rugged, perpendicular escarpments, rising abruptly from the water's edge for over one hundred feet. These scarped faces are very much stained with iron oxide. Cypress Lake.

On the portage between Cypress and Jasper lakes black crystalline hornblende schists are exposed, striking N. 56° E., and in vertical attitude.

On Jasper Lake, the massive greenstones appear associated with schistose traps and black crystalline hornblende schists. The structural planes of the schistose rocks strike in a direction between N. 55° E. and N. 60° E., and are, for the most part, vertical. Near the point at the south end of Jasper Lake, the rock is a fine-grained dark greenish-gray altered trap, which shows evidences of crushing and shearing. On a small island in the centre of this lake, is a fine grained dark gray siliceous rock, probably a variety of eruptive rock. In the bottom of the bay to the north-east, the rock is dark greenish-gray, compact and fine-grained, and would appear, macroscopically, to be an altered diabase. The shores of this lake are less rugged and precipitous. Jasper Lake.

On the portage going north out of Jasper Lake, massive greenish-gray hard greenstones are exposed. Associated with them, is here a band of ribanded jasper and hæmatite. The alternating bands of purplish hæmatite and cherry-red jasper have a comparatively uniform width of somewhat less than an inch; they are contorted and twisted in the most curious way, and present a beautiful appearance on the surface. This band is about forty or fifty feet wide, flanked on both sides by the greenstones above described. Banded jasper and hæmatite.

There are, no doubt, many other occurrences of this banded jasper and hæmatite associated with the greenstones to the south-west, the localities of which would be indicated by the mining locations shown along the route, the rocks of which I have briefly described.

This occurrence of jasper and iron ore associated with massive greenstones in this Keewatin belt, has great importance and significance, and is most encouraging to those interested in the iron industry of western Ontario. This belt of Keewatin rocks is shown on the "Geological Map of Iron Regions of Minnesota,"* as being in direct continuance with the belt of rocks, which the Messrs. Winchell also Importance of occurrence of jasper and hæmatite. Same belt as at Tower and Ely.

* Published in 1890 by N. H. & H. V. Winchell, State Geologists of Minnesota.

call Keewatin, in which are located the exceptionally rich mines of the neighbourhood of Tower and Ely.

Similar association of rocks at Tower and Ely.

There the ore bodies are found associated with greenstones and greenstone schists, and capped by formations of banded jasper and hæmatite, the removal of the silica and its replacement by iron oxide under favourable conditions giving rise to the solid ore bodies below. There is every reason to believe that beneath the jasper and ore capping in the region south-west of Saganagons Lake, the same agencies have produced the same result of concentrating the ores in workable bodies, that have operated to produce this result in the same belt less than sixty miles to the west-south-west. It is to be regretted that these Canadian localities have not been thoroughly tested, not only from an economic stand-point, but from the increased knowledge that systematic testing would give of the relation of the ore to the inclosing rocks.

Greenstone.

On the lake between Jasper Lake and the long south-west arm of Saganagons Lake, are light greenish-gray altered traps or greenstones, in some places quite schistose on the surface and fissile under the hammer, and in others quite massive.

On the portage between this lake and Saganagons Lake hornblende schist is exposed. It strikes N. 40° E. and dips at a very high angle to the north-west. There is seen also on this portage a very slightly schistose rock, probably related to the greenstones, which holds fragments of jasper.

South-west area of Saganagons Lake, Greenstones.

Passing up the westerly arm of Saganagons Lake the rocks exposed are massive, hard greenstones on both sides. These rocks continue up the north shore past the portage into Slate Lake, above mentioned.

The rocks near the line of contact with the Laurentian, along the north-west shore, have been described as far as Deadman's Portage.

Saganagons Lake rocks.

On the south shore from the trail, which is part of the winter route shown to Saganagons Lake, east to the mouth of the first bay running to the south, the rocks are light greenish-gray, fissile schists, apparently quartzose, chlorite schists, but possibly derivatives, by crushing and shearing, from the massive greenstones. These rocks on the fresh cleavage surface have a somewhat greasy feel. In the bay to the south a massive hard black eruptive rock is seen, which is probably of later age; whether it is diabase or diorite cannot be macroscopically determined with certainty owing to its fine texture. At the mouth of this bay on the eastern side, massive, hard greenstones are exposed, while on the small islands and on the large one opposite, the fissile, light greenish-gray rocks, above described, are seen.

Chlorite schists.

The large island to the east presents few exposures, but there is one of greenstone which is also exposed almost continuously on the main shore opposite.

On the small island between the east end of this island and the main south shore, the rock is schistose and weathers a dull light greenish-gray. While it closely resembles the chloritic schists to the west it does not break with the same smooth cleavage nor has the cleavage surface the same unctuous feel. It probably differs from it, however, only in degree of alteration.

Rocks in Saganagon Lake.

The rocks adhere in their strike very closely to the general trend of the shore line, striking N. 85° E., and dipping south < 80° On the shore to the south a local flexure in the strike is seen in conformity with the trend of the south shore of the little bay which strikes of S. 70° E.

Quartz porphyry.

On the east end of the large island no exposures are seen, but on the north shore a continuation of the schistose chloritic rocks exposed on the large island to the west is seen; the strike is here N. 85° E., dip S., angle 80°. On the shore of Deadman's Point, opposite the west end of this island, a rock is exposed which is very much sheared and crushed, it is rather coarse grained and contains felspar, quartz and chlorite, some of the felspar crystals appear to be porphyritic as well as some of the grains of quartz, and it would thus seem to be allied to the quartz porphyries; lying so near the granites, however, it may be genetically associated with them, and have received its present structure from accidental causes. To the west no occurrence of it is seen. An exposure of it is seen on a low hill a few chains to the north, but it does not occur along the north shore of Deadman's Point.

Rocks of Saganagons Lake.

It is exposed for a few chains along the south shore, to the east, where its southern contact with the green schists can be closely defined, although the actual line of junction is concealed under the sand. These exposures, therefore, probably represent a narrow lenticular subordinate band. It is in strict conformity with the associated green schists, which strike of N. 60° E., and are vertical, or dip at a very high angle to the south.

East of this at the southern extremity of Deadman's Point, the green schists are seen; here they are not very fissile.

Greenstones.

On the island nearly half a mile east north-east of this, the rock, while slightly schistose, assumes more the appearance of a greenstone. North-east of this the rock decidedly belongs to the greenstone series. The chain of small islands between here and the south-west point of the large island east of the extremity of Deadman's Point, are composed of schistose rocks, somewhat darker in colour and partaking more

Rocks of Saganagons Lake.

of the character of hornblendic schists ; these rocks are also exposed on the northern part of this island. On the south-west point of it, however, is an abrupt high rounded *roche moutonnée*, of massive rock, somewhat darker in colour than, but no doubt related to, the greenstones. Along the south shore of this island there are few exposures ; but near the middle and the east end, the greenstones are again seen, here containing irregular and crooked stringers of quartz. The small island lying off the main south shore opposite, also exhibits the same rock, containing similar stringers of white quartz. These quartz veins are comparatively a common feature, not only in the greenstones but in the more fissile chloritic schists.

None were seen of any considerable width, they are not more than two or three inches, and seem to be veins of infiltration, which, as a rule, cut across the structural planes of the rock.

Magnetite in greenstones.

The greenstones of Saganagons Lake do not generally affect the compass strongly ; but in this neighbourhood they contain sufficient magnetite to cause the needle to diverge considerably from the magnetic meridian.

On the main shore, opposite the east end of the large island last referred to, the rock is schistose but not fissile, it is light greenish-gray in colour and strikes N. 75° E. with a vertical dip. East of this the strike curves to the east in conformity with the shore and the rock becomes very fissile. Then for a mile along the south shore of this eastern part of the lake, there is no exposure. From here these light greenish-gray fissile schists are exposed all along the south shore to the eastern end of the lake. The strike changes from east to N. 75° E. in strict conformity with the general sweep of the shore line. The dips are south at angles never less than 75° and often vertical.

Saganagons Lake, east end.

Crossing the strike of the rocks along the eastern shore at the end of the lake, we find in adjacent exposures the rocks becoming darker in colour, coarser in texture and revealing distinct crystals of hornblende ; the rock is quite schistose, although harder and more compact than the chlorite schists.

Hornblende schist.

This hornblende schist is seen in the north-east corner of the lake, and all along the north shore of the large island south-west, and on the small islands between this and the north shore of the lake.

Hornblendic schists merging into ordinary black medium grained hornblendic schists are seen at several points along the north shore westward to the north-westward contact of the granites, and in the channel forming the outlet of Cross and Beaver Lakes. East of this channel the shore line adheres closely to the strike of the rocks.

There is considerable evidence in support of the belief that the light greenish-gray chlorite schists described as representing a large proportion of the rocks exposed about Saganagons Lake, and seeming to differ from the greenstones in external character, only in the varying degree of their schistosity, are derived by crushing, shearing and metasomatic change from these greenstones. Chloritic schist derived from greenstones.

Their macroscopic appearance is extremely suggestive of this, and the change in mineral composition involved is a simple one, frequently exemplified. I have not traced, in unbroken section, a passage from one into the other, but the scattered exposures afforded by the islands show a variation in degree of schistosity, hardness and texture, in such a way, and in such localities, as to render it highly probable that a Passage of this kind actually occurs. From the localities of greenstone already enumerated in Saganagons Lake, it will be seen that of the two south-western arms, the most westerly one is eroded out of these massive rocks. From the mouth of this arm the greenstones seem to strike in a north-east direction, under the waters of the lake and reappear on the south side skirting the channel between the south shore of the lake and the off-lying islands, occurring sometimes on the main shore, sometimes on the islands and sometimes on both, disappearing altogether in the open part of the lake east of Deadman's Point.

South-west of Saganagons Lake, Jasper, Cypress, Big Rock and Emerald lakes are eroded, for the most part, out of the massive greenstones.

It is inconceivable that these hard rocks altered chemically to their most stable form, can have been the most susceptible to denuding agencies, and we are forced to the conclusion that this channel that we have traced for twenty-two miles from the west end of Emerald Lake to the east end of Saganagons Lake, must have been originally occupied by soft fissile schists, flanked for the most part by greenstones. The sinuous line of this channel, which sweeps across the main Keewatin trough from the north side to near the south-west side, renders it improbable that these soft schists were originally the upper portion of the series, folded within the underlying traps, and it would seem more probable that this assumed schistose belt marks the plane along which the traps yielded, within themselves, to the crushing and shearing forces induced by the sharp folding of the series. Fissile schist flanked by greenstones.

The breadth of the Keewatin series here revealed, does not afford any certain criterion by which to estimate its original thickness. The dips show an apparently simple synclinal structure of a series folded on itself. I have nowhere examined a complete section across the belt, Thickness of Keewatin series.

and cannot say whether the series affords any evidence of having been repeated by multiple folding or not. Again, from what is known of the distribution of the rocks on the American side of the international boundary, the hornblende granites of Saganaga Lake and Cache Bay, which from Swamp Lake sweep to the south around Gull Lake, would appear to be the south-westward ovoid termination of a large granitic area, dividing the main Keewatin trough into two branches, of which the northerly one is that seen on the Canadian side and above described, and the southerly one is seen only in a narrow tapering band of greenstones south of Gull Lake in township 65, ranges IV. and V., Minnesota, and no doubt represented, further east on the Canadian side, by the greenish-black schists of the north side of Gunflint Lake. This southern fork is largely concealed under sediments of a later age, and partly interrupted by the gabbro of the Mesabi range.

This belt branch of belt to south-west.

Thus the volume revealed between Saganagons and Saganaga lakes probably does not include the whole of the series, the upper members in all likelihood being wanting.

Width of belt.

The distance from the contact at the Deadman's portage, across the strike, to where the line of junction intersects the north-west shore of Saganaga Lake, is four miles. The rocks dip on the north at a high angle to the south, usually about 75°, and on the south side at about the same angle to the north and are vertical at the central synclinal axis; an average dip of 85° will not be far from correct, and this would give 1·992 miles as the average thickness of the series developed in this trough.

Thickness.

South-westward extension.

North-easterly extension of Keewatin belt.

As before stated, this belt has been traced in connection with that holding the iron ores of Tower and Ely to the south-west. This Keewatin belt, characteristically an iron-bearing series throughout its whole length, would appear to bend somewhat sharply to the north, east of Beaver Lake, then to sweep round more easterly, with its northern limit about three or four miles south of the south-east corner of Moss Township, thence to skirt south of Greenwater and Shebandawan lakes.

Iron ores.

Iron ores, of good quality, have been found at several points in this band, and on the line of the Canadian Pacific Railway, at several points west of Port Arthur, in a broader development of Keewatin rocks, no doubt magnified by the union of several broad bands.

Small isolated bands of hornblende schist.

Small isolated bands of hornblende schist, apparently included in, but quite conformable with the granitic rocks, are seen in several localities, sometimes at considerable distances from the Keewatin belt with which they would seem to be genetically identical.

Four miles and a half north-west of the Keewatin area, near Burk Lake, at a point between the north and north-east bays in the west end, occurs a band of hornblende schist, forty or fifty feet wide, in foliated pink-gray biotite granite gneiss. Large inclusions or lenticular bands of hornblende schist are seen in the pinkish-gray gneiss at the east end of Sunday Lake, two miles north-west of the main Keewatin trough. These bands would appear to indicate an original synclinal fold of the overlying Keewatin, yet the latter locality is in a direct line with the anticlinal, indicated by the diverging dips of the rocks, of Agnes Lake, two miles to the north-east, and which axis of divergence of foliation planes can be traced along the north-west shore of Louisa Lake to Farquier Lake.

Burk Lake. Sunday Lake. Agnes Lake. Farquier Lake.

On the second lake north-east of Farquier Lake, the red granite contains dark gray schistose hornblendic rock, with felspar, which more closely resembles a hornblende schist than a hornblende gneiss, but it may have been derived from the latter by crushing and shearing.

There is a band of coarse-grained hornblende schist, about three chains wide, on the west side of the large island in Agnes Lake, one mile south-east of the outlet of Lake Silence. It also occupies a small island close to the larger one. This is interbanded with thin bands of gneiss. The rock is more coarsely crystalline and also more schistose near the contact than in the central portion of the band. This may be a crushed and sheared hornblende eruptive rock.

Lake Silence.

Included in the granitic rocks are frequently found small areas of massive, coarsely crystalline, greenish black hornblendic rock, not at all schistose, sometimes measuring only a few feet in greatest length, which appear to be scattered angular fragments included in the granites. Several such areas are seen on Agnes Lake. They are here linear in their distribution, and are seen occasionally on the islands near the west shore, from the north end of the lake to the south-west bay, where they are seen on the west shore. Large irregular fragments or areas are seen on the portage south from Shade Lake included in micaceous gneiss, and they are here so frequent as to constitute the most abundant rock. From this locality, both north-east and south-west, the occurrences of this hornblende rock become less frequent, and the fragments are of smaller size, disappearing altogether about a mile each way.

Hornblende rock. Agnes Lake. Shade Lake.

Bands of hornblendic schist are also seen included in the red medium-grained granite of McNiece Lake. The granite here contains little bi-silicate, which now is mostly chlorite. On the point at the south end of Yum-Yum Lake, a local narrow band of micaceous siliceous hornblende schist is also seen.

McNiece Lake. Yum-Yum Lake.

Kahnipiminanikok Lake

A coarse grained sheared hornblende rock is associated with the mica schists of the south side of the inlet of Kahnipiminanikok Lake leading to McKenzie Lake, the most northerly one of the two deep inlets running north-east from the centre of the lake. As I shall have frequent occasion to refer to these two inlets, it will be convenient to call the north-westerly one McKenzie bay or inlet, and the one to the south-east of this Kahwawiagamak bay or inlet.

Brent Lake.

On the south side of Brent Lake, due south of the portage leading to Conmee Lake, is a narrow lenticular band of dark gray, decomposed felspathic hornblende rock, probably lithologically allied to those already described; most of it is concealed under the waters of the lake and only a few feet of its width is revealed.

Saganagons Lake.

At the north-western extremity of Saganagons Lake is a small area coloured Keewatin, but in which the rock is a hard, coarsely crystalline hornblende rock, with occasionally a few scales of biotite, and more rarely a little felspar. It is not at all schistose, and its general aspect and mode of occurrence is that of an eruptive rock, perhaps post Keewatin in age. The extension of the rocks composing it, east and west of the channel, is a matter of conjecture.

Keewatin volcanic vent.

Explanation of angular fragments in granite.

The small isolated areas described about Agnes and Shade lakes, on account of their diminutive size and proximity to each other, are probably highly metamorphosed fragments of Keewatin rocks, broken off from the troughs of synclinal axes, at the time that the Keewatin series was so sharply folded, and imbedded in the underlying rocks, and representing now all of the Keewatin series that denudation has spared in these localities.

Dikes.

Diabase dikes.

There were not observed in the Hunters Island region, many of those "Port Archæan Diabase Traps," described by Dr. Lawson[1] and by Dr. Lawson and Mr. F. Shutt, M.A.[2]. Indeed only two such dikes were observed by the writer, the one shown on McKenzie Inlet of Kahnipiminanikok Lake, and the other exposed on an island lying off the east shore of the bay running north, one mile west of the mouth of this inlet. This dike is not seen on the north side of this bay and the only indication of it, south of the island, is afforded by the strong magnetic attraction observed on the point at the mouth of this bay, on the east side.

Kahnipiminanikok Lake. Bay north of McKenzie Inlet.

1. Geol. Survey of Canada, Annual Rep., 1887-88, Vol. III., part I., pp. 147-163 F.
2. American Geologist, vol. VII., No. 3, March, 1891.

The island is less than one chain wide and two chains long. The whole of it is occupied by a fine-grained black crystalline diabase, which in one place, on the south-east extremity of the island, has become serpentinized. Detached hand specimens exhibit distinct polarity. As near as can be judged, the direction of the dike is a little west of south. On the west side of the island the rock becomes finer in texture which indicates the proximity of the wall. It is not seen on the south side of the lake across the channel.

McKenzie Inlet dike.

The dike indicated on the map in McKenzie Inlet can be much more closely studied, particularly on the south side of the inlet, where its contact with the inclosing mica schists is clearly seen.

The differentiation in texture between the wall and the centre, which is such a characteristic feature of these dikes was observed. The rock is a fine to coarse-grained, black, weathering pepper and salt gray, crystalline diabase. The width of the dike is sixty feet. Its course from the exposure on the south to that on the north side is due north, which is also the direction of the walls on the south side. It would not appear to extend very far south, as it is not seen in this direction, this, however, may be accounted for by the prevalence of drift in some of the localities where it might be expected to occur. It cuts the Laurentian rocks on the north side of the inlet, and the Coutchiching on the south, in such a way as to leave little doubt that it was intruded since the period of the last folding, which on the assumption that the Coutchiching and Keewatin rocks were folded at the same time, would establish their geological age as post-Keewatin.

Age of dikes.

Other dikes.

Other dike-like masses have been alluded to in previous pages, but they are not lithologically allied to these diabases, and their intrusive character is but conjectural.

Glacial Phenomena.

Lake of the Woods and Rainy Lake region.

The remarks made by Dr. Lawson in his report on the Lake of the Woods region, in the annual report of the Geological Survey for the year 1885, Part CC, and on the Rainy Lake region in the annual report for 1887, Part F, are generally applicable to this region also; the same features of glaciated surface, exhibiting generally rounded hill features and *roches moutonnées*, with the prevalence of drift, usually gravel, on the sides of elevations away from the direction from which the ice moved, are met with here. But while the broader features of glaciation are not less general or less marked in this region than in those reported on by Dr. Lawson, the minuter features of striations and groovings of the rocks are neither such conspicuous or universal

Roches moutonnées.

Glacial drift.

Glacial striæ less frequent.

features as in those districts; indeed in the area embraced in the western half of the accompanying sheet such indications are extremely rare, and only one observation is recorded. This is no doubt due to the prevalence of mica schists in this portion; the comparatively soft and friable nature of these rocks has no doubt yielded so readily to aerial influences, as to obliterate the striations in the period that has elapsed since glacial times; but the comparative evenness of this part of the country in minute superficial features as in great, attest that these rocks have yielded more profoundly, and have been planed to a greater uniformity of level by the passage of glacier ice, than have the harder granitic rocks of the Laurentian and eruptive and even schistose rocks of the Keewatin series.

Profound glaciation of Coutchiching rocks.

Preservation of striæ in different rocks

The only striation recorded in the western part of the sheet, occurs in the felsitic granites of Sand Point Lake; which is in accordance with the general rule that the granitic rocks preserve the striations for longer periods than the mica schists. In this region the Keewatin rocks have preserved the striations with still more clearness and persistency than the granitic rocks.

Nearly all the striæ observed are represented by a conventional sign which indicates their direction; and from these we can gather an approximate estimate of the general direction of ice movement.

Striæ in Sand Point Lake.

The single observation near Sand Point Lake indicates that there the direction of movement was S. 28° W.

Sturgeon Lake.

In the neighbourhood of the western part of Sturgeon Lake the directions of the striæ vary from S. 3° W. to S. 22° W.; and average direction of the greater number of the striæ is about S. 20° W.; south of this on Hoffmann and Pooh-Bah lakes, the same direction is indicated by striæ not recorded on the map.

Pooh Bah and Hoffmann Lakes.

In the neighbourhood of the middle part of Sturgeon Lake, the striæ vary in direction from S. 17° W. to S. 30° W.; and in the vicinity of the eastern part of this lake and of Russell Lake they vary from S. 2° W. to S. 32° W.; both extremes doubtless represent local deflections in ice movement due to local inequalities, and may be neglected in computing the general direction of movement, which would appear to be from S. 17° W. to S. 23° W.

Russell Lake.

Two observations in the shores of the McKenzie inlet of Kahnipiminanikok Lake give S. 27° W. and S. 29° W., and a third observation not recorded on the map indicates a direction of S. 17° W.

Lake Silence. McIntyre Lake.

Single observations on Lake Silence, and at the north end of McIntyre Lake, give directions of S. 19° W., and of S. 12° W., respectively.

The striæ observed on Knife, Emerald, and Carp lakes, and on The Other Man's Lake, vary between extremes of S. 10° W. and S. 38° W., and the general direction is S. 23° W. Knife, Emerald, Carp and Other Man's lakes.

On Cypress and Jasper Lakes, and on Cache Bay of Saganaga Lake, the striæ range between S. 10° W. and S. 28° W., and the most common direction is nearly the mean of these two, or S. 20° W. Cypress, Jasper and Saganaga lakes (Cache Bay).

In the vicinity of the western part of Saganagons Lake, the direction of ice movement has varied from S. 15° W. to S. 32° W.; and on the eastern part of the lake the movement has diverged very little from S. 20° W.; a local variation north of this is indicated on Beaver Lake, by striæ bearing S. 8° W. Saganagons Lake. Beaver Lake.

At a locality on the south shore of Saganagons Lake, near the middle, two sets of striæ were observed intersecting each other; but from the indistinctness of both sets it could not be determined with certainty which was the more recent. One set has a direction of S. 43° W. and the others bear S. 23° W. Two sets of striæ.

Mr. Robert Chalmers of this department in his paper on the "Glaciation of Eastern Canada,"* says: "The divergent courses of striæ, "often seen upon the same rock surface, are, however, sometimes "explicable on the theory of their having been produced by successive "portions of the diminishing glaciers, conforming in their motions more "closely to the surface features, during the period of melting." From the rarity of occurrence of this phenomena it would seem to be accounted for with more probability on this assumption, than by supposing these intersecting striæ to indicate the passage of two successive fields of ice at important intervals of time.

Roches moutonnées, well marked and prominent, form a conspicuous feature of shore surface in Kahnipiminanikok Lake and elsewhere, and prove the south-westerly flow of the ice. The direction of their axes (about S. 42° W.) appears to be rather a function of the structure of the rock, with whose strike it agrees, than of the direction of movement of the ice; which movement so far as observed in this region is never so westerly in its course. *Roches moutonnées* Kahnipiminanikok Lake.

It will be seen from the above records that over this whole area the direction of the ice flow has varied between extreme limits of S. 2° W. and S. 39° W.; and that the general direction is roughly S. 20° W. General direction of ice movement.

Dr. Lawson calculated the average direction of the ice flow in the Rainy Lake region† to be about S. 40° W. and in the Lake of the Woods region‡ to be about S. 45° W. These diverging directions are Rainy Lake region. Lake of the Woods region.

* Canadian Record of Science. April, 1889.

† Geol. Survey of Canada, Annual Rep., 1887-88, vol. III., part I., p. 164 F.

‡ " " " " 1885 " I., p. 138 CC.

doubtless a function of the direction of the general slope of these different portions of the country in glacial times, and would indicate that the glaciers have been shed from the higher northern slopes of the Archæan nucleus, in varying directions normal to the periphery of this nucleus, and determined by the general slope of each region, as suggested by Mr. Chalmers in the paper above quoted.

Erratic boulders.

Boulders transported by ice are not uncommon, but none were observed which by their composition indicated that they had necessarily been carried from any great distance.

South-east arm of Sturgeon Lake.

A curious boulder of granite, weighing many tons, and evidently transported by ice for some distance, rises ten or twelve feet out of the water in the middle of the first expansion, south of Sturgeon Lake, of the south-east arm. The under surface sloping out of the water is finely striated and the corners and edges well rounded.

Sometimes the surfaces of the rocks are seen to be indented by curious cracks in the shape of the arc of a circle and concentric with each other. These "chatter cracks" are doubtless caused by a large boulder being forced over the surface by an inclosing ice sheet, in which it is held very tightly, and in such a way that it cuts the surface of the rock for a short distance, then slips to catch the surface again a few inches further on. An instance of this kind occurring in Basswood Lake is figured in Plate IV.

Economic Geology.

Land suitable for farming.

No actual lumbering has been done in this part of the country. The forest trees have been already referred to. While the portion of Western Ontario depicted on the map which accompanies this report, offers practically no inducement to the agricultural settler, it is by no means devoid of areas covered by post glacial drift deposits, which would yield good crops for the sustenance of settlers led there by other interests, such as the miners, and for this purpose there is good land amply sufficient to fulfil all the possible requirements for many years.

Farming land in Indian reserves.

The largest drift areas, and those conspicuously the best, from an agricultural stand-point, have been granted to the Indians, and are for the most part included in the boundaries of Reserve D and Reserve 24C. The soil of the western part of the former is a sandy loam, but the eastern half is characterized as wild lands, and does not offer many agricultural facilities. The latter I have not visited in person, but I am informed that in the valley of the lower part of the Kawawiagamak River good farming land occurs.

Much good land in separate areas, sometimes of considerable extent, is seen in the whole valley of the Maligne River, including both shores of Tanners Lake, and extending in a broad belt along both sides of the river. Maligne River valley.

Very good land is also afforded by the alluvial drift near the mouth of the Namakan River, on the north side. North of Namakan Lake, in the western part, are also some areas of drift which would be worth cultivating if a market for the products were provided. Namakan River and Lake.

It is generally assumed that Laurentian and Coutchiching rocks do not contain metalliferous veins; narrow and subordinate veins of quartz do occur in the rocks of both these series, but they are as a rule not very persistent, and have not been found to contain any mineral, with the one exception of the molybdenite bearing quartz vein of the Bears passage of Rainy Lake, described by Dr. Lawson in his report, Vol. III., Part I.; 1887-88, p. 181 F. Granites in the neighbourhood of its contact with Keewatin rocks frequently contain valuable veins. Barrenness of the Laurentian and Coutchiching series with regard to metalliferous deposits.

Quartz veins are more abundant, larger and more important in rocks of the Coutchiching series, than in the underlying rocks; and some of them may yet be found to contain economic quantities of precious metals. The writer has since found low grade magnetic iron ores in rocks probably of Coutchiching age. In the rocks of these series however, one mineral may be hopefully looked for. The mica of the pegmatite patches, veins and dikes, is of excellent quality; while on the surface I have seen no sheets of considerable size, it is not unreasonable to hope that beneath the surface, below the level of aerial influences, sheets sufficiently large to be of commercial value will be found. Quartz veins. Mica.

The iron ores of the Keewatin belt of rocks, indicated on the south-eastern part of the sheet, have been already referred to at considerable length. These would appear to offer the brightest promise of future mining activity of any iron ores known between Lake Superior and the Lake of the Woods. The iron ores of the Atikokan River are very promising; but for these no other worked deposits, quite similar in occurrence, afford criteria by which their value can be more closely estimated, such as the mines of Tower and Ely afford for the estimation of the Hunters Island ores.

Additional prospecting, in the rocks of this Keewatin belt, will very likely be rewarded by the discovery of gold-bearing veins, as well as occurrences of other minerals.

In 1866 there was considerable excitement over the discovery of auriferous quartz in the Keewatin schists of Vermilion Lake in Minnesota. From twenty to thirty dollars of gold to the ton of quartz was

assayed from specimens brought in.* The gold-bearing quartz of the Lake of the Woods occurs generally in rocks of Keewatin age, but the veins of the "Sultana," "Ophir" and other mines of this district occur in granitic rocks, which the writer is inclined to regard as later post-Keewatin eruptives, but which may be of Laurentian age. The gold-bearing veins discovered north of the Atic-Okan and Seine Rivers, in the district north of that to which this report refers, occur in quartz-porphyries (often very similar macroscopically to the coarse grained granites of the Lake of the Woods in which the gold-bearing veins occur) and which are very probably post-Keewatin in age.

The development of the great mineral wealth of this counry is hampered by the entire lack of transportation facilities and is retarded by a spirit of petty speculation encouraged by laws which make clever speculation more immediately lucrative than active mining.

---

* *Vide* 18th Annual Rep. of Minnesota, p. 19.

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON THE

GEOLOGY AND ECONOMIC MINERALS

OF THE SOUTHERN PORTION OF

PORTNEUF, QUEBEC, AND MONTMORENCY COUNTIES

PROVINCE OF QUEBEC

BY

A. P. LOW, B.Ap.Sc.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1892

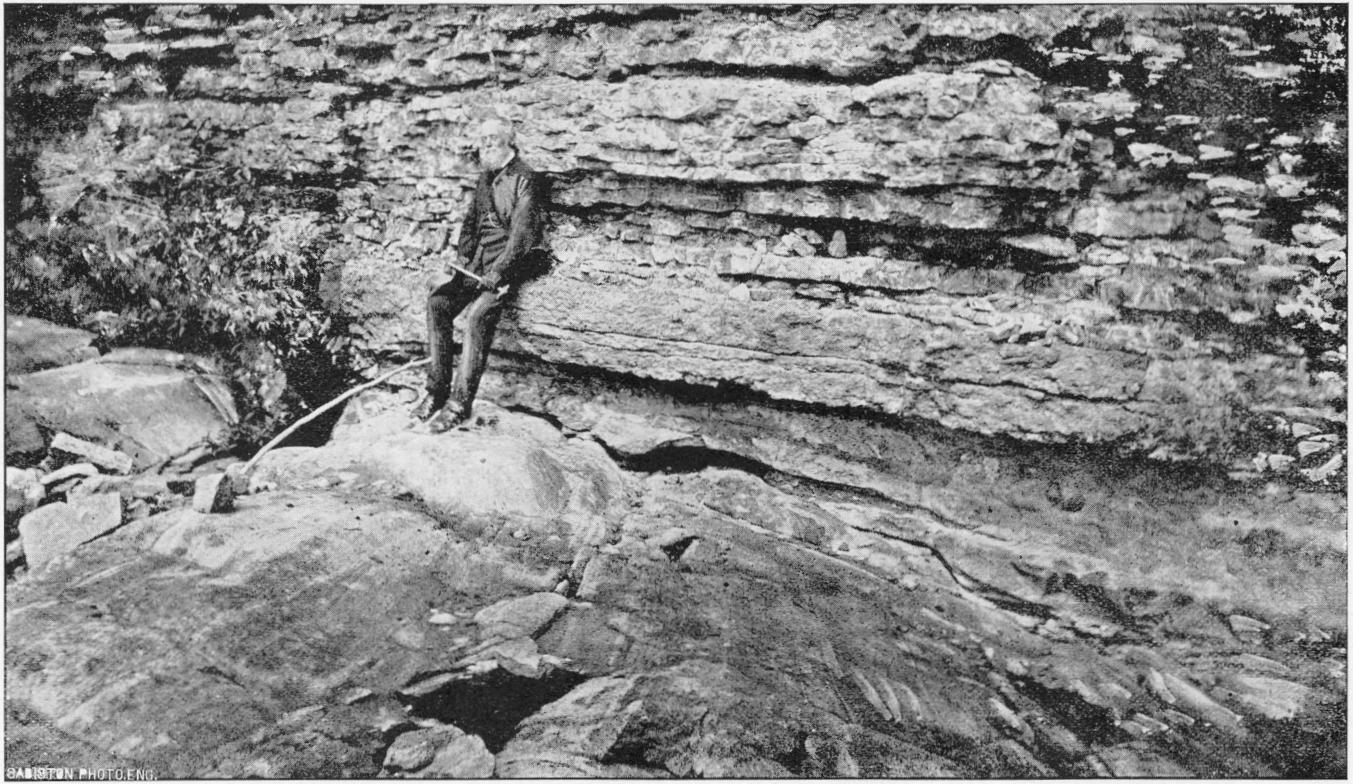
To Alfred R. C. Selwyn, C.M.G., F.R.S., LL.D., &c.,
Director of the Geological Survey of Canada.

Sir,—I have the honour to herewith submit my report on the geology and economic minerals of that portion of the counties of Portneuf, Quebec and Montmorency, included in the north-east sheet of the Eastern Townships map.

I have the honour to be, sir,
Your obedient servant,

A. P. LOW.

NOTE.—The bearings given throughout this report refer to the true meridian.



From Photograph Presented by Mr. C. D. Walcott, U. S. Geol. Surv., 1891.

UNCONFORMABLE CONTACT OF GNEISS AND TRENTON LIMESTONE; A HALF-MILE UP FROM MONTMORENCY FALLS Q. DR. SELWYN IS STANDING ON THE GNEISS AND IS LEANING AGAINST THE LIMESTONE.

REPORT

ON THE

GEOLOGY AND ECONOMIC MINERALS

OF THE SOUTHERN PORTION OF

PORTNEUF, QUEBEC AND MONTMORENCY COUNTIES

PROVINCE OF QUEBEC

BY

A. P. LOW, B.Ap.Sc.

The following report is the result of an exploration during the season 1889 in that portion of the province of Quebec embraced in the north-east sheet of the Eastern Townships map, north of the St. Lawrence River, comprising the southern portions of the counties of Portneuf, Quebec and Montmorency. This area is triangular in shape, and is bounded on the west by a line running north from one mile west of Grondines Point on the St. Lawrence, west long. 72° 04′ 40″, and passing through the seigniories of West Grondines, East Grondines, La Chevrotière, Tesserie and Perthuis, and the townships of Alton and Colbert, in all, thirty-five miles in length. The northern boundary is on the 47° 05′ parallel of latitude; it is sixty-two miles long, and cuts the St. Lawrence in the parish of St. Joachim, near Cape Tourmente. The southern and eastern boundary is the north shore of the St. Lawrence River from Grondines to Cape Tourmente. Area embraced in Report.

The total area is twelve hundred and seventy-five square miles, the northern part of which nine hundred and eighty square miles is occupied by Archæan rocks, with a narrow irregular margin between their southern limit and the St. Lawrence, occupied by Cambro-Silurian limestones and shales.

The physical features of the country depend to a great extent on this distribution of the rocks, the Archæan area being high and mountainous, while the Cambro-Silurian area is comparatively low and flat. The greatest elevation is towards the north-east, where the country rises abruptly into an uneven plateau, with a general elevation of over Physical features.

fifteen hundred feet above sea level, while rounded hills rise above the plateau to heights in places exceeding five hundred feet.

Small lakes

This plateau is cut by numerous river valleys, all of which take their rise from innumerable small lakes on the watershed between the St. Lawrence and the Saguenay rivers, mostly to the north of the sheet. The general elevation decreases slowly from east to west, being from one thousand to twelve hundred feet at the north-western limit of the map, but even here many of the higher points rise to elevations of two thousand feet and upwards.

The country slopes gradually towards the south in the western part of the sheet, where near the boundary between the older and newer rocks the general elevation does not exceed three hundred feet, and the hills rising above the average level are fewer and lower than to the northward, while the river valleys spread out and are filled with broad flat deposits of terraced, stratified sands, gravels and clays. The outline of the boundary between the gneisses, and the limestones and

Difference of level.

shales is irregular and usually easily defined, as the country drops suddenly on passing from the older to the newer rocks, and from there to the St. Lawrence River presents a comparatively low, flat surface. Along the western portion of the boundary the marked subsidence is wanting, as both series of rocks are covered by deposits of sand and clay.

Rivers.

The principal rivers draining this area are the Ste. Anne de la Pérade, Portneuf, Jacques Cartier, St. Charles, Montmorency, Sault à la Puce and Ste. Anne de Montmorency. Of these the Ste. Anne de la Pérade, Jacques Cartier and Montmorency, taking their rise beyond the northern limit of the map, are the longest and largest. A curious feature is the course of the former two, they flow from north-east to south-west, or at an angle of about 150° to the course of the St. Lawrence into which they empty ; this westward flow is not so marked in the other rivers, but they all possess that tendency.

The valleys in the Archæan area are in a general way parallel to the strike of the rocks and consequently have a roughly north and south direction.

Previous explorations.

Previous to the present exploration little work had been done on the Archæan area, but the southern country underlain by the Cambro-Silurian rocks has been accurately reported on by Sir Wm. Logan in the Report of Progress of the Geological Survey of Canada, 1852-1853, of which a complete summary is given in the Geology of Canada, 1863.

More recent work has been done in parts of the same area by Rev. J. C. K. Laflamme, Annual Report, Geological Survey of Canada, 1886, pages 36A, 38A, and Annual Report, 1887-88, pages 31A 32A, also

by Dr. R. W. Ells, assisted by N. J. Giroux and H. M. Ami, Annual Report, 1887-88, pages 18K, 25K.

ARCHÆAN.

Investigations in this northern Archæan area are made at great disadvantage owing to its rough and broken character.

Rough country.

The rivers falling from the high interior plateau are much broken by rapids and falls, and owing to their rapid descent are liable to great and sudden variations in volume of discharge, and are, therefore, only navigable with canoes on their lower courses. The valleys of the rivers and their tributary streams are deep, with almost perpendicular walls, rendering cross country travel very arduous and in places impossible, while the dense forest growth adds to the difficulties and hides many of the rock exposures.

Except the poor roads which follow the principal river valleys no means of travel exist, and, consequently, the observations on the geology of the region are in the main confined to these valleys.

Irregular southern boundary.

As before stated the southern boundary of the Archæan is irregular, several spurs projecting from the main mass southward giving it a sinuous outline. Of these spurs the Deschambault, Pointe aux Trembles and Montmorency are the most marked, and have an important bearing on the deposition of the Cambro-Silurian rocks upon them.

Southern boundary.

Starting from the western limit of the sheet the Archæan rocks are seen on the west side of the Ste. Anne de la Pérade River, and crossing it at Gorrey's fall, twelve miles north from the St. Lawrence, continue on an east course until they touch the road between the fourth and fifth ranges of Portneuf; here they turn immediately south, between the La Chevrotière and Belisle rivers to the back of the third range of Deschambault, where they cross the latter stream and run south-east between it and the road passing back from Deschambault village, to within one mile and a-half of the St. Lawrence. From here they turn north 50° east and pass in rear of the second range road behind Portneuf village, and from the highland on the west side of the Portneuf River, which they cross in the parish of St. Jacques and then sweep round to the southward crossing the Jacques Cartier River a short distance above Ste. Jeanne de Neuville, where the course again changes slightly to the north and passes into the third range of Fossambault, here an abrupt turn to the south brings them within two miles of the St. Lawrence in the high land behind Pointe aux Trembles village, where the course again changes to N. 50° E. and continues thus through the village of Lorette to the Montmorency River where they

again turn south and outcrop in the bed of the river at the Falls. Thence eastward they run almost parallel to the St. Lawrence again approaching it at Château Richer, beyond which they sweep more to the northward crossing the Ste. Anne River three miles inland and then again reach the coast at the limit of the map near Cape Tourmente.

General strike. The general strike of the Archæan rocks is from ten to twenty degrees west of south in the northern part of this area, while in the southern and western portions they sweep around to the westward and have an average strike of S. 50° W.

General Divisions of Archæan Rocks.

Before entering into a detailed description of these rocks, it is proposed to give a rough section across the northern portion, and consequently nearly at right angles to the general strike. This section runs from Lake Simon on the west to the eastern extremity of the area, and is so made on account of the greater number of exposures near it than on any line run directly east and west.

General section.

In this section the rocks are grouped in accordance with the predominating rock, and although no mention is made of them, bands of other vareties, of lesser importance and extent, are included in all of these rough divisions.

From the western limit of the map the section is as follows:

(1) Dark schistose mica gneiss, interbanded with coarser red and grey mica gneisses.	10	miles.
(2) Fine banded grey, pink and red mica and mica-hornblende gneisses.....	10	"
(3) Dark grey garnetiferous hornblende gneiss	2	"
(4) Fine banded grey, pink and red mica and mica-hornblende gneisses.....	7½	"
(5) Dark green basic, crushed granitic gneiss.	1½	"
(6) Coarse red and grey augen-gneiss.....	2½	"
(7) Fine banded gneiss (2) and (4)	6	"
(8) Coarse red and grey augen-gneiss.....	6	"
(9) Fine banded grey and pink mica-gneiss...	14	"
(10) Anorthosite.....	2	"
(11) Fine banded grey and pink gneisses	12	"

Description of section. The rocks of divisions 1, 2, 3, 4, 7, 9 and 11 appear to have been originally clastic rocks, subsequently completely metamorphosed and subjected to great pressures, which have folded and twisted them so

that their original horizontal succession is greatly obscured, while their composition has been changed into the material of schists and gneisses. As these rocks are very old, if they were originally laid down as clastic rocks, the conditions of deposition must have been greatly different from those which prevailed in later times, when carbonate of lime formed one of the chief materials deposited, whereas in these older rocks it is markedly absent; quartz, orthoclase, mica, hornblende and plagioclase being the principal components, and what they may be the products of is difficult to say. There is at present no reason for dividing the above rocks into more than one group of the Laurentian, as they seem to be separated from one another by no unconformity, and the different bands appear to grade into one another, the difference of composition being local. The fifth division embraces rocks of probably igneous origin, which have been injected along a line of weakness between the banded gneisses and the coarser-grained rocks of the sixth division. Smaller areas of a similar rock occur along the north branch of the Ste. Anne and to the south-east of the anorthosite area.

The sixth and eighth divisions are coarse-grained rocks, showing in places gneissic structure, but often granitic. They appear to underlie the banded gneisses, and are either the remains of older beds that have been re-fused, or are original molten matter from the interior which has dissolved and floated portions of the banded beds, and, as fragments of them are inclosed in the coarser gneisses, have cooled subsequent to the deposition and hardening of these banded gneisses. The anorthosite is also of igneous origin, having been apparently intruded into its present position after the formation of the banded gneiss with which it is in contact. This contact is not so sharp as in many localities and is difficult to map, as the gneisses near it seem to have been infiltrated by basic felspar material from the anorthosite, causing the passage from the one to the other to be gradual.

Division I.

The rocks of this division are best seen in the cuttings along the line of the Quebec and Lake St. John railway.

Quebec and Lake St. John railway.

Starting from the western limit of the sheet, near the bridge over Black River, and following the line eastward, many exposures are seen in the cuttings and on the hillsides south of the track, but as the railway runs nearly parallel to the strike, only a small cross section is obtained.

A highly contorted dark grey micaceous, schistose gneiss predominates; most of the bands contain quantities of black hornblende

associated with biotite, sufficient in some cases to change the rock into a hornblende schist; all the bands contain more or less grey translucent quartz and pink and grey orthoclase. Small dark red garnets are present in many of the bands, also small disseminated grains of magnetite, to the decomposition of which the rusty weathered appearance of these bands may be due.

Lenticular masses of hornblende.

Associated with the above are bands of coarser pink and light grey mica-hornblende gneiss, often holding lenticular masses of schistose black hornblende. These lenticular masses frequently follow one another in bands, and have the appearance of having been stretched and broken while inclosed in a softer surrounding mass. A less marked shattering of basic bands inclosed in a more acidic mass is frequently seen in these rocks, where the dark band has been unevenly pulled out, during which operation it has reached the tensile limit under the conditions and become broken into angular fragments. The cracks between these have been filled by the softer matter of the inclosing rock, showing that at the time of the pressure and motion the acidic rocks were in a sufficiently fluid condition to be pressed into all the cavities formed by the breaking of the more basic rock which apparently continued in a much more solid state. Fragments of the basic rock, with their angles more or less rounded by the dissolvent action of the fluid magma in which they were inclosed, are often found floated away from the band to which they belong.

Segregations of hornblende and mica.

Hornblende and mica segregations, generally of an oval form, are also common in these rocks and are often hard to distinguish from the broken lenticular bands, but are apparently formed in a different manner by the segregating of the mineral from the surrounding magma, which is generally found to be remarkably free from the segregated mineral. These segregation masses sometimes have a concentric structure, and occasionally show a difference in hardness and colour between their outside and inside laminæ.

Pegmatite veins.

All these bands are everywhere penetrated by coarse pegmatite veins composed largely of cleavable masses of pink orthoclase, holding rounded masses of quartz and inclosing crystals of mica and hornblende, with magnetite and hæmatite in some cases. The mica crystals are often of large size, but nearly always badly contorted and bent, rendering them useless for economic purposes.

Origin of pegmatite veins.

These pegmatite veins appear to have been formed in the cracks of the surrounding rocks, by a solfataric action, from saturated highly heated waters under high pressure, and not like the basic dykes which are met with occasionally in the same rocks and which have clearly been injected into the later cracks in a molten state. Exposures of

these rocks continue along the railway line to Allan's mill station. One mile east of Allan's mill the line bends southward around the base of a rocky hill. Here the rock is a fine-grained grey granitoid gneiss, while a short distance southward, on the road east of the track, exposures occur of a medium-grained micaceous granitic gneiss, deeply weathered on the surface and on a fresh fracture of a light pink colour. Along with this is a very fine-grained pink highly quartzose granitoid gneiss holding small light red garnets. This is followed by bands of highly contorted coarse grey gneiss, rich in white orthoclase and mica. The next exposures along the railway are at the crossings of the road running between the third and fourth ranges of Bourg Louis. Here medium-grained highly felspathic mica-gneiss is interbedded with dark grey micaceous gneiss.

One-quarter of a mile beyond, a small cutting is made through a fine-grained blackish hornblendic schist, composed chiefly of black hornblende and greenish triclinic felspar and a small quantity of quartz. A small dyke of dark green fine-grained diabase cuts this rock. No exposures are now seen along the line for a mile, when a small cutting shows fine-grained highly quartzose gneiss with small quantities of pink orthoclase and brown mica. Diabase dyke.

Division II.

Division 2 extends from the east side of the Ste. Anne River to near Lake St. Joseph. Roads run up on either side of the North Branch of the Ste. Anne River; that on the west side crosses the river and joins the east road about the middle of the seventh range of Gosford; while the latter continues on to the upper forks, near the northern limit of the map. Passing southward from its end the first exposure occurs one-half mile below, where the rock is a brownish, weathering, medium-grained mica-gneiss. The next is where the road crosses the line between the second and third ranges of Rochmont; and here the rock is a fine-grained pink mica-gneiss. An exposure of similar rock associated with coarser-grained bands occurs on the hill at the Roman Catholic chapel. Distribution. North Branch Ste. Anne River.

From here to the junction with the road on west side stratified sands and gravels are passed over, with rocky hills from two to six hundred yards to the eastward, composed chiefly of medium-grained light grey mica-gneiss.

A short distance below the junction of the roads is the last exposure of these rocks. The hills then run eastward toward the main river, and the road from there to the river passes over a broad sandy plain, with terraced faces towards the rivers.

West side of North Branch.

The road on the west side from the bridge near its junction with the east road passes immediately over a drift-covered hill of fine-grained pinkish grey granitic gneiss, the colour varying with the proportion of mica present in the bands. From here to the Mauvaise River bridge, the road passes along the side of the mountain, forming the western boundary of the river valley; the rock outcrops in a number of places in this distance, and is a medium-grained grey granitic gneiss, with a few pink bands.

Just south of the Mauvaise River and forming the point between it and the North Branch is an isolated, rounded hill, made up chiefly of coarse red and grey mica-hornblende granitic gneiss. The other exposures, seen to the east of the Ste. Anne River, are along the roads between ranges two and three, and ranges three and four of Bourg Louis West; also on the Jacko River, in range B.

The first of these roads is continued beyond the third range and forms the route road to Lake Simon, running for the greater part of its western half near the railway line. The first exposure seen on it westward from the Ste. Anne River is on the hill one mile east of Allan's mill, and has already been described in connection with the railway section. In the second range, one mile north of the last, are medium-grained grey and pink mica-gneisses associated with a brownish grey mica-hornblende granite. These rocks are highly contorted on the strike and appear to be near the great bend, where the strike changes from south to south-west.

West side of Ste. Anne River.

At Allan's mill, one-quarter of a mile south of the railway, fine grained light grey mica-gneiss outcrops in the river, while at the crossing of the discharge of Lake Simon, one-quarter of a mile from the lake, these rocks are found associated with a coarser grained variety of the same rock; the finer grained holding considerable quantities of small dark red garnets. At the bridge of the Jacko River, in range B, of Bourg Louis, the rock is a fine-grained dark grey schistose mica-gneiss, similar to that found along the railway. On the North Branch of the Ste. Anne River, two miles below the upper forks, and at intervals for one mile and a-quarter below, are exposures of coarse-grained greyish gneiss, composed of white orthoclase, quartz, black mica and hornblende, and containing grains of magnetite; on exposed surfaces the rock weathers a rusty brown. Where the river crosses the line between ranges eight and nine of Gosford, on the west bank, is an exposure of medium-grained dark flesh-red gneiss, highly quartzose, with dark red orthoclase and black mica. One-quarter of a mile farther down stream, the rock is a very fine-grained light pink gneiss, highly quartzose with small quantities of pink orthoclase and

Lake Simon.

black mica in a finely divided state; the rock approaching an impure quartzite, and penetrated by small veins of light green epidote.

In crossing range six of Gosford the river passes through a narrow rocky gorge half a mile long, with a descent of over 60 feet, including a direct fall of 30 feet. Here the rock was found to consist of a medium-grained dark greyish-green basic granitic gneiss, made up of greenish triclinic felspar and black hornblende with little quartz, and a considerable quantity of finely divided pyrite. Banded with this rock is a dark pink coarse-grained gneiss composed of orthoclase, quartz, black hornblende and some biotite. Basic gneiss.

Near the point where the river crosses the line between Gosford and Bourg Louis, a heavy rapid is caused by an outcrop of dark red fine-grained schistose mica-gneiss, greatly contorted and penetrated by small veins of green epidote. One mile and a half below the last, and continuing down stream for half a mile, are exposures of dark red medium-grained gneiss, composed of red orthoclase, quartz and biotite. These are followed by thin bands of pink and grey fine-grained orthoclase-biotite-gneiss, with many of the dark bands composed almost wholly of mica. Below these exposures the river passes between steep banks of sand, gravel and clay, and no rock is seen to the junction with the main river. The main branch of the Ste. Anne River crosses the line between St. Ignace and St. Gabriel at the north limit of the map where it descends in a succession of chutes 150 feet. Here is a pink fine-grained gneiss composed of light pink orthoclase, greyish translucent quartz and dark mica; the mica, forming the chief constituent, is arranged in thin bands from one-half to one inch apart which gives a fine banded structure to the rock mass. Upper Ste. Anne River.

On the north side of Markham pool, two miles and a-half below the falls, the mountain rises precipitously 1,000 feet above the stream, its face is covered with a dense forest growth and the few rock exposures are difficult of access. From the small exposures seen here gneiss similar to that above appears to be interbedded with a more basic variety which weathers a rusty grey from the decomposition of the iron present. On a fresh surface its colour is greenish-grey, and the minerals composing it are a greenish triclinic felspar with small quantities of dark hornblende and quartz.

Near the mouth of the Jambon River, a tributary from the north, the Ste. Anne flows close to the base of the high hills on the north west side, and a large mass of fallen rock has cleared out the forest from an elevation of 200 feet to the perpendicular cliff. Here large fresh surfaces of fine-grained grey and pink gneiss are exposed; the constituent minerals being pink and grey orthoclase, and moderate

quantities of quartz and biotite, the latter arranged in thin bands from one-quarter to one-sixteenth of an inch apart.

The next outcrop on the river occurs one mile and a-half above the east line of Gosford, where a coarse-grained dark flesh-red orthoclase mica-gneiss was observed. Near the mouth of the FitzCharles River, a small tributary from the south, in the fourth range of Gosford, is a fine-grained grey gneiss, composed of grey orthoclase, black hornblende and quartz, and penetrated by small pink pegmatite veins.

At the mouth of the Talayarde River, and for some distance below, the river descends over a number of rocky ledges forming a heavy rapid. Here the rock is chiefly a flesh-red gneiss, made of dark red orthoclose and biotite, varying in structure from coarse to fine grained, the coarse grained predominating. Interbanded with this red gneiss are thinner masses of a grey colour, the difference of colour being due to the orthoclase, which in the grey bands is a dirty white.

Below this the river valley, which has not been over a half mile wide, and bounded by high steep cliffs, widens out, and the stream flows in a crooked channel between cut banks of stratified sand and clay until Jackson's mill is reached, one mile and a half below its junction with the North Branch. Here the river falls thirty feet over a ledge of medium-grained grey micaceous gneiss, holding numerous small dark red garnets, and penetrated by large veins of pink pegmatite, inclosing masses of rounded quartz and broken crystals of mica.

Lower Ste. Anne River.

The next exposure is three-quarters of a mile below, where a small rapid is caused by an outcrop of coarse-grained pink gneiss, composed of grey and pink orthoclase, quartz and biotite, banded with a fine-grained highly quartzose mica-gneiss.

One mile and a half below this the river takes a bend to the westward, and flows in that direction three miles to Ford's mill, crossing the line between Bourg Louis and D'Auteuil. For the first three-quarters of a mile the river passes over a number of rocky ledges with considerable fall, forming Kelley's rapids. At the upper end the rock is a fine-grained pink gneiss, holding many small red garnets. At the lower end a very fine-grained pink gneiss, highly quartzose, with pink orthoclase and little mica, prevails, and associated with this are thin bands of dark mica-schist, which have been apparently segregated from the surrounding rock. These bands are very much shattered and faulted. At Ford's mill the river falls twenty-five feet over a fine-grained grey gneiss, approaching mica-schist in structure, being composed chiefly of that mineral, along with thin bands of pink orthoclase-gneiss, and quantities of impure pink quartzite. All are penetrated by pink pegmatite veins.

Kelley's Rapids.

The next exposures occur at the bridge crossing the river, near the line between Jacques Cartier and Portneuf seigniories. From this point to Gorry's mill, a distance of six miles, the river is a succession of heavy rapids and falls. Along this portion exposures of gneiss outcrop in the river at short intervals, and everywhere were found to be of the same character as those described above; the greater part being dark grey schistose gneiss, composed chiefly of mica, with grains of quartz and orthoclase, interbedded between the plates of mica which curve around the grains.

Along with the schists are thinner bands of pink orthoclase-gneiss, and fine-grained highly quartzose pink gneiss, nearly free from mica. In many places veins of pegmatite, varying from one to several feet in width, cut the different bands. In one large vein of this kind, a mile and a half below the mouth of the Jacko River, crystals of quartz, black mica, dark red garnet, black hornblende and hæmatite were found scattered through the mass of orthoclase. Pegmatite veins.

At Gorry's mill the river has a sheer drop of ninety-five feet and below this no rock exposures occur in the winding valley for four miles and a half, when an outcrop of Cambro-Silurian limestone crosses the stream; the distance in a straight line between the last gneiss and the first limestone is one mile and a half. Along the road on the east side of the Ste. Anne River, in the fourth range of Gosford, four exposures of dark grey mica-gneiss occur with a general strike of N. 15° E., while to the south along the road between Gosford, Fossambault and Bourg Louis, these rocks associated with broad bands of light pink, fine-grained, highly quartzose, hornblende-gneiss, holding minute garnets and grains of magnetite, bend round to the westward with a general strike of S. 80° W.

The grey gneisses are again seen one mile south of the river on the road along the second range of Bourg Louis.

From here westward and southward to the limits of the Archæan the south side of the Ste. Anne River is occupied by a broad flat terraced sandy plain varying from two to five miles wide and bounded on the south-east side by the low hills of the Deschambault spur of the gneiss, which in its southern extension, as has been already stated, reaches to within one mile and a half of the St. Lawrence. Deschambault spur.

The rocks of this spur, and its eastern extension, are seen in numerous exposures along the roads running back from the St. Lawrence. They show generally fine-grained grey and pink orthoclase-biotite gneiss arranged in alternate thin bands, the grey being the most common, and often containing black hornblende in association with the mica, while the red is formed chiefly of red orthoclase and quartz. Both varieties

often hold small dark red garnets. Associated with these fine-grained bands are some of coarser texture. In a few of the latter, as seen on the road between D'Auteuil and Jacques Cartier, where it turns westward one mile south of the bridge over the River Claude, grains and small splotches of magnetite are common; and similar rock is seen on the road between the parishes of St. Paul and St. Charles in Portneuf, where the rock is a highly contorted coarse-grained very ferruginous gneiss.

Augen-gneiss.

Towards the Jacques Cartier River, in the parish of Ste. Marie, a broad band of coarse pink granitic augen-gneiss occurs; and this or a similar band is seen on the east side of the Portneuf River immediately north of the Quebec and Lake St. John railway, where the hills have been burnt over and large exposures laid bare. Here the augen-gneiss is generally light grey in colour and composed of thin bands of black mica inclosing partly developed crystals and lenticular masses of grey and pink orthoclase, varying in thickness from one-eighth to one-half an inch in thickness and from half an inch to an inch and a half in length, the longest axis being parallel to the plane of foliation. The plates of mica are continuous and folded round the felspar masses, but little quartz is present.

Smaller bands of fine-grained pink gneiss composed of quartz and orthoclase with small quantities of mica, are associated with the above, while the whole are penetrated by large veins of pegmatite.

For a mile beyond this to the eastward, the railway skirts along the base of the hills on the north, and several cuttings show dark grey fine-grained mica-gneiss, more or less quartzose, interbanded with narrow pink and grey bands of medium texture.

Beyond the outlet of Lake Sargent to Lake St. Joseph, numerous cuttings along the railway show black schistose mica-gneiss, associated with narrow banded, pink and grey, medium-grained orthoclase-mica-gneiss.

These rocks have a dip to the east of north at angles of from 10° to 40°. Pegmatite veins are common and often of large size. Three small veins, seen in the first cutting west of the road from Ste. Catherine to Lake Sargent, contain considerable quantities of magnetite scattered through them in small grains.

The above rocks, embraced in the Deschambault spur, vary considerably as to the local direction of their strike, but on the whole seem to pass down from the Ste. Anne River directly southward to within a couple of miles of their southern limit and then sweep round to the direction of N. 35° W. as far as the end of the spur.

The valley of the Jacques Cartier River above Ste. Jeanne de Neuville, like that of the Ste. Anne, is filled with thick deposits of sand and clay,

which cover all the underlying rocks, and no exposures are seen on its west side until the railway line near Lake St. Joseph is reached.

Division III.

In the bed of the river, for three miles above the Cambro-Silurian contact, an almost continuous exposure occurs, but as the strike is southerly and consequently at an acute angle to the course of the river, only a small cross section is afforded. The rocks are all a dark grey hornblende-mica-gneiss, varying in texture from fine to medium-coarse grained. Some of the bands are rich in dark red garnet. Numerous large veins of pegmatite cross the rock. Some of them carry small quantities of hæmatite. Jacques Cartier River.

Rocks similar to these are seen along the shores of Lake St. Joseph and are evidently their northern extension. On the hills north of the railway track, between Lake St. Joseph and Ste. Catherine stations, they are associated with thin bands of alternate pink and grey mica-gneiss. The bands are all highly contorted on the strike, and in places shattered into angular blocks, the joints being filled with pegmatite. Lake St. Joseph.

Division IV.

These rocks are followed to the eastward by fine and medium-grained red gneiss, with fine-grained red and grey, narrow banded gneiss; the former being seen at the falls of the Jacques Cartier, one mile and a half above Ste. Catherine church, where the rock is contorted along the strike and dip, which latter changes from 15° to 45°. Jacques Cartier River.

Midway on the road between Ste. Catherine and St. Gabriel stations, on the north side of the railway, outcrops of fine-grained grey and pink gneiss occur. Exposures of similar rocks are seen on the road following the Rivière aux Pins from Lake St. Joseph, and in a small cutting on the railway, where the red variety predominates.

To the south of the Jacques Cartier River, these rocks, associated with a few bands of coarser texture, and penetrated by large pegmatite veins, outcrop along the road running south from Ste. Catherine church and for one mile on the road between the fourth and fifth ranges of Fossambault.

One of the bands along this road is very felspathic and weathers white on the surface, forming a pleasing setting to the quantities of small light pink garnets it contains. At the railway bridge over the Jacques Cartier River at St. Gabriel, the rock is slightly coarser and contains some hornblende with the mica; while one mile south of

the bridge, on the road along the east side of the river, a quarry of red medium to coarse-grained syenitic gneiss has been worked and the stone taken out used for bridge piers for the railway.

As far south as the third range of Fossambault, the general strike is about S. 10° W., but on crossing the west end of the Bonhomme Mountain it bends around to the west with a general direction of S. 65° W., and holds this course until the gneiss passes under the Cambro-Silurian rocks.

Bonhomme Mountain.

On the south side of the Bonhomme Mountain, in the Pointe aux Trembles spur, after the change in the direction of the strike above noted, a number of bands of dark grey mica-gneiss appear with an aggregate breadth of 2,000 yards. These rocks are associated with narrow bands of pink gneiss, generally coarse in texture.

There are no exposures of gneiss on the south and east sides of the Bonhomme Mountain, and the next section across the strike to the eastward is seen, to the north, on the road from Valcartier bridge, up the west side of the Jacques Cartier River, and thence over the mountain to the Rivière aux Pins. Here, for a distance of four miles, an almost continuous exposure is seen, the rocks being fine banded red and light grey, fine-grained orthoclase-mica-gneiss, with more or less quartz, often holding lenticular segregations of mica-schist, and interfoliated with a few narrow bands of coarser grained pink mica-gneiss. The general strike is S. 15° E.

Division V.

Along the road, on the east side of the Jacques Cartier River, where the road bends north behind Valcartier village, similar rocks outcrop on a small hill, and again where the road crosses the St. Ignace line, they are found in contact with a dark brownish-green compact basic rock. This rock, examined microscopically by Mr. Ferrier*, is found to

Basic granite.

be a hornblende granitic gneiss, made up chiefly of orthoclase, quartz, plagioclase, hornblende, a rhombic pyroxene and biotite, with magnetite, zircon, apatite and pleonaste. It owes its brownish-green colour to the decomposition of the pyroxene, and shows that it has been subject to great pressure. It occurs in the field as a triangular mass, extending like a wedge from the northern limit of the map, southward on the east side of the Jacques Cartier River, and terminating in a point about two miles north-east of Valcartier village. In places it shows distinct lines of foliation, probably caused by pressure, while in other parts it has a granitic structure, and appears to have been a

Extent of area.

*See Appendix, p. 74 L.

basic granite irrupted along a line of weakness between the fine-grained, fine-banded, grey and pink gneisses to the westward, and the coarse-grained augen-gneiss on the other side. Similar rocks in similar positions are met with in the country immediately north of the area under consideration, and as far as seen, this basic granite always, when present, comes in between the fine-grained gneiss and the coarse granitic augen-gneiss. Other areas of similar rock.

In the present case the crushing of the rock has not been accounted for, but must have taken place, subsequent to the injection of the mass and may be due to the great pressure acting on the mass during and after the period of solidification, as the rock does not seem to have been erupted, but rather forced into place or irrupted far below the surface. Along the contact with the fine banded schists portions of these rocks appear to have been broken off and partly floated into the granite, causing them to look as if interfoliated. The contact with the augen-gneiss is concealed, and consequently the relation between the rocks on that side are unknown.

Division VI.

Following this wedge mass of granite, as before stated, comes a mass of augen-gneiss. This rock varies in colour from dark red through dark yellow to pink and grey, the colour depending on that of the orthoclase which forms the greater part of the mass. On the surface this rock is generally greatly decomposed, and then is of a yellow colour. There is nearly always evidence of structure, the large orthoclase crystals being arranged with their longer axis in parallel lines, which correspond to the lines of foliation, although in some places no such lines of foliation appear, and the rock then has a true granitic structure. This rock and the other similar masses appear to be of the same origin, and are likely the lowest members of the Archæan complex met with in this region, as from the limited study made of them, they now appear as bosses, around and over which the fine-banded gneisses have been laid down, while their structure is such as would lead to the belief that they are of igneous origin, and were formed at a considerable depth below the surface, by a slow cooling of the magma probably subsequent to the deposition of the fine grained fine-banded gneisses which have the appearance of clastic rocks, although their high state of crystallization leaves little or no trace of such origin. Augen-gneiss. Granite structure.

The structure shown by these rocks can be accounted for wholly by pressure, and is not due to anything like stratification. The rock macroscopically consists largely of orthoclase, generally arranged in lines of crystals, greatly rounded and lenticular in shape, around these

masses of orthoclase continuous bands of mica, and at times hornblende, fold. Quartz is also always present, but seldom abundantly.

Distribution. This mass of rock is seen on each side of the Jacques Cartier River, in the seventh range of Stoneham, near the limit of the map, where the strike of the foliation is directly south. They are seen again on the road from the river to Stoneham village in the sixth, fifth and fourth ranges, and from there pass southward, crossing the road between Valcartier and Lorette at the bridge over the Nelson River, and then form the high isolated hill east of Valcartier station. Farther southward along the strike they are covered by thick deposits of drift, to where they pass under the Cambro-Silurian shales near St. Ambroise.

Division VII.

Fine banded gneisses. Proceeding eastward across the strike, the next six miles is occupied by fine-banded pink and grey mica-gneisses, which appear to occupy a trough between the last boss of augen-gneiss and a similar boss to the eastward.

Interbanded with these fine-grained rocks are thin layers having a coarser texture, and also bands in which black hornblende replaces the mica, but these are few and relatively insignificant. Many of the grey and pink bands hold quantities of small dark red garnets.

Distribution. These rocks are seen along the road from Stoneham in the first, second and third ranges; also along the road through Tewkesbury, where they are three miles wide. Southward from Stoneham they outcrop along the roads leading to Lorette and Charlesbourg, and extend to the east side of Lake Beauport with a breadth of six miles which is maintained until they pass under the Cambro-Silurian rocks near Lorette and eastward.

At the junction of the road from Charlesbourg with that following the Jaune River to Lake Beauport, is an exposure of graphic gneiss, composed of parallel bands of dark brownish translucent quartz and red orthoclase. The quartz is in the form of flat plates varying from one-eighth to one-third of an inch in thickness, no visible mica or hornblende is present and the rock is stained dark red with splotches of peroxide of iron. A similar band, probably a continuation of the one above, is seen half a mile in rear of Lorette village, on the road along the east line of St. Ignace.

Division VIII.

The next large area of augen-gneiss occupies the country between these fine-banded gneisses and the Montmorency River, in the north-

ern part of the area. These rocks are seen along the road leading from Tewkesbury to St. Adolphe, after crossing the east line of the township; to the south they occur on the lower road leading from Lake Beauport to the Montmorency River, and along the road up the west side of that stream. The southern extension cannot be traced further owing to the deep deposits of till and stratified sands, with which they are covered to beyond the edge of the Cambro-Silurian limestones. Augen-gneiss.

Where foliated, these rocks have a general strike N. 10° W., and like those previously described have usually a rusty-yellow colour on the surface, and are often highly decomposed to a depth of three or four inches. Unlike the Stoneham area, lines of foliation from pressure are here unfrequent, and the mass as a whole resembles a very coarse-grained granite, in some parts of which hornblende takes the place of mica. Rare foliation.

Divisions IX. and XI.

The Montmorency River appears to be on or near the eastern boundary, as the rock in the bed of the river above the falls is of the ordinary fine-banded red and grey varieties, while on a traverse line across the mountains from the Montmorency to the Sault à la Puce River, near the northern limit of the map, nothing but angular blocks of fine-grained yellow-weathering hornblende-mica-gneiss was met with, before reaching the anorthosite area on the latter river. Fine banded gneiss.

Eastward of the Montmorency River, the fine-banded gneisses again appear, but they are of a more basic character than those previously described, being composed chiefly of orthoclase, plagioclase, mica, ilmenite and quartz, and generally of a light grey or pink colour-weathering a light yellow. Between the anorthosite area of Château Richer and the Cambro-Silurian outcrop, these fine-banded rocks are again seen, with a breadth from one to three miles across the strike, which is nearly N. 50° E. The bands furthest from the anorthosite appear to hold normal quantities of quartz, mica and orthoclase, and closely resemble those before described; but as the anorthosite is approached they are found to be interfoliated with darker coloured, more basic bands, holding large quantities of green pyroxene. These, on further study, may prove to be somewhat of the same character as those of the crushed granite area of the Jacques Cartier River. Distribution.

A band of crystalline limestone occurs in these rocks and extends from the road in rear of Château Richer to beyond the road running from Ste. Anne church. This limestone is highly crystalline and generally flesh-red in colour, but varies through pink to greenish-white with frequent grains and masses of dark green pyroxene scattered through it. Crystalline limestone.

Between the limestone and the anorthosite the gneiss becomes more and more basic as the latter is approached, until near the contact it is a mica-diorite-gneiss composed almost wholly of plagioclase. The bisilicates originally present have been so decomposed that it is impossible to state what they were. A small amount of biotite remains, with large proportions of ilmenite.* From the character of this rock, it is difficult to define the exact junction of the anorthosite, as there appears to have been some action subsequent to the injection of the anorthosite, by means of which much basic felspar and iron materials were removed from the igneous rocks and transferred to the surrounding gneisses rendering them closely similar in composition. In places along the contact these gneisses have a cataclastic structure, probably produced by the pressure due to the injection of the anorthosite mass, but this structure is not constant, as other specimens fail to show evidence of such crushing, and in these cases the anorthosite would appear to have eaten away and replaced the surrounding rocks, which would account for the want of any marked division between the two series.

Gradual change into anorthosite.

Division X.

Anorthosite.

The anorthosite mass extends from about two miles from the Montmorency River eastward, roughly parallel to the shore line of the St. Lawrence, and is crossed by the road in rear of Château Richer two miles inland. Its southern boundary appears to closely follow the strike of the enclosing gneisses, which is nearly N. 50° E. It is seen at about the same distance from the St. Lawrence on the road back from Ste. Anne where it passes behind Mount Ste. Anne and leaves the map. The breadth of the area is nearly two miles on the road up the north-east branch of the Sault à la Puce River and is somewhat greater on the road up the north-west branch, while to the eastward it does not exceed that breadth within the limits of the map. These boundaries are only approximate, as the greater part of the area is covered with a thick forest, which renders the tracing of the boundaries difficult and uncertain. The greater part of the rocks is made up of a fine granular greyish-green to greenish-purple triclinic felspar, holding cleavable masses of reddish-purple felspar, the cleavage faces varying from one-tenth of an inch to several inches in diameter.

Boundaries of area.

Composition.

Hypersthene and ilmenite are common constituents of the rock, and occur in flattened irregular masses, generally arranged in a more or less banded structure, which corresponds with the direction of the foliation

* See Microscopic Examinations by Mr. Ferrier. Appendix.

of the surrounding gneisses. These vary in size from small particles to masses one inch thick by several inches broad.

Specimens of the granular rock were examined*, and were found to consist largely of plagioclase and diallage with some biotite and ilmenite. What was probably originally diallage is now almost entirely changed into serpentine, although here and there a minute unaltered portion may be detected, and much of the material shows good crystal outlines. Some biotite is present associated with the serpentinous decomposition product, and the ilmenite is accompanied by a considerable amount of leucoxene. No traces of hypersthene were noticed and that mineral seems to have been wholly segregated out of the general mass of the rock into the bands and patches before mentioned. Microscopic examinations.

Dr. T. Sterry Hunt made a close study of the rocks from this locality, and the following is taken from his report :—†

"In this region there occur several varieties of the rock, but the most interesting is one made up of a fine granular base, greenish or greyish-white in colour, holding masses of a reddish cleavable felspar, which are sometimes from one-tenth to one-half an inch in diameter, but often take the form of large imperfect crystals, frequently twelve inches long and four or five inches wide. These dimensions correspond to the faces M and T, while the face P, characterized by its perfect cleavage, is from half an inch to two inches broad. Twin crystals sometimes occur, having a composition parallel to M. Hypersthene is met with throughout the rock in flattened masses, which, although variable and irregular in their distribution, exhibit a general parallelism; they are occasionally four or five inches in breadth, by an inch or more in thickness, and are separated from the granular felspathic rock by a thin film of brownish-black mica. Titaniferous iron ore is also found in the rock in grains and lenticular masses, occasionally an inch or two in thickness; these occur in the granular base and generally near the hypersthene, but grains of ore are occasionally found in the crystalline felspar. Quartz in small grains is imbedded in the titaniferous iron ore, but was not observed elsewhere in the rock, nor have any other minerals than these been detected. In the specimens of the rock which I selected on the spot for examination, the crystalline felspar constitutes from one-half to seven-eighths, while the hypersthene does not equal more than two-hundredths, and the titaniferous iron more than one-hundredth of the mass. The amounts of quartz and mica are insignificant. In other portions of the rock, however, the Examination by Dr. T. Sterry Hunt.

* See Appendix.

† Report of Progress Geological Survey of Canada, 1854, page 375.

proportion of the ore may equal five-hundredths, and in some parts the amount of the hypersthene is nearly as great. By the action of the weather the surface of the rock becomes of a dull opaque white; the cleavable masses of felspar are, however, less affected than the granular portion, and by their obscure reddish colour are distinctly visible on the weathered surfaces; this change extends but a little distance into the rock. The colour of the iron ore of course remains unaltered, but the dark brown hypersthene becomes lighter, and inclines to pinchbeck brown. This felspar is triclinic in cleavage; the angle of P : M = 80° 30′; cleavage with P, perfect; with the other planes distinct; P is often delicately striated, and sometimes curved; hardness, 6·0; and density, 2·667 to 2·674. Lustre vitreous, sometimes pearly on P; colour flesh-red passing into reddish, greenish and greyish-brown; the surfaces are sometimes clouded with these different tints, but the red predominates. The following analyses are made of three different specimens, which were carefully selected, pulverized, and then dried at 212° F. The earthy ingredients were determined after fusion with carbonate of soda, and the alkalies by the method of Dr. J. Lawrence Smith, which consists in igniting for thirty minutes the finely levigated mineral with five or six parts of carbonate of lime, and three-fourths its own weight of sal-ammoniac. The agglutinated mass slakes by the action of water, and yields to that liquid its alkalies in the form of chlorides, mixed with chloride of calcium. A second ignition of the undissolved residue with two-thirds of the first amount of sal-ammoniac, ensures the separation of the last portions of alkali. These processes were adopted in all the analyses of felspars here given :—

Analyses of felspars.

	I.	II.	III.
Silica	59·55	59·85	59·80
Alumina	25·62	25·55	25·39
Peroxide of iron	·75	·65	·60
Lime	7·73	6·94	7·78
Magnesia	Traces.	·11	·11
Potash	·96	·96	1·00
Soda	5·09	5·09	5·14
Loss by ignition	·45	·30	·00
	100·15	99·45	99·82

"In a fourth specimen the quantity of lime was found equal to 7·89 per cent. The composition of this felspar is very nearly that of andesine, which according to Abich, consists of silica, 59·60; alumina, 24·18; peroxide of iron, 1·58; lime, 5·77; magnesia, 1·08; potash, 1·08; soda, 6·53, 99·92. The greenish base of this rock is in general

finely granular, and strongly coherent; the grains possess the cleavage, lustre and hardness of felspar, and the density of carefully chosen fragments, was from 2·665 to 2·668. The greenish white of the powder is changed to fawn colour by ignition. When pulverized and digested with acetic acid, the mineral loses two or three thousandths of carbonate of lime, with traces of magnesia, alumina and oxide of iron. A portion which had been thus treated and carefully dried, gave the following results :—

	IV.
Silica	58·50
Alumina	25·80
Peroxide of iron	1·00
Lime	8·06
Magnesia	0·20
Potash	1·16
Soda	5·45
Loss by ignition	0·40
	100·57

"It is therefore a felspar, differing but little from the crystalline andesine in its composition.

"The hypersthene occurs in foliated masses with curved surfaces. Besides the basal cleavage thus exhibited, it cleaves readily with the sides and longer diagonal of an oblique prism of 87°. The hardness of the mineral is 6·0, and its density from 3·409 to 3·417. Lustre vitreous, submetallic; colour blackish-brown, in thin laminæ yellowish-brown; streak and powder ash-grey, the powder turning reddish-grey on ignition. Sub-translucent, brittle; fracture, uneven. The fragments which had served to determine the density, still contained between their laminæ flakes of felspathic matter, which were as far as possible removed in breaking up the hypersthene for analysis. The results of two analyses by fusion with carbonate of soda were as follows :—

	V.	VI.
Silica	51·85	51·35
Alumina	3·90	3·70
Peroxide of iron	20·20	20·56
Lime	1·60	1·68
Magnesia	21·91	22·59
Manganese	traces.	traces.
Loss on ignition	0·20	0·10
	99·66	99·98

"It is almost identical in composition with the hypersthene from Labrador, analysed by Damour.

"The accompanying ilmenite was more or less interpenetrated with felspar and quartz, which could not easily be separated. Its hardness was 6·0 and the density of selected fragments from 4·65 to 4·68. Colour and streak iron-black; lustre sub-metallic; not attracted by the magnet. When decomposed by fusion with bisulphate of potash it gave:—

	VII.
Titanic acid	39·86
Peroxide of iron	56·64
Magnesia	1·44
Insoluble, quartz, &c	4·90
	102·84

"A large portion of the iron is to be regarded as existing in the form of protoxide.

"Another variety of felspar rock from Château Richer is pale greenish or bluish-grey, with occasional reddish grains, and is finely granular. The lustre is vitreous upon the cleavages but waxy elsewhere. The only foreign mineral in the rock was brownish-black mica in small scattered patches. The density of the greenish-grey portion was 2·681, and its analysis gave as follows:—

	VIII.
Silica	55·80
Alumina	26·90
Peroxide of iron	1·53
Lime	9·01
Magnesia	·27
Potash	·86
Soda	4·77
Loss on ignition	·45
	99·59

To this last variety belong the specimens cut for microscopic examination.

CAMBRO-SILURIAN.

Resting immediately on the Archæan rocks in the southern portion of the area under consideration are beds of Trenton limestone and Utica shale, without the intervention of the older Cambro-Silurian and

Cambrian beds met with farther to the westward, or of the rocks of Quebec City, which, in part at least on palæontological evidence, alone are by some supposed to be below the Trenton. The absence of these formations is probably due to the deposition of the Trenton and Utica in deeper water at a higher relative level than the earlier formations, causing an overlap of deposition which brings the newer rocks in direct contact with the gneisses on which they, of course, rest unconformably. The Quebec and Lévis rocks, from their lithological character, appear to have been deposited in shallow muddy water with the Archæan area at a considerably higher level than during Trenton time. Their fossils also show, from their diminutive size, that the water inhabited by them was probably very cold, so that at the time of deposition of these rocks, there was an elevation of the Archæan mass with cold water about the foot of its eastern face, conditions favourable to a period of glaciation. The surface of the Archæan rocks on which these newer beds were laid down had a rounded undulating form closely resembling the present exposed surface. The amount of denudation subsequent to the time of deposition of the Trenton does not seem to have been very great in depth on gneisses, as the portions overlaid by the Trenton have almost exactly the same appearance as those exposed during the last glacial period. The gneisses when the limestone is removed, present fresh surfaces and are not decomposed or disintegrated to any appreciable depth, showing that at the time of deposition of the Trenton rocks, either no decomposition of the gneisses due to subaerial decay had taken place, or else the decayed parts had been removed to a great extent, either by water currents or ice action.

Absence of older Cambro-Silurian and Cambrian rocks.

Rounded surface of Archæan rocks.

Contacts between the Trenton and the gneisses showing these characters are seen at Deschambault Station, on the Jacques Cartier River immediately above the Canadian Pacific railway bridge, at Jeune Lorette along the foot of the Archæan hills, above the falls of the Montmorency, and along the Sault à la Puce and Ste. Anne de Beaupré rivers.

Contacts between Trenton and Archæan.

The Trenton limestones appear to have been laid down at the close of a period of subsidence accompanied by an amelioration of climate, as its fossils are normal in size and indicate warmer water, but the finding of a rounded mass of dark red mica gneiss imbedded in the limestone strata some ten feet above the base of the terrane appears to point to floating ice at that time. The above gneiss mass is six feet long, four feet wide and four feet thick, and has been estimated eight tons in weight. It can be seen in the position above described on the west bank of the Jacques Cartier River, fifty yards above the Canadian Pacific railway bridge, and near the present northern limit of the Trenton,

Boulder in limestone.

but as the country to the north is almost flat for some miles, the limestones probably extended to the base of the Archæan hills, and have since been largely denuded away. If such is the case, the presence of this large foreign mass cannot be accounted for except that it was dropped there from floating ice, as no ordinary ocean or river current could carry such a large block and deposit it in its present position.

Basal sand rock.

In various places at the contact of the Trenton with the Archæan beds or patches of a calcareous sand rock are seen resting in the hollows of the Archæan surface. These patches vary from a few inches to several feet in thickness, and appear to be formed from detrital material collected in the hollows by water or ice action previous to the deposition of the limestones, and subsequently cemented by calcareous infiltrations.

This sand rock was formerly taken to represent the Potsdam sandstones, but more detailed examination shows it to be of local development, while the upper portions hold fragmental Trenton fossils. Patches of this rock are seen on the Jacques Cartier River, at Lorette on the road where it rises to that village, at the falls of the Montmorency, and on the Ste. Anne de Montmorency River. Beyond the limits of the present report, they are met with on the St. Maurice River, where a thickness of fifty feet is seen, and thence westward are frequently met with where the Trenton comes in contact with the Archæan in eastern Ontario, and also to the east at Bay St. Paul and Murray Bay.

Disturbance and Faulting.

Tangential pressure.

As is well known a great folding, breaking, and faulting of the Cambrian and Cambro-Silurian rocks of eastern Quebec, in common with the other coast rocks of eastern America, occurred in post-Silurian time, and was occasioned by some great tangential pressure, which in the area under consideration acted at right angles to the Archæan mass and consequently from a south-south-east direction.

This force in the more disturbed region twisted the strata into great overfolds and in many places by a series of upthrow faults brought older strata to positions seemingly above newer, and all having been subject to subsequent great denudation their relative age can only be accurately determined by careful palæontological work along with that of the stratigraphy.

Disturbance due to pressure.

The region embraced in this report being near the western limit of the action of this tangential thrust, affords an interesting field to study the difference of intensity of disturbance caused by it. Towards

the western limit of the map, about the valley of the Ste. Anne de la Pérade River, the Cambro-Silurian rocks rest comparatively undisturbed upon the gneisses. Proceeding eastward, evidence of disturbance is seen in the beds being thrown into low anticlines with the angle of inclination greater to the south-east, in the direction of the thrust than on the opposite side, while farther eastward the anticlines are sharper and overturn dips appear, followed by prevailing overturns, accompanied by upthrow faults, where in the eastern half of the map the tangential thrust appears to have reached a maximum. In this part the stratigraphy is further complicated by what appears to be a series of downthrow faults along the face of the solid Archæan mass, and formed subsequent to the period of maximum thrust, when owing to relief from pressure, lines of weakness appear to have been developed between the immovable gneisses and the crushed limestones and shales. The spurs of gneiss projecting southward from the main mass which have been before referred to, were important factors in the deformation of the overlying limestones and shales, as it was against and over these spurs that the tangential thrust forced the newer rocks and formed an anticline on each. These anticlines are sharp towards the south-east with low flowing dips in the opposite direction, and show that the gneisses acted as a buttress and relieved the newer rocks on the west side from the full effect of the thrust, while on the other side the limestones and shales were squeezed up, and over these immovable barriers at times with breaks in the strata caused by upthrust faults.

Variation in intensity of pressure.

Gneiss buttresses.

Passing from west to east the first anticline is that over the Deschambault spur. Here the Trenton limestones fold with flowing dips of 3° to 5° towards the west, where they pass into the low domes of the Ste. Anne valley. On the south-east side the dip is sharper (23°), and the rock is slightly broken on the crest of the anticline, but no evidence of faulting of the limestones or shales is apparent on the next anticline, that over the weakly developed Jacques Cartier spur, where the rocks are in positions corresponding with the Deschambault anticline; the south-east dips being sharper than the north-west ones. Evidence of slight faulting in the shales is seen along the Jacques Cartier River on the east side of the spur, the greatest fault being in the river bed, near the mill, on the small stream which falls into the river on the west side some two miles above its mouth.

Deschambault anticline.

Jacques Cartier anticline.

At the Pointe aux Trembles spur, the limestones on the west side dip away at low angles until they pass under the shales. On the crest of the anticline they are considerably crumpled and bent into small

Pointe aux Trembles anticline.

sharp folds, the folding increasing as the east side is approached and slickensided faces give evidence of faulting among the beds of limestone, culminating in a heavy overthrust fault at the junction of the limestones with the overlying shales. Here the shales are shoved over the limestone, so that they are found in contact with the gneisses along the south-east slope of Bonhomme Mountain to one mile beyond St. Ambroise station, where the limestone again intervenes, and the overthrust fault apparently dies out, the rocks being again partly protected by the gneiss spur of Montmorency, which probably extends westward beneath the limestone to near Beauport village, and forms the high ground, along the edge of which the Montmorency road passes. Southward from Lorette towards St. Foy, the Loraine shales first form a low syncline and anticline, followed by a sharper syncline and anticline, and then a syncline with overturn dips on its south side, which brings the greyish Loraine shales in contact with the red and green shales of the Sillery on the hillsides, about 200 yards north of Ste. Foy church.

Fault.

Contact of Loraine and Sillery.

This contact of the Loraine and Sillery shales is brought about by an upthrust fault by which all the measures between the Lower Cambrian and Loraine have been thrown up, and subsequently denuded away, leaving the Sillery rocks in a position apparently conformably above the Loraine.

Champlain Fault.

This fault, as pointed out by Dr. Selwyn,* is met with on the north side of the Island of Orleans where it separates the Lévis and Sillery rocks. From there it passes westward in the bed of the St. Lawrence a short distance in front of the city of Quebec, and reaches the north shore at Wolfe's Cove, about one mile north of Point Pizeau, whence it crosses to Ste. Foy as above described, and here turning south-west comes out again on the north shore two miles above Cap Rouge, where it crosses to the south shore and is seen in the cliffs two miles south of the mouth of the River Rouet, and not far from St. Nicholas church. Thence it extends south-west in the direction of Lake Champlain to Missisquoi Bay.†

Section from Charlesbourg to Quebec city.

A section southward from Charlesbourg, passing through Quebec near the Martello towers on the Plains of Abraham, shows the thickness of the Trenton limestone between the gneiss and the Utica black shales to be much greater than at Lorette. The limestone is seen along the Lake Beauport road for seven hundred yards behind Charlesbourg church, which is situated near the summit of the limestones. The limit between the Trenton and Utica cannot be closely defined here as

* Report of Progress, 1869.

† See R. W. Ells, Annual Report, 1887-88, p. 45 K.

the limestones gradually become stratified with shale beds, which increase in thickness until shale predominates over limestone, and the latter finally dies out in a few thin beds well up in the shale series.

To the north of Charlesbourg church, on the Archæan plateau, the limestone is almost undisturbed and dips towards the south at angles of 3° to 5°, but as the edge of the hill is approached the dips become greater, and immediately behind the church the angle is 38°. Seven hundred yards south of the church and near the bottom of the hill, close to the junction of the black and upper grey shales, the beds are disturbed with dips varying from 43° to 80°, with an average of 50°. This variation in dip points to some small unseen fault, perhaps a continuation of the Montmorency downthrow fault, mentioned later on. Change of dip.

From the foot of the Charlesbourg hill to beyond the St. Charles River, the ground is almost flat, and no rock exposures are seen, but as exposures of greyish-green arenaceous shales, holding Loraine fossils, are met with on either side of the river, it may safely be taken that they occupy the interval between the foot of Charlesbourg hill and the north escarpment of the city, where they are again seen in contact with the Quebec city rocks. Near this contact both formations are broken and crumpled, evidence of a fault along the bedding plane, which brings the beds of Quebec rocks into a position apparently conformably above the shales, but the fossils from the former are held by Mr. Ami to indicate a position below the Trenton*, while the underlying grey shales are undoubtedly at the summit of the Trenton group, their contact north of the city must be an upthrust fault which has lifted out the intermediate strata. Contact of Loraine with Quebec city rocks.

This fault is apparently a branch of the great Champlain fault. It seems to leave the latter a short distance east of the road running north from Ste. Foy church and, passing eastward along the face of the northern escarpment of the city, runs under the St. Lawrence. According to Dr. Ells, the same or a similar fault separates the Loraine from the Quebec city rocks, on the north side of the Island of Orleans, one mile and a half from its west end; a short distance beyond, it again joins the main fault between the Sillery and Loraine rocks.† Direction of fault.

On the Montmorency spur of the Archæan rocks, and its apparent extension to the back of Beauport church, the limestones rest almost horizontally and undisturbed with dips varying from 3° to 5° towards the south. Montmorency.

---

*Prof. Lapworth, Trans. Royal Soc. of Canada, 1886, also Annual Report, 1887-88, p. 46-48 K., H. M. Ami, Bulletin Geo. Soc. of Am., vol. 2.

†Annual Report, 1887-88, p. 71 K.

On the eastern flank of the spur, folding and faulting of the shales have taken place, as on that face of the other anticlines. Added to these disturbances of the strata, downthrow faults now farther complicate the stratigraphy. The section along the Montmorency River shows the limestones resting on the gneiss above the fall to be almost undisturbed, with patches of the arkose sandrock in hollows of the gneiss between the latter and the limestone. The fossils in the limestones show that they belong to the lowest beds of the Trenton, and are overlain by newer beds as the stream is ascended. Near the brink of the cliff at the fall, the beds curve over the edge, while on the west side of the river they are traversed by small crest faults. To the west of the fall along the lower face of the cliff, patches of the arkose sandrock are seen, while on the face of the cliff only a thin band of limestone lies between the gneiss and the Utica shales. The patches of sandrock on the face of the cliff must have been placed there during the period of pressure and folding, when the Trenton must have been bent out of the horizontal and flattened against the almost vertical cliff, with the sandrock below it; and this is now the only record of such a folded and vertical position of these strata against the cliff, the rest of the beds having been let down by a subsequent downthrow fault along the line of weakness between the immovable gneiss and the compressed limestones and shales. This slip must have occurred on the relief from the great thrust pressure which folded up the rocks. The throw of the fault is not less than 500 feet; the difference of level between the top and bottom of the fall is 250 feet, and at least a like thickness can be allowed here for the limestone between the top and bottom of the Trenton. Between the foot of the fall and the mouth of the river are indications of another downthrow fault in the Utica shales, which gives a repetition of the beds of that formation.

Downthrow faults.

Throw of fault.

To the westward of the fall the course of the downthrow is easily traced to near Beauport church, as it runs parallel to and at a short distance from the main road from Beauport to Montmorency; for the greater part of this distance the road passes over bare ledges of flat limestone, while close to it, on the south side, the shales are seen tilted up at a high angle.

West of Beauport the ground is flat and drift-covered, concealing any evidence of the south-west extension of the Montmorency fault. Near this point the flat-lying Trenton limestones are cut off and thrown to the north, by a transverse dislocation, together with the overlying shales. At Parent's quarry a quarter of a mile from the mouth of the Beauport River there is a very

apparent dislocation of the limestones; the shales as they continue to the westward maintain a high angle of dip on the west side of the dislocation, a new condition, not apparently caused by the thrust action but by a transverse downthrow fault.

Eastward of Montmorency.

To the eastward of Montmorency it is very difficult to trace the limits of the downthrow fault, as the beds are here folded up and faulted by the thrust, rendering it impossible to tell, from the denuded patches near the contact with the gneiss, whether the beds have been shoved up or let down.

Château Richer anticline.

The thin tilted beds of limestone and overlying shale cross the main road half a mile beyond the Montmorency bridge, immediately to the north of which the gneiss rises from beneath them. The limestone outcrop between the gneiss and shales is very narrow and the dips are high until the Château Richer spur is approached, where on the protected west side and top of the anticline the dips are lower, and the limestone outcrop broader. On the south-east side of the spur the rocks are in a condition similar to those at Montmorency, having first been folded up and then let down by a fault, so that at the fall of the Sault à la Puce River, where the water drops sixty feet over the face of the gneiss, above the fall are beds of limestone and sandrock patches, while below are seen the arenaceous shales of the Loraine. These shales continue in contact with the gneiss for two miles to the north-eastward, when the fault apparently dies out, and a thin strip of Trenton is interposed and continued to the River à la Rose.

Ste. Anne anticline.

The dip is at a high angle, but diminishes as the Ste. Anne spur is approached where the limestone again spreads out over the top of the anticline.

On the south-east side at the foot of the lowest cascade of the Ste. Anne River the limestones are seen to dip south at angles varying from 30° to 70° and are followed conformably by black Utica and grey shales.

The Trenton and Utica are also seen on the east side of this anticline along the road from St. Joachim to Bay St. Paul, and on the Friponne River where it descends from the gneiss, in both localities the limestone resting on the gneiss dips nearly south, at an angle of 30°.

Distribution of the Trenton.

West of Deschambault anticline.

Westward of the Deschambault anticline to the limits of the sheet, is a large development of limestone. On the Ste. Anne de la Pérade River they are first seen at the Three Rapids, half a mile in a straight line south from the last exposure of gneiss, the intermediate rocks being covered by stratified clays. The dip is S. 80° W. $<7°$, and the beds have a transverse measurement of 650 yards, giving a thickness

of 250 feet. The beds here are thin; the lower ones hold considerable quantities of cherty nodules, with an occasional band of the same mineral, and also some small crystals of blende.

The fossils also are silicified and weather out in a beautiful manner; the following fossils found here place the beds in the Trenton:

Prasopora lycoperdon, Vanuxem.
Lingula, sp.
Orthis testudinaria, Dalman.
Leptæna sericea, Sowerby.
Strophomena alternata, Conrad.
Rhynchonella increbescens, Hall.
Platystrophia biforata, var. *lynx*, Eichwald.
Orthoceras, sp.

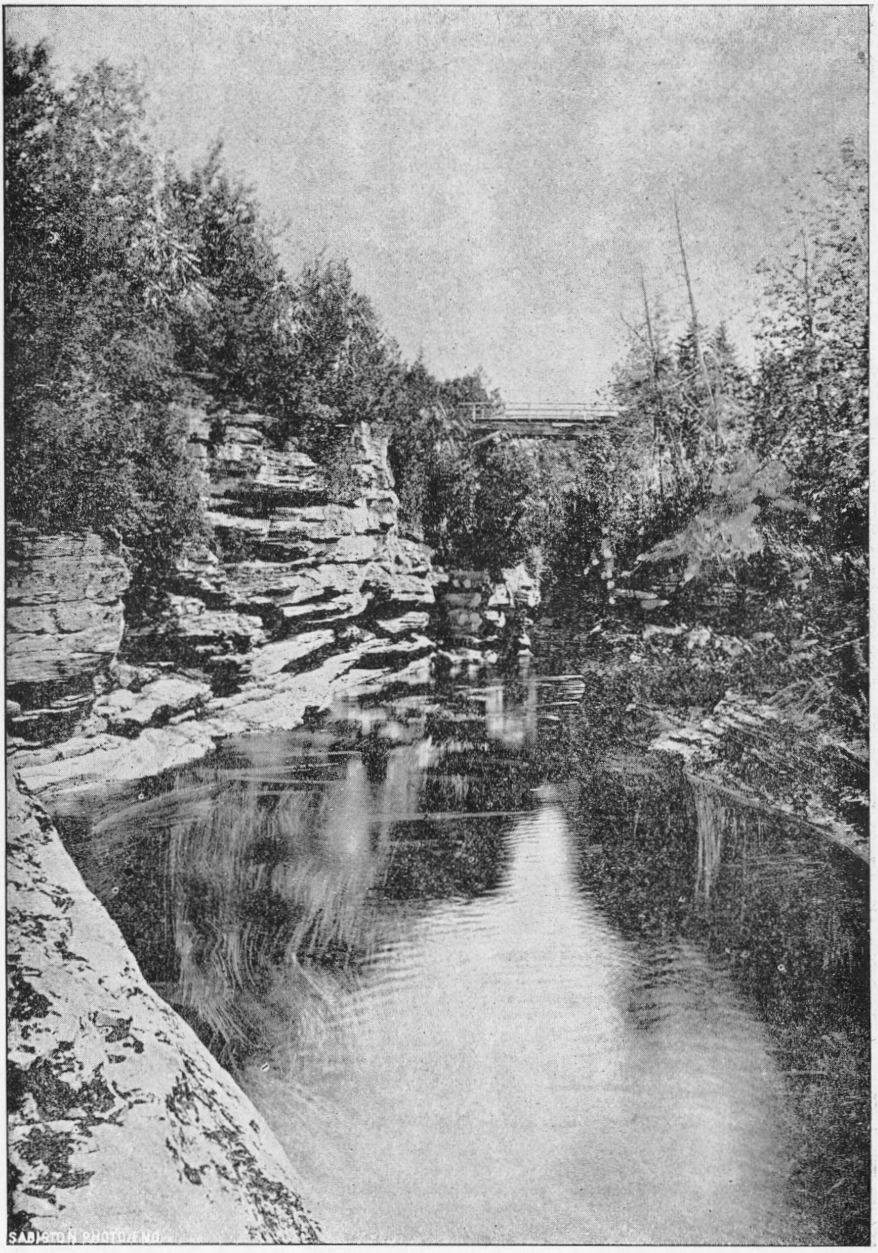
St. Alban.

Three miles further down stream and one mile and a half from the gneiss, similar limestone, with silicified fossils, is seen at the Cascades, and from there past the village of St. Alban to beyond the limit of the map, the river passes through a narrow gorge in the limestone, with vertical walls from twenty to sixty feet high. The limestone is only disturbed by low undulations, and the entire section exposed does not exceed 300 feet. Among the fossils collected at and below St. Alban bridge are: *Stictopora acuta*, Hall; *Prasopora lycoperdon*, Vanuxem; *Lingula quadrata?* Eichwald; *Orthis pectinella*, Conrad; *Strophomena alternata*, Conrad; *Cyrtodonta cephalus*, *Asaphus platycephalus*, Stokes.

Western extension.

From the Ste. Anne River the limestone passes westward to the St. Maurice River, beyond which the rocks are concealed by drift. To the south and east of the Ste. Anne, with the exception of the small triangular area of Utica shale west of Grondines Point, the limestones are abundantly seen on all the roads in the seigniories of East and West Grondines, Tesserie, La Chevrotière and Deschambault, coming out on the St. Lawrence a short distance above the old windmill at Pointe à Maçon. From here to the La Chevrotière River, a distance of four miles, the coast presents a naked and often perpendicular cliff of limestone in slightly inclined strata, in some places over 100 feet above the river.

On all the roads running back from the St. Lawrence in this locality the limestone is constantly seen outcropping from under a thin covering of soil. Further inland, towards the Ste. Anne River, the stratified surface deposits become thicker and the rock exposures fewer, but sufficient are seen to show that no shales occur in this area. Along the road between St. Alban and La Chevrotière station, in the fourth range of La Chevrotière, and the south part of St. Alban parish,



A. P. Low, Photo., 1889.

GORGE IN TRENTON LIMESTONE
AT ST. ALBAN BRIDGE ON THE ST. ANNE DE LA PÉRADE RIVER, P. Q.

extensive quarries are worked where massive beds of limestone outcrop. The beds are few in number, and as they are everywhere near the surface, the excavations are seldom over ten feet deep. From their position these beds would appear to represent the middle Trenton, and hold the following fossils: Extensive quarries.

Prasopora lycoperdon, Vanuxem.
Strophomena alternata, Conrad.
Orthis testudinaria, Dalman.
Anastrophia hemiplicata, Hall.
Ceraurus pleurexanthemus, Green.
Asaphus platycephalus, Stokes.

From the mouth of the La Chevrotière River, where the limestone passes under the Utica shales, its summit runs north-east and crosses the road and Belisle River about one mile from the St. Lawrence, where it is seen in an old quarry; the rock here occurs in massive beds and is of a dark grey colour, but the stone is injured by thin patches and beds of black bituminous shale, and is often traversed by small cracks filled with bituminous matter. From here to the second range road and along it to the eastward numerous exposures of limestone are seen dipping at a low angle towards the west. Belisle River.

On the line between the first and second ranges, one quarter of a mile to the west of the road which runs back from the village of Deschambault, and also immediately to the east of the same road, just inside the second range, the limestone is seen folding over the anticline, and in both places dips N. 85° E. $<23°$-$40°$. In the first mentioned place the crest of the anticline is seen, with a few cracks and breaks on it, while in the second the beds are broken off against the gneiss, which here rises to a higher level. These beds are massive and granular. Deschambault anticline.

On the east side of the Archæan spur the limestone appears to form only a narrow strip along the base of the hill, between the gneiss and shale, until it again broadens out in the valley of the Portneuf River to the south of St. Basile, where it has a breadth of one mile between the church and the railway station; and is seen in the river valley, for a short distance on either side of the St. Basile bridge, with a dip S. 30° E. $<2°$. Portneuf River.

From here the northern edge sweeps round through the parish of Terrebonne, and comes out on the Jacques Cartier River two hundred yards above the Canadian Pacific Railway bridge, while its summit passes south through the parishes of L'Enfant Jésus and Grand Bois, folding over the anticline on the road from Cap Santé to Ste. Jeanne de Neuville near the line between D'Anteuil and Neuville; and from Jacques Cartier anticline.

there sweeps round to the eastward, crossing the Jacques Cartier River half a mile below the white or middle bridge, and one mile and a half from the lowest exposure on the river.

Jacques Cartier River.

Like the Ste. Anne River the Jacques Cartier has cut a deep gorge in the limestone, through which it runs with a strong current, especially in the lower part where it passes around a narrow neck, and rushes under the white bridge with a considerable fall. Across this neck is a subterranean channel through which passes a body of water sufficient to drive a mill on the lower side where it pours out of an opening in the vertical cliff.

East of the Jacques Cartier River few exposures of limestone are seen, but its northern boundary appears to follow the Archæan outline along the north side of the road from Ste. Jeanne to the second range of Fossambault, where it turns south and bends around the gneiss at Pointe aux Trembles.

The summit beds on leaving the Jacques Cartier cross the Rivière aux Pommes near the bridge in the fourth range, and then bend towards the south, crossing the road from Pointe aux Trembles in the middle of the third range, and again near the line between the first and second ranges, and come out on the north bank of the St. Lawrence, seventy-five chains west of Pointe aux Trembles wharf.

Pointe aux Trembles.

From here they occupy the shore line for a distance of 140 chains, where, folding over the anticline, they again pass under the Utica shales. As before stated the section here shows that the limestone on the west side of the anticlinal axis is only slightly disturbed into long folds with dips not exceeding 20°; while on the east side the folds are shorter and the angles higher, ranging up to 40°. Slickensided faces are also common and the beds are somewhat broken, with the shales thrust over them. The following characteristic Trenton fossils from this locality were collected principally by Dr. R. W. Ells and named by Mr. H. M. Ami:—

Heterocrinus Canadensis, Billings.
Leptæna sericea, Sowerby.
Strophomena alternata, Conrad.
Strophomena deltoidea, Conrad.
Anazyga recurvirosta, Hall.
Anastrophia hemiplicata, Hall.
Orthis testudinaria, Dalman.
Modiolopsis, sp.
Dalmanites callicephalus? Green.
Calymene senaria, Conrad.
Calymene, sp.

Asaphus platycephalus, Stokes. (= *Isotelus gigas*, DeKay.)
Ceraurus pleurexanthemus, Green.

From Pointe aux Trembles to St. Ambroise no limestone is seen, the Utica shale resting directly on the gneiss along the south-east flank of the Bonhomme Mountain.

Directly north of the road leading from St. Ambroise station to Lorette, about three-quarters of a mile east of the station, thin beds of black bituminous limestone followed by grey beds, all highly slickensided, come in between the gneiss and the shale. Lorette.

The limestone in this position is seen along the face of the Archæan hill to the south of the village of Lorette, where it conforms in dip with the irregular contour of the gneiss bosses. The basal beds of recemented Archæan debris are only represented by one small patch along the road rising to the village.

At the falls of the St. Charles River, dark-coloured limestone is seen resting directly on the gneiss, and is followed by lighter coloured grey beds, showing in the river section a breadth of seven hundred yards, dipping southward at angles varying from 15° to 30°, and giving a thickness of six hundred feet, when they pass under the shales. St. Charles River.

The following is a list of fossils from the limestones at the falls of the St. Charles River, collected by Dr. Ells, L'Abbé Laflamme, and Messrs. Giroux and Ami, and determined by the last-named gentleman :—

Stictopora acuta, Hall.
Batostoma Ottawaense, Foord.
Prasopora lycoperdon, Vanuxem. = *P. Selwyni*, Nicholson.
Discna Pelopea, Billings.
Linigula Philomela, Billings.
Leptæna sericea, Sowerby.
Strophomena alternata, Conrad.
Orthis testudinaria, Dalman.
do sp. indet.
do sp. nov. (?)
Anastrophia hemiplicata, Hall.
Bucania punctifrons, Emmons.
Bellerophon bilobatus, Sowerby.
Conularia Trentonensis, Hall.
Theca, nov. sp.
Ctenodonta dubia, Billings.
Pterinea Trentonensis, Emmons.
Ambonycia orbicularis, Emmons, or n. sp.
Trochoceras Halli, Foord. *Lituites undatus*, Emmons.

Endoceras proteiforme, Hall.
Primitia Logani, Jones.
Aparchites mundulus, Jones.
Primitia mundula, J.
do *do* var. *incisa*, Jones.
Beyrichia quadrifida, Jones.
Isochilina Whiteavesii, Jones.
do *Amii*, Jones.
Leperditia (?) obscura, Jones.
Polycope, sp.
Ceraurus pleurexanthemus, Green.
Calymene senaria, Conrad.
Encrinurus vigilans, Hall.
Dalmanites callicephalus, Green.
Trinucleus concentricus, Eatm.
Asaphus platycephalus, Stokes.
Illœnus Milleri, Billings.
Lichas, sp.

On the Rivière des Mares the summit of the limestone passes just south of the mill on the Lorette-Charlesbourg road. It then sweeps
Charlesbourg. round the escarpment to Charlesbourg, where it is seen in several small quarries opened for road metal, the stone being divided into small beds by partings of shale, and holding considerable quantities of bituminous matter in cracks and partings in the beds, which render it inferior as a building stone.

Passing immediately north of the Charlesbourg church, the summit continues eastward to the Bourg Royal road, where it bends towards the south as it rises to the Montmorency anticline and crosses the
Beauport. Quebec and Beauport road a little west of Beauport River. Near here is Parent's quarry, in the limestone beds which are extensively worked for building stone. An evident dislocation of the beds occurs here as the dip changes from S. 30° W.$<$28° on the west side of the quarry to N. 67° W.$<$6° on the east.

From a collection of fossils made at this locality by Mr. D. N. Saint-Cyr, in 1888, the following have been determined by Mr. Ami:

Prasopora lycoperdon, Vanuxem.
Amplexopora discoidea, James.
Lingula obtusa, Hall.
Strophomena deltoideo, Conrad.
Anastrophia hemiplicata, Hall.
Conularia Trentonensis, Hall.
Orthoceras, n. sp.

Asaphus platycephalus, Stokes.
Calymene senaria, Conrad.
Ceraurus pleurexanthemus, Green.

As before stated, from Beauport to the Montmorency River, the summit of the limestone is immediately south of the main road, where the tilted beds of shale are seen overlying it and are brought into position by the downthrow fault.

From the St. Charles River the northern limit of the limestone coincides with the base of the Archæan hills extending north-east, and on the L'Epiphanie road shows a breadth of one mile and a-half. On the Charlesbourg and Lake Beauport road, the northern limit is one mile from the summit of the terrane; and, unlike in most places, presents an escarpment on the north side, with a considerable interval of lower level country between it and the next Archæan rise.

Templeman's quarry.

At Templeman's quarry, situated to the east of Lake Beauport road, near the edge of the escarpment, the limestone is in thin beds interstratified with a considerable number of thin bituminous shale beds. The fossils from this quarry, collected by Messrs. Ami and Giroux, represent the following species :—

Pachydictya acuta, Hall.
Ptilodictya falciformis, Nicholson.
Prasopora lycoperdon, Vanuxem.
Crania, sp. (parasite on a large orthocerite).
Schizocrania or *Discina*, sp.
Lingula reciniformis, Hall.
Leptæna sericea, Sowerby.
Stropomena alternata, Conrad.
Orthis testudinaria, Dalman.
Murchisonia gracilis.
Endoceras proteiforme, Hall.
Calymene senaria, Conrad.

Along the Bourg Royal road the breadth is about one mile and a quarter from the shales to the gneiss, the latter contact being covered with drift.

In rear of Beauport.

The road running back from Beauport passes for three miles over almost horizontal ledges of limestone with a small dip towards the south; to the eastward as far as the Montmorency River outcrops of limestone are very numerous, especially along the road from Charlesbourg to Laval, where a lime kiln and quarry seem to be a necessary part of the equipment of every farm.

Above the falls of the Montmorency River flat beds of limestone, form the bottom and sides of a gorge through which the river rapidly

flows for two miles. These beds extend eastward a short distance until they are cut off by the Archæan spur and the downthrow fault.

Mont-morency.

The position and relation of the limestone and other strata at and below the Falls of Montmorency have been previously described, and it only remains to add a list of fossils collected from the limestones in this vicinity, these collections were made by Dr. Ells and Messrs. Ami and Giroux, and have been determined by Mr. Ami.

From the left bank of the river, near the bridge above the Falls, the following come :—

Stictopora acuta, Hall.
Prasopora lycoperdon, Vanuxem.
Solenopora compacta, Billings.
Lingulaacurta, Hall.
Strophomena alternata, Conrad.
Leptæna sericea, Sowerby.
Orthis testudinaria, Dalman.
Orthis pectinella, Conrad.
Anazyga recurvvisrostra, Hall.
Zygospira modesta, Say.
Conularia Trentonensis, Hall.
Bucania punctifrons, Emmons.
Bellerophon bilobatus, Sowerby.
Murchisonia gracilis, Hall.
Murchisonia perangulata, Hall.
Orthoceras laqueatum, Hall.
Vanuxemia, sp.
Harpes, sp.
Encrinurus vigilans, Hall.
Asaphus platycephalus, Stokes.
Ceraurus pleurexanthemus, Green.
Illaenus Milleri, Billings.

Thin bedded bituminous limestone on the property of Mr. Hall to the West of the Falls gives the following species :—

Sponge-like organisms.
Lingula, sp. indst.
Orthis testudinaria, Dalman.
Strophomena alternata, Conrad.
Strophomena ? sp.
Conularia, sp. indst.
Trinucleus concentricus, Eaton.

Along the brook, on the east side of the gorge at the foot of the Falls, the following fossils were collected from beds of light grey-weathering,

impure bituminous limestones and overlying black bituminous shale, on the south side of the fault. The fossils from the lowest beds are marked thus (*):

* *Hyalostelia*, sp.
Diplograptus, sp.
Climacograptus.
Retesgraptus eucharis, Hall.
Orthograptus quadrimucronatus.
* *Glyptocrinus glyptocystites*, sp.
Lingula curta, Hall.
Leptobolus insignis, Hall.
* *Leptæna sericea*, Sowerby.
* *Strophomena*, sp.
* *Orthis testudinaria*, Dalman.
Serpulites disvolutus, Billings.
* *Primitia*, sp.
* *Calymene senaria*, Conrad.
* *Illaenus*, sp.
Triarthurus, Green.

The distribution of the Trenton limestone to the east of Montmorency has already been referred to, in conjunction with the faulting, and it only remains to say that where the limestone folds over the Château Richer anticline, extensive quarries are worked, and excellent building stone is produced.

Loraine.

Immediately overlying the Trenton limestones are beds of black bituminous shale. These in most places pass imperceptibly upwards into an arenaceous friable grey-green shale. The black shales, from their fossils, are undoubtedly Utica shales, while the latter represent the Hudson River rocks. From the difficulty found in defining their exact line of junction in many of the sections it has been deemed advisable to unite them under the name of Loraine, especially as the black shales nearly everywhere form only a thin band, seldom exceeding one hundred feet in thickness and consequently impossible to map on the scale of the present sheet. These shales are first met with in a small triangular area, to the west of the limestones of the Deschambault anticline, where a few exposures are seen on the low points west of Pointe à Maçon on the St. Lawrence; and they occupy the low ground south of the limestone to the Ste. Anne River.

Utica shale.

Pointe à Maçon.

On the east side of the anticline, the shales are first seen on the river front a short distance east of the mouth of the La Chevrotière

River, and from there occupy the north shore of the St. Lawrence until again displaced by the limestones of Pointe aux Trembles. From Deschambault to within two miles of Cap Santé the shore line is low with a few exposures of shale resting almost horizontally. Below this the grey shales form a bold cliff as far as the mouth of the Jacques Cartier River. Rising from below these shales at a low angle, are thin beds of a greenish argillaceous limestone about twenty feet thick. The limestone is seen along the base of the cliff until it crosses the anticline and again passes below the shore line, about half way between Cap Santé wharf, and the Jacques Cartier River. Above the main band of limestone and included in the grey shales are some half dozen thin beds of similar stone, which serve admirably for window-sills, hearths, etc. These limestones appear to have been considerably jointed; the planes of division running in three principal directions. On the east side of the anticline the limestones are somewhat folded and dip at a higher angle than to the west where the angle is not above 2° or 3°.

Cap Santé

Back from the St. Lawrence the shales are seen resting on the limestone at the first rise near the Belisle River, and from there appear to occupy the low ground between the St. Lawrence and the first step to the Portneuf River, where they come out in its bed about one mile from its mouth, and again on the road near St. Basile station.

Portneuf River.

From here they sweep southward over the Jacques Cartier anticline, and are seen along the lower three miles of the roads leading from Ste. Jeanne de Neuville to Cap Santé.

The valley of the Jacques Cartier River, below where the summit of the Trenton passes under the shales, affords a good section of the shales, as the river descends rapidly in a narrow channel between almost vertical walls of shale from fifty to one hundred feet high. Along this section of eight miles, the shales are generally seen in long low undulations, but in a few instances they are tilted up and appear to be faulted; one marked fault is seen where a small brook falls in from the west bank near the east line of Jacques Cartier seigniory. Owing to the precipitous sides of the valley, and almost continuous rapids of the river, no detailed examination can be made in this valley.

Jacques Cartier River.

In the shore section of the St. Lawrence, east of the Jacques Cartier River, the black and grey shales form the bold vertical cliff of L'Ecureuil, until they give place to the limestones of Pointe aux Trembles. Throughout this distance the beds are arranged in a series of long low anticlines and synclines, with dips never exceeding 8°, and showing only slight local twistings of the strata. Interbedded with the shales are a few thin bands of bituminous limestone, which well mark the undulations on the cliff face.

L'Ecureuil.

Inland the beds are more contorted in places and have higher dips.

Numerous exposures are seen along the river road, on that of the second range, and along the road leading to the white bridge over the Jacques Cartier River. These exposures show the northern limits of the shales to extend from the Jacques Cartier eastward through the front of the fourth range, to the road running back from Pointe aux Trembles, which it crosses three miles and a half from the St. Lawrence, and then sweeps round recrossing the road at the second range line and comes out on the St. Lawrence, seventy-five chains west of Pointe aux Trembles wharf. West of Pointe aux Trembles anticline.

As before stated, on the east side of the Pointe aux Trembles anticline, the shales have been thrust over the limestone, and are found in contact with the gneiss on the east flank of the Bonhomme Mountain, they rest on the gneiss at angles approaching the vertical and give evidence of overturn dips near the contact in the third range of Des Maures. East of Pointe aux Trembles anticline.

On the shore, near the contact with the limestone east of Pointe aux Trembles, the following fossils were collected by Dr. Ells and others :—

Diplograptus, sp.
Orthograptus quadrimucronatus, Hall.
Climacograptus, sp.
Leptobolus insignis, Hall.
Triarthrus Becki, Green.

Along the St. Lawrence the shales are seen on the low points, and in the cliff, from the fault below Pointe aux Trembles, to where they are cut off by the Champlain fault above Cap Rouge. As the contact with the Sillery rocks is approached, the Loraine shales are found to be broken and contorted both in dip and strike, evidence of the disturbing action of the great upthrust fault. Junction with Sillery above Cap Rouge.

In this shore section the dips vary from 15° to 75°, and are generally towards the south-east.

Inland, on the roads throughout the southern portions of the seigniories of Des Maures, Gaudville and St. Gabriel, exposures of shale are frequently seen overlaid by a stiff clay soil, largely formed from the disintegration of the shales. In these exposures the strike, N. 30° E., is very uniform, with the dip at high angles generally to the southward, but some to the northward of the vertical, giving evidence of sharp folding, and probable repetition of the beds in the section from the gneiss to the Cambrian rocks. Inland.

Eastward from St. Ambroise, where the limestone again comes in between the shales and the gneiss, black shales follow the face of the St. Ambroise.

limestone plateau and are seen along the St. Charles and Des Mares rivers, the quick change in dip from nearly horizontal on the plateau to angles of upwards of 40° on its sides, is the only evidence here of any fault action.

Along the road from Lorette to Charlesbourg *Climacograptus*, sp., *Orthograptus quadrimucronatus*, Hall, and *Leptobolus insignis*, Hall, are common in the black bituminous shales. About one hundred yards south of the Charlesbourg church, along the main road from Quebec, Mr. Ami collected the following species :—

Charlesbourg.

Climacograptus.
Orthograptus quadrimucronatus, Hall.
Leptograptus flaccidus, Hall.
Leptobolus insignis, Hall.
Strophomena, sp.
Bellerophon bilobatus, Sowerby.
Leperditia, sp.
Triarthrus Becki, Green.

Skirting the face of the hill the shales cross the Charlesbourg road ; where the lower beds are interstratified with several thin bands of bituminous limestone. East of this they soon bend to the southward, on the west line of the Seigniory of Beauport, crossing the Quebec and Beauport road, a short distance west of the river, and here resting apparently unconformably on the limestone along the western extension of the Montmorency fault. In the black bituminous shales overlying the limestone at Parent's quarry, the following fossils were collected by Mr. St. Cyr :

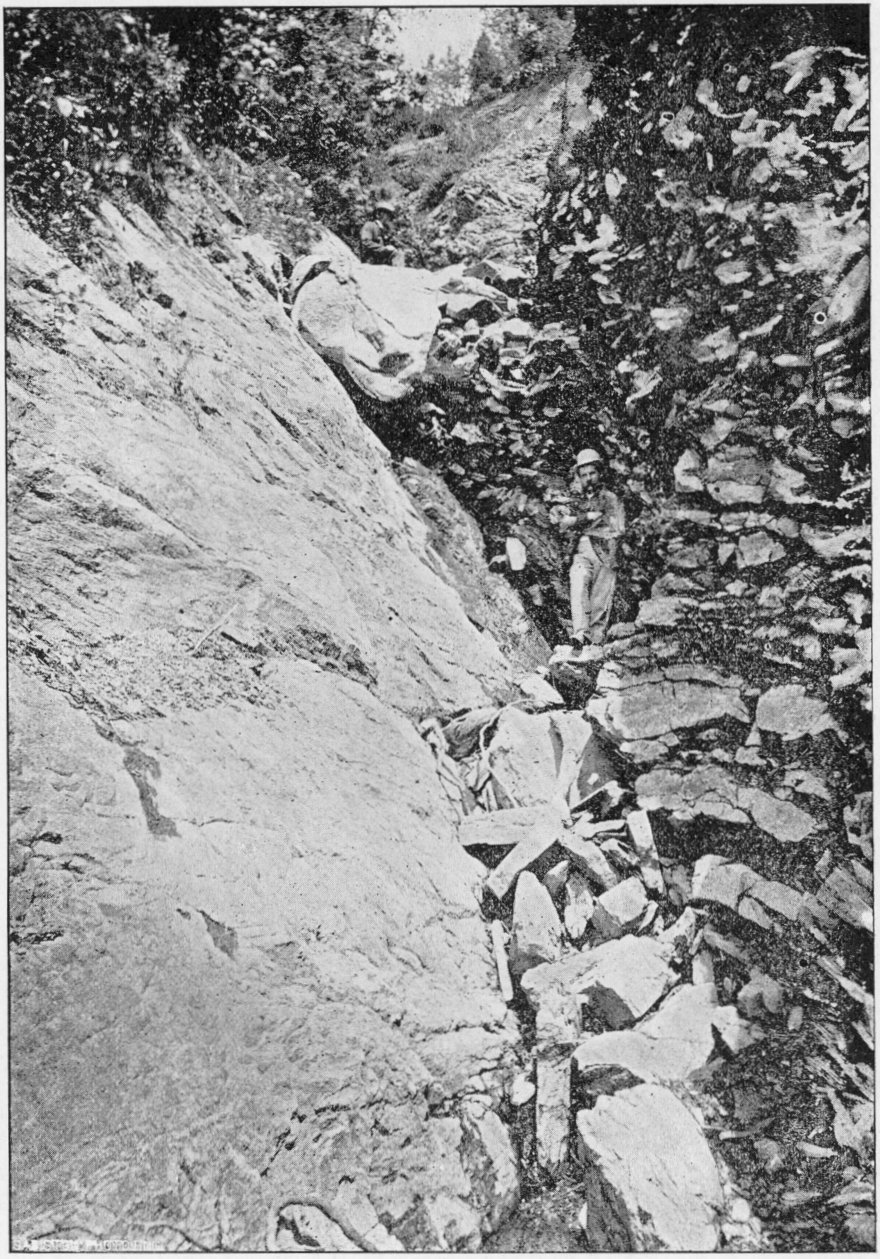
Beauport

Schizocrania filosa, Hall.
Leptœna sericea, Sowerby.
Lyrodesma pulchellum, Emmons.
Endoceras proteiforme, Hall.
Asaphus Canadensis, Chapman. =(*A. latimarginatus*, Hall.)
Diplograptus, sp.

From Beauport to Montmorency Falls the shales occupy the hillside and low ground south of the main road, resting on the flank of the limestone plateau. Below the falls and between them and the mouth of the river, Mr. Ami has collected the fossils below, from the black and grey shales which there conformably overlie the upper Trenton beds tilted up at the base of the cliff :

Mont-morency.

Climacograptus, sp.
Orthograptus quadrimucronatus, Hall.
Leptobolus insignis, Hall.



From Photograph Presented by Mr. C. D. Walcott, U. S. Geol. Surv., 1889.

FAULT BETWEEN ARCHÆAN GNEISS AND TRENTON LIMESTONE AND UTICA SHALE, JUST SOUTH OF MONTMORENCY FALLS, Q.

Endoceras proteiforme, Hall.
Triarthrus Becki, Green.
Serpulites, sp.

The southern limit of these rocks in the vicinity of Quebec, and their relations to the Quebec City and Sillery rocks, have been referred to previously when tracing out the course of the faults that separate them. To the eastward of the Montmorency River, as before stated, the shales are seen along the shore, and occupy the lower interval between it and the gneiss, except where the limestone intervenes on the crests and western sides of the anticlines.

Ste. Anne de Montmorency River.

Along the Ste. Anne de Montmorency River an excellent section of the black bituminous Utica shales, with the overlying grey shales and sandstones, is seen extending from the foot of the lower fall, which is caused by tilted up beds of limestone, on which the shales rest. The section extends down stream to the junction of its tributary, the River à la Rose. This section, carefully measured by Sir Wm. Logan, and published in the Report of 1852-53, and in "The Geology of Canada," 1863, is as follows, in ascending order:

Section of shales.

	Ft.
(1) Black, brittle, bituminous shale, with *Lingula* and *Graptolithus*	19
Black, brittle, bituminous shale, with two bands of yellow weathering limestone, black within	8
Black, brittle, bituminous shale	23
Black, brittle, bituminous shale, breaking into small fragments in consequence of a cleavage independent of the bedding	11
Black, brittle, bituminous shale, with *Graptolithus*	245
Grey, hard sandstone, interstratified with bands of black shale	5
Black, brittle, bituminous shale, interstratified with beds of sandstone	7
	318
(2) Light grey, yellow weathering sandstone, with black argillaceous nodules at the top; in some parts the sandstone beds hold fossils, which are obscure, but appear to be *Orthis testudinaria* and *Leptæna sericea*	10
Concealed	13
Black, brittle, bituminous shale	6
Dark grey argillo-arenaceous shale	51
Dark grey argillo-arenaceous shale	192
Dark grey argillo-arenaceous shale, with thin beds of sandstone	8

Section of shales.

	Ft.
Light grey sandstone in a massive bed, weathering greenish in the air, and reddish in the water; two bands of conglomerate occur in the middle, holding pebbles of limestone and quartz; some parts appear to weather faster than others in bands conformable to the bedding	18
Dark grey, slightly greenish argillo-arenaceous shales	58
Light grey, conglomerate bed, with about two feet of fine-grained sandstone at the bottom; the conglomerate parts hold pebbles of limestone and quartz, of various sizes up to two inches in diameter, those of limestone being in greater abundance than the quartz	5
Grey sandstone, a massive bed becoming of a conglomerate character in parts	14
Grey calcareous conglomerate, as before	3
Light grey sandstone, weathering brownish	3
Grey calcareous conglomerate, with soft shaly sandstone as a matrix	2
Greenish argillo-arenaceous shale, striped with dark grey bands	84
Greenish argillo-arenaceous shale, striped with dark grey, and having a six-inch band of hard, light grey, reddish weathering sandstone at the top, and another at the bottom	18
Greenish argillo-arenaceous shale, striped with dark grey, with occasional bands of hard, light grey sandstone, weathering reddish brown, as before	125
Greenish argillo-arenaceous shale, striped with dark grey, with thinner and finer bands of light grey sandstone	39
Greenish argillo-arenaceous shale, with dark stripes, without any bands of sandstone	70
	719
(3) Black, brittle, bituminous shales, weathering reddish and yellowish brown, and holding *Graptolithus ramosus* and *G. bicornis*, with a small *Orbicula* and *Triarthrus Becki*	16
Black bituminous and slightly arenaceous shale, not quite so brittle as the preceding, except in a few hard black bands which have *Graptolithus*	17
Black bituminous and slightly arenaceous shale, with two bands of the harder, more brittle and more bituminous character, the latter with *graptolithus*	4
Dark grey bituminous and slightly arenaceous shale, finely striped with black lines	33

	Ft.
Black brittle bituminous shale, weathering a light or yellowish-brown, without grit and holding *Graptolithus* and *Orthoceras*	7
	77
	1,114

"The first division of the above section presents the lithological characteristics of the Utica formation, and the second those of part of the Hudson River. The third so thoroughly resembles the first division that it is very difficult to distinguish them, particularly as there is a resemblance between the two in the few fossils which are met with. An additional amount of dark grey bituminous and arenaceous shales, interstratified with occasional light grey, brown-weathering sandstones, overlies the third division on the Ste. Anne, occupying the distance between the mouth of the Rivière à la Rose and the St. Lawrence."—Geology of Canada, 1863, pp. 199-200.

SUPERFICIAL DEPOSITS.

The entire area under consideration has been subject to extensive ice action, but not to so great a degree as other parts of eastern Canada, more to the northward and westward. This lack of energy in the glacial force may be in part due to the amelioration of climate caused by the proximity of the sea, and in part to the limited extent of southern incline from the high coast range between the St. Lawrence valley and the lower, less mountainous country of the northern interior. This range of highlands has to a considerable extent impeded the movement of the great interior ice cap, and used up a great part of its energy before it reached the St. Lawrence slope; so that, although the entire surface of the high region south of Lake St. John appears to have been glaciated, the evidence of intense ice action is not so marked as in the lower country to the north of that lake. There the deeply denuded and highly grooved surfaces of the gneiss, show that an immense flow of ice passed down from the interior plateau, in a remarkably straight course over all obstructions, in a direction of S. 5° W., with no variation on either side exceeding 10°.

Causes of modified ice action.

This ice flow crossed the valley of Lake St. John, at an elevation of three hundred and fifty feet above the sea, and, in part, pushed up over the higher country south of the lake, carrying with it boulders of Trenton limestone, from deposits in that basin, to an elevation of

Probable source of ice.

eleven hundred feet above the position of its present highest bed and to a distance of twenty miles from its present nearest exposure.

It farther probably passed over the summit between the waters of the Saguenay and those of the St. Lawrence, at a general elevation of fifteen hundred feet above sea level, and thence descended to the St. Lawrence.

As the difference in elevation between the valley of Lake St. John and the general level of the southern summit is fully eleven hundred and fifty feet, it will be seen that an immense mass of ice must have existed to give the pressure necessary to overcome such a rise, and in all probability this energy was largely used up in overcoming this obstacle, for we find, from the glacial striæ on the southern slopes of the summit, that the glacier followed and had its direction modified by the valleys of that slope, while any obstacle of magnitude caused the ice stream to turn from its direct course, in marked contrast to its action north of Lake St. John, where no obstruction appears to have had the power to more than slightly divert it from a uniform course.

Lack of energy of ice flow.

The area included in this report shows this modified action ; the glacial striæ are here found to conform in direction with the courses of the river valleys, and the slopes of the higher isolated hills to the south. These striæ may have been the latest formed, and may have worn away older sets, which may have shown a more uniform direction for the ice flow at the period of maximum glacial development ; evidence of more than one set of striæ have been found on the limestones, and in a few places on the gneiss, but these older striæ are too few, and are not uniform enough, to show that at an earlier time during the period of glaciation, any other motion than that recorded by the later striæ prevailed.

Divergent glacial striæ.

The following list of striæ observed in this area shows the diversity in direction of the ice movement, and nearly all of them are parallel to some valley or prominent slope, in the immediate neighbourhood of the place where they were observed.

List of Glacial Striæ.

List of glacial striæ.

Quebec and Lake St. John Railway, summit between Black River and Lake Simon	S	25	E
One-quarter of a mile east of last	S	20	E
Quebec and Lake St. John Railway, half a mile east of Lake Simon	S	28	E
Quebec and Lake St. John Railway, one mile east of Allan's mill	S	7	E

Fourth Range Bourg Louis, one mile east of Allan's mill....	S	8	W	Glacial striæ.
On hill near Ry., three-quarters of a mile east of Allan's mill	S	55	W	
West side of North Branch of the Ste. Anne River on hill, near mouth of the Mauvaise River.....	S	23	W	
West side of North Branch of Ste. Anne River, on hillside half a mile north of mouth of Mauvaise River.....	S	23	W	
West side of North Branch of Ste. Anne River, one mile north of mouth of Mauvaise River.....	S	13	W	
On road between II. and III. Range, Bourg Louis, on summit of hills south of Ste. Anne River.....	S	55	E	
On road of IV. Range, Bourg Louis, rolling country.....	S	3	W	
Quebec and Lake St. John Railway, near Bourg Louis station.	S	18	W	
Road between Fossambault and Bourg Louis, on hillside, north of Lake Sargent.....	S	33	W	
Road between Fossambault and Bourg Louis, on hill top, south of Ste. Anne River.....	S	25	W	
Road between Fossambault and Bourg Louis on hill top, north of Lake Sargent.....	S	33	W	
River Ste. Anne, two and a half miles above Talyrade River	S	15	W	
River Ste. Anne, at mouth of Talyrade River.....	S	13	W	
North Branch of Ste. Anne, near V. Range, Gosford.....	S	5	W	
North Branch of Ste. Anne, at Pointe des Fourches.....	S	12	W	
Ste. Anne River, at Jackson's fall.....	S	22	W	
Ste. Anne River, at head of Kelley's rapid.....	S	35	W	
Ste. Anne River, at foot of Kelley's rapid.....	S	30	W	
Ste. Anne River, near east line of Jacques Cartier.....	S	4	E	
Ste. Anne River, two miles below Jacko River.....	S	60	E	
Road from St. Basile towards Ford's mill, one mile from St. Basile.....			S	
Road from St. Basile towards Ford's mill, two miles north of last.....			S	
Road from St. Basile towards Ford's mill, near the river....	S	20	W	
Road on D'Auteuil line, where it bends across Jacques Cartier, north of low gneiss hills.....	S	25	W	
Road between St. Paul and St. Charles parishes, Portneuf.	S	25	W	
	S	50	W	
	S	85	W	
Road on fifth range Portneuf, two miles south of Ste. Anne River, flat country.....	S	70	W ?	
Road on fifth range of Portneuf, one-quarter mile south of last, on hill.....	S	13	W	

Glacial striæ.	Road on third range of East Grondines, flat limestone	S	7	E
	Road west of Portneuf River, Ste. Marie parish	S	12	E
		S	20	W
	Road west of Portneuf River, one-half mile north of last	S	10	E
		S	35	W
	Near Episcopal church, third range, Portneuf	S	10	W
	At forks of roads near church, third range, Portneuf			S
	Road, fourth range, near east line of Portneuf	S	8	W
	Road on east line of Portneuf, one-quarter mile south of Canadian Pacific Railway	S	17	W
	Road, third range Portneuf, near junction with road to Portneuf village	S	15	W
	Road, fourth west of Portneuf, on north of Canadian Pacific Railway			S
	At La Chevrotière quarries	S	43	E
		S	23	E
	Road from Ste. Catherine to St. Gabriel station	S	40	E
	Falls of Jacques Cartier River, south of Ste. Catherine	S	40	E
	Road on fourth range of Fossambault	S	50	E
	Road south from Ste. Catherine, near road between fifth and fourth ranges west of Bonhomme Mountain	N	85	W
	On road between sixth and fifth ranges Fossambault, west of Bonhomme Mountain			W
	On road south from Ste. Catherine, in front of fourth range west of Bonhomme Mountain	N	80	W
		N	70	W
	On road second range Fossambault, south-west of Bonhomme Mountain	S	47	E
	On line between Fossambault and Des Maures, south of Bonhomme Mountain	S	45	E
	Lake St. Joseph, opposite mouth of Rivière aux Pins	S	23	W
	Lake St. Joseph, at East Point	S	20	E
	Jacques Cartier River, three miles above Ste. Jeanne de Neuville	S	5	W
	Quebec and Lake St. John Railway, at Belanger's siding	S	15	E
	Quebec and Lake St. John Railway, one-quarter mile west of Belanger's siding	S	15	E
	Quebec and Lake St. John Railway, east of Lake Sargent	S	30	E
	Quebec and Lake St. John Railway, one mile east of Portneuf River	S	15	W
	Quebec and Lake St. John Railway, one-quarter mile east of Portneuf River	S	35	W

	°		Glacial striæ.
Quebec and Lake St. John Railway, 300 yards east of Lake St. Joseph station	S	30 W	
On hill, east of Valcartier	S	70 E	
	S	60 E	
On hillside, Jacques Cartier River, near east line of St. Ignace	S	80 E	
On hillside, Jacques Cartier River, one-half mile beyond last.	S	45 E	
Road on west side of Jacques Cartier River, above Valcartier bridge on lower hillside	S	70 E	
On same road as last, on mid-hill	S	72 E	
	S	45 E	
On same road as last, on mountain summit	S	45 E	
On same road as last, on mountain between the Jacques Cartier and Rivière aux Pins	S	45 E	
Same as last, on summit of mountain	S	75 E	
On road up east side of Jacques Cartier River, at west line of Stoneham	S	85 E	
On same road as last, at line between Stoneham and Tewkesbury	S	63 E	
On Stoneham Road, north of fifth range	S	55 E	
On Stoneham Road, in fourth range	S	75 E	
On Tewkesbury Road, second range, near south forks of roads.	S	75 E	
On upper road from Stoneham to Jacques Cartier River, in second range of Stoneham	S	55 W	
On the same road as last, in III. range of Stoneham	S	67 W	
On road from Stoneham to Charlesbourg at south line of Stoneham	S	60 W	
On same road as last, two miles south of last	S	53 W	
On same road as last, one mile south of last	S	53 W	
On same road as last, along the face of Archæan escarpment	S	55 W	
On north-east flank of mountain, on road from Valcartier to Lorette	S	35 W	
	S	50 W	
On hill immediately north of Lorette	S	50 W	
On hill north of road from Lorette to Charlesbourg	S	60 W	
On road north-east of Lake St. Charles, near bridge over River Hurons	S	15 E	
On road from Charlesbourg to Lake Beauport, where it descends to valley of River Jaune	S	75 E	
On same road, 100 yards up River Jaune	S	70 E	
	S	50 E	
On north side of Lake Beauport	S	55 E	

Glacial striæ.

On road on west side of Montmorency River, quarter mile above Beauport road ..... S 45 W
On same road, two miles above the Bras, high on hillside... S 20 E
On road up west side of the Bras..... S 75 W

Till.

Extent of distribution.

Till is found everywhere throughout the Archæan area, covering to a greater or less thickness the rounded hills; and only in the valleys of the rivers and their tributaries, is it removed or concealed by later stratified deposits of sands, gravels and clays of fluviatile origin.

On the lower levels of the Archæan spurs to the southward, the presence of drift is nearly always noticeable, even below the level of the later stratified deposits of marine sands and clays.

Absence of thick deposits on lower area.

On the still lower margin of Palæozoic rocks along the St. Lawrence thin deposits of coarse grey sand, with numerous large boulders, are often seen resting on the underlying rock; these are probably the remains of large masses of till which have first been deposited on the bare rocks, and then washed away by the strong current down the wide valley of the St. Lawrence during the subsequent subsidence, only the large boulders with small patches of coarse sand and gravel escaping from the transporting action of the waters. On this southern margin the only thick deposits of till are seen in the ancient river mouths, those of Portneuf and Jacques Cartier are most noticeable; the mouths of these streams in pre-glacial times were much wider than now; at present they discharge into the St. Lawrence through narrow valleys, cut out between the till and shales on the western side of the ancient valleys, while the remainder of these ancient valleys is blocked up with till. In the Jacques Cartier River the till extends eastward from the present mouth to the shale cliff, a distance of one mile, and the deposit presents a bold escarpment in height equal to that of the shale. The extent of the till deposit in the ancient mouth of the Portneuf River cannot be so well defined, as it is overlaid by deposits of stratified sands, but the shale cliff does not come out on the St. Lawrence for two miles from the present mouth.

Deposits in ancient river valleys.

Boulders.

All inequalities and ancient watercourses cut into the cliff of limestone or shale along the St. Lawrence have been filled with coarse till, while large boulders are plentiful along the top and face of the escarpment and on the beach below, where they are chiefly found on the points and in lines across the small bays from point to point, having been arranged in this manner by floating ice on the tidal waters of the St. Lawrence.

The scattered boulders resting on the limestones and shales appear, in places, to be roughly arranged in lines, and are probably the remains of lateral moraines; a striking example of this arrangement is the one on which the village of Deschambault is situated. This band of boulders can be traced from the foot of the Archæan spur, across the road running north from the village, and culminates on the river front in a prominent point which rises seventy feet above the water and extends backward behind the village over a-quarter of a mile. This hill is almost wholly made up of large boulders of gneiss, from which many of the houses of the village are constructed. Moraines.

At the Grondines lighthouse another band comes out on the St. Lawrence, and can be traced northward to beyond the railway in the third range, where a huge boulder of gneiss, ten by ten, by fifteen feet, is seen resting on the bare limestone immediately south of the track.

On the east side of the Portneuf River, between St. Basile and Cap Santé, boulders are again numerous without signs of being laid down in bands, but are loosely scattered about in sandy drift. West of Pointe aux Trembles spur, boulders are seen in a similar condition; and again on the plain of the St. Charles River, south of the Archæan escarpment at Lorette; on the west side of the river the boulders are most plentiful, and lie roughly in bands, one band running south parallel to the old line of the Quebec and Lake St. John railway.

The composition of the till varies as to the amount of sand and clay which go to form its finer parts, but the former generally predominates.

On the higher portions of the Archæan area the smaller material of the till has a sub-angular character, showing that it has not been subjected to any great friction, and consequently that it is not far travelled; the inclosed boulders also bear out this fact, the majority coming from rocks of the immediate vicinity, while the far-travelled ones do not make one per cent of the whole. Character and composition of till.

On the lower levels about the southern face of the Archæan, the drift as a whole is much more rounded and worn.

Kames.

The almost unbroken forest which covers the northern area, where the till is most highly developed, and the absence of similar deposits in the more settled southern country makes it impossible to enter into a detailed study of structure in the till, except in the larger river valleys.

In the Ste. Anne de la Pérade River valley, that portion east of Ford's Fall, and southward to the vicinity of the Island bridge, has an Kames of Ste. Anne River valley.

uneven surface, which forms a succession of low rounded hills arranged with their longer axes parallel to the valley. These hills are made up partly of till and partly of stratified, coarse, yellow sands, and their lower portions were probably formed under the valley glacier, while the upper parts are largely made up of stratified sands of post-glacial age, as they are below the level of subsidence, and they have been subsequently modified by the cutting action of the river, so that they cannot be termed wholly glacial kames in the strict sense of the term.

Jacques Cartier River valley kames.

On the Jacques Cartier River, at the Quebec and Lake St. John Railway bridge, and for some two miles below, similar rounded sandy hills are seen; these, where cut for ballast pits, show a composition of coarse sand and small gravel, with numerous large boulders, not well stratified, and evidently only modified till, laid down under the glacier of the Jacques Cartier valley. These low hills extend along the west side of the river, and separate it from a large peat swamp which extends from these hills to the foot of the Archæan mountains of St. Gabriel. The area of the swamp is over ten square miles.

Montmorency River.

The kames along the west bank of the Montmorency River, above the lower road to Lake Beauport, are similar to those of the Ste. Anne, and probably owe their origin more to river than to glacial action.

Stratified Deposits.

Extent of subsidence.

At the close of the period of glaciation a period of marked depression occurred, the land sinking to at least six hundred feet below its present elevation, as shown by the stratified deposits of marine clays and sands which now overlie the till up to that elevation.

During this period of submergence the sea extended inland up the valleys of the rivers tributary to the St. Lawrence, forming wide, deep estuaries in which thick deposits of sand and clay were laid down.

Cause of absence of stratified deposits along the St. Lawrence.

Only along the margin of the Archæan highlands, and in a few isolated patches protected from the river currents, are similar deposits seen on the lower lands facing the St. Lawrence, showing that the force of the currents in that stream during the period of subsidence was sufficient to carry away any clay or sand brought down by its tributaries, and so prevented the formation of thick stratified deposits similar to those found in the wide mouths of the smaller streams. These strong currents of the St. Lawrence were probably only local, and were caused by the contraction of the great river between the highlands north and south of the area under consideration; as to the westward, where the old valley broadens, extensive deposits of clay and sand are found laid down in the valley, in marked contrast to the

Such deposits elsewhere.

low lands of this portion, where the surface covering of the limestones and shales is very thin, and often of clay formed from the direct disintegration of the under-lying shales, sometimes of the remains of till patches, and seldom of stratified clay and sand.

Two groups of deposits.

These stratified deposits are easily divided into two groups; the first laid down in tidal waters in the estuaries of the rivers below the ancient sea level; the second in the upper valleys of the rivers and their tributary streams. The former are made up altogether of clay laid down beneath sand; the latter chiefly of interstratified sands and gravels, with few beds of clay.

Marine terraces with fossils.

The limit and extent of the subsidence is marked by the terraces seen along the flanks of the Archæan highlands; and their marine origin is proved by the presence of fossil marine shells in some of the beds. These shells do not appear to have existed any great distance up the estuaries. Their highest limit in the Ste. Anne valley is near where the west line of Portneuf seigniory crosses the river, between the junction of the Archæan and Trenton, at an elevation of one hundred and fifty feet above sea level. Although the fossils are not found beyond this point, the clays and sands have undoubtedly the same origin to beyond the forks with the North Branch at St. Raymond. Proceeding eastward, the next locality where Post-pliocene shells were found is on the banks of Belisle River, where it crosses in the third range, the second road running back from the St. Lawrence west of Portneuf, and in rear of the higher part of the Deschambault spur, with an elevation of three hundred and ten feet. Fossils are abundant in the thin sandy clay resting on till, at the first rise of the road immediately west of Portneuf, and are also found on the banks of the Rivière aux Pommes, where the road from Pointe aux Trembles to the White bridge crosses it; here the elevation above sea level is one hundred and seventy-five feet.

Highest level of fossils.

The next locality is important as it is the highest level at which these fossils have been found in the vicinity of Quebec, and one of the highest in eastern Canada. It is in a cutting immediately north of St. Ambroise station on the old line of the Quebec and Lake St. John railway. Here a thin deposit of stratified clay rests upon hummocks of till, the thickness of the clay beds varies from five to ten feet, and they are overlaid by stratified coarse yellow sand. In the highest bed of the clay *Saxicava rugosa* is found. The fossil bed does not exceed eighteen inches in thickness. The altitude of these deposits, from the railway profiles, is five hundred and fifteen feet above high tide level at Quebec.

On the summit of the road from Beauport to Bourg Royal a thin deposit of arenaceous clay, resting on the shales, holds fossils at an elevation of two hundred and sixty-five feet. On the Beauport River, in the gulley behind the old mill, thin beds of stratified sands and gravel overlying a thin bed of sand which rests on till, hold a great number of species especially in the lowest sand bed.

Numerous fossils.

To the eastward of the Montmorency River the margin between the Archæan highlands and the shore of the St. Lawrence is very narrow and terraces everywhere flank the high hills. The lower ones rest on the plateau of the Cambro-Silurian rocks which rises a short distance behind high water mark and extends inland rising by a succession of terraces as the higher hills are approached.

Terraces of this description are met with crossing the roads leading up the valleys of the Sault à la Puce, Chiens and Ste. Anne rivers. From the mouth of the Ste. Anne River to the foot of Mount Ste. Anne nine terraces are passed on the road to St. Féréol having respectively elevations of fifteen, twenty, twenty-six, one hundred and fifty, one hundred and eighty-five, two hundred and fifty, three hundred and ten, three hundred and fifty-five and five hundred and seventy-five feet above sea level.

Terraces.

On the road back from Ste. Anne church, Post-pliocene shells were found at the foot of a terrace two miles and a half inland, and three hundred and eighty-five feet above the present sea level.

The following species of Post-pliocene fossils have been determined by Sir J. W. Dawson, from the vicinity of Quebec, the greater number coming from the Beauport locality :—

List of Post-pliocene Fossils. *

Lagena sulcata (var. distoma).
" " *(var. semisulcata).*
Entosolenia globosa.
" *costata.*
" *marginata.*
" *squamosa.*
Bulimina Presli.
" *(var. squamosa).*
Pulvinulina repanda.
Polystomella crispa (var. Striatopunctata).
" " *(var. Arctica).*

* Sir J. W. Dawson, "Canadian Naturalist," New series, vol. VI., 1871, pages 254-256, 370-470.

Nonionina scapha.
" " (*var. Labradorica.*)
Textularia pygmœxa.
Quinqueloculina seminulum.
Biloculina ringens.
Triloculina tricarinata.
Strongylocentrotus Drobachiensis, Müller.
Hippothœa axtenularia, Jameson.
" *expansa*, Dawson.
Tubulipora flabellaris. Johnston.
Lepralia hyalina, Johnston.
" *pertusa*, Johnston.
Rhynchonella psittacea, Gm.
Saxicava rugosa, Linn.
Mya truncata, Linn.
" *arenaria*, Linn.
Macoma Grœnlandiça.
Macoma calcarea, Chemnitz.
Astarte Laurentiana, Lyell.
" *Bánksii*, Leach.
Serripes Grœnlandicus, Chemnitz.
Mytilus edulis, Linn.
Modiolaria discors, Leach.
Leda (Potlandia) glacialis, Grey ; *L. truncato*, Brown.
Pecten Islandicus, Chemnitz.
Puncturella (Cemoria) Noachina, Linn.
Lepeta cœca, Möller.
Bela harpularia, Couthuoy.
Natica affinis, Gmelin. (*Natica clausa*, Brod. and Sowerby.)
Lunatsia heros, Say.
" *Grœnlandica*, Beck.
Velutina zonata, Gould.
Scalaria Grœnlandica, Perry.
Acirsa Eschrichtii, Holboll.
Chrysodomus tornatus, Gould.
Spirorbiis vitrea, Fabricus.
Balanus Hameri, Ascanius.
" *porcatus*, DaCosta.
" *crenatus*, Brug.

The elevation of six hundred feet to which the highest beds of sand of undoubted marine origin were deposited, must not be taken as the

Thickness of stratified deposits.

thickness of these deposits, as they were laid down on the irregular sloping surface of the ancient sea bottom, and at present nowhere exceed two hundred feet in any section, while seventy-five of sand and one hundred feet of clay would probably cover the thickness of the greatest deposit in any single place throughout this area.

Marine Terraces.

Level of highest terraces.

The elevation of the highest terraces, with their cut faces towards the lower open country of the St. Lawrence, is more than six hundred feet above the present sea level.

Terraces from St. Raymond south to the St. Lawrence.

On the east side of the Ste. Anne River, south of St. Raymond, is a generally level drift plain, extending southward through Bourg Louis and St. Basile to the St. Lawrence. This plain is broken into a succession of terraces, and separated by a number of sharp rises which all face toward the open country, and are only slightly modified by the small local river valleys. The highest of these terraces is immediately behind St. Raymond, where the land rises in two river terraces of ten and one hundred and twenty feet to the plain above, at an elevation of five hundred and eighty feet above sea level. From here the surface is nearly level on the road to Bourg Louis for one mile, where it descends sharply over two small terraces, each twenty feet below the last. The cut faces of these terraces, composed of coarse yellow sand, can be traced from the base of the gneiss hills on the road between St. Raymond and Bourg Louis station, westward across the Bourg Louis road and then along the north side of the road to Jackson's mill, where they are lost in the river terraces. Below these, the next sandy terrace extends from the foot of the gneiss hills near Lake Sargent, westward towards the Ste. Anne River, its cut face crossing the Bourg Louis road to the south of the Episcopal church and passing south-west, touches the road from St. Basile to Ford's Fall, one mile south of the Ste. Anne River, where it passes into the kame structure before described.

Portneuf River valley.

From the foot of this terrace, three hundred and fifty feet above the sea, the country passes downward to the valley of the Portneuf River near St. Basile, by four narrow terraces, having faces of thirty, sixty-three, twenty-seven, and thirty-five feet front elevation ; the soil is stratified greyish-blue clay overlaid by thin beds of dark yellow ferruginous sand.

West side of Ste. Anne River.

The Ste. Anne River valley is cut deep into similar deposits of clay and sand, along the base of the crystalline rocks on its west side ; and between it and the hills of the Deschambault spur, the land slopes away from the Ste. Anne with distinct terraces towards the open St. Lawrence valley.

These terrace faces are well developed on the road from La Chevrotière to St. Alban and thence along the road on the east side of the Ste. Anne River to the Island bridge. To the west of Deschambault, the first rise along the St. Lawrence margin is at a distance varying from one to six hundred yards from the present shore line. This rise, where the limestone cliff is not present, is generally low and nowhere exceeds fifty feet in elevation; it is followed by slowly rising ground, underlaid by limestone without a sufficient covering of surface material to produce marked terraces; this continues until the swampy land of the fourth range (elevation one hundred feet) is passed, when sandy terraces are met with roughly facing the St. Lawrence, and rising towards the Ste. Anne River.

Low lands along St. Lawrence.

Absence of drift.

The first of these commences near the Ste. Anne, one mile and a half south of St. Alban bridge, and has a rise of sixty feet. It crosses the St. Alban road one mile and a half to the north of the quarries, and the La Chevrotière River in the middle of the third range; it then turns south-west, crosses the range road and is lost against the gneiss hills, along the west side of Belisle River.

The next terrace behind has a rise of twenty-eight feet; its face crosses the road along the east side of the Ste. Anne, three-quarters of a mile to the north of the St. Alban road, whence it sweeps around the swampy land at the head of the La Chevrotière River, and crosses the fourth range road a short distance to the east of the river, and then runs south between the hills and Belisle River to near the second range.

Terraces in Ste. Anne River valley facing St. Lawrence.

Beyond this terrace on the Ste. Anne road the rise is gradual, from one hundred and ninety to two hundred and fifty feet, to where it joins the fifth range road of Portneuf; here a rise of thirty-five feet is made to a flat sandy terrace, and soon followed by another thirty feet higher; these skirt the Archæan hills between the Ste. Anne River and Deschambault; they are met with in their southern course crossing the third and fourth ranges to the east of the road running north from Deschambault station, and die out to the north of the third range road.

These terraces are followed to the north of the hummocky country, between the Island bridge and Ford's fall by the higher terraces before described, which reach to near St. Raymond.

The Archæan hills cross from the North Branch to the Ste. Anne River, about five miles above the junction of these streams, and with them form a narrow triangle of stratified drift-covered land, with the base three miles in length, along the foot of the hills. This triangle forms a high plain, with terraced faces towards the rivers, and with the exception of a narrow ridge along the Ste. Anne face, the general level is 635 feet above the sea; the surface soil is a coarse yellow sand.

Terraces between Ste. Anne River and the North Branch.

The higher ridge referred to has a breadth of one-quarter of a mile in the widest part, where the road up the North Branch crosses it, and extends along the margin of the Ste. Anne escarpment, terminating in a round hill behind St. Raymond. This ridge is quite flat on top and has cut faces on either side, rising thirty-five feet above the general plain, and evidently laid down as a narrow point between the mouths of the rivers. Its elevation, six hundred and seventy feet above sea level, is the highest at which stratified estuarine deposits have been noted in this region.

Highest estuarine deposit.

Terraces facing Ste. Anne River.

In descending from this ridge towards the Ste. Anne River, the first drop of thirty-five feet is followed almost immediately by another of fifteen feet, to a narrow terrace, from which a steep descent of one hundred and twenty feet brings the road to the level of the river valley, only a few feet above the stream. In the last descent the cut face shows the upper twenty-five feet to be sand and the remainder grey clay.

These two principal terraces are seen facing the North Branch in a similar manner, beyond the low lands, which extend from the point of the forks one mile up both streams.

Terraces on west side of North Branch

On the west side of the North Branch and of the Ste. Anne River south of the forks, similar terraces are met with. On the road from St. Raymond, crossing the North Branch at the black bridge, a low swampy clay flat, ten feet above the river bed, is passed over to the first rise of sixty-five feet, half a mile from the river. The section of the cut face here gives, in ascending order, thirty-five feet of stratified clay, fifteen feet coarse grey sand, ten feet yellow sand, eighteen inches fine gravel, eighteen inches yellow sand, and two feet of fine gravel on top.

Section of stratified deposits.

From the top of this rise the road passes backward three-quarters of a mile over a sandy and generally swampy country to the second rise, of eighty feet. This terrace is composed of yellow sand, and its top is six hundred and ten feet above sea level. Behind this the country gradually rises to the gneiss hills, and the evidence of cut terraced faces at a higher level than the last are wanting.

The face of this upper terrace can be traced from the high lands north of the railway on the road along the west side of the Ste. Anne to the rocky hill at the junction of the Mauvaise River with the North Branch.

Terraces on west of Ste. Anne River.

To the south as far as the island bridge on the west side of the Ste. Anne, and between it and the Archæan hills, terraces closely corresponding in height to those of the more open country on the east side

of the river, flank the hills and face diagonally towards the river valley. The elevation above sea level of the principal terraces on the west side are as follows: 556 feet, 515 feet, 480 feet, 420 feet, 410 feet and 365 feet.

Between Deschambault village and the Portneuf River two marked terraces, cut out of the boulder till, along the foot of the Archæan hills, are crossed by the roads running back from the St. Lawrence. On the road to the Deschambault station the first rise is three-quarters of a mile behind the river road, and the difference in elevation between its foot and top is eighty-five feet; the second rise, of thirty feet, is at the crossing of the second range road. Terraces cut out of till.

On the road one mile west of Portneuf the first rise from the St. Lawrence, of forty-six feet, occurs 350 yards behind the river road. Here the face is composed of boulder drift with thin patches of sandy clay resting on it and holding *Leda truncata*. Beyond this the road rises gradually to the foot of the gneiss hills. Portneuf River Valley.

The road from Portneuf village to the railway station first passes over a clay terrace forty feet above the river, then as the station is approached two other terraces of one hundred and ten feet, and one hundred and fifty-five feet elevation, the lower having a sandy clay face, the upper composed of sand.

Similar terraces are met with on the west side of the Portneuf River and its tributary the Claude, extending to the base of the low hills which cross to the eastward behind St. Basile.

Along the St. Lawrence to the east of the Portneuf River the cliff is composed of till for two miles, and its face is roughly terraced, but not markedly so, except along the side towards the mouth of the Portneuf; here on the road to St. Basile station are terraces of twenty, forty-five, sixty-two, one hundred and thirty, one hundred and fifty-five, and two hundred feet, the last two being inland from the river and front towards the Portneuf valley. The cliff on the road which descends to the St. Lawrence one mile and a half to the east of the last, has an elevation of one hundred and seventy-five feet with a gentle rise behind to the summit of the land facing the Portneuf valley. St. Lawrence, east of Portneuf.

To the eastward the lower part of the escarpment of till is gradually replaced by a cliff of shale which comes out on the river front and is ninety feet high at Cap Santé while the terrace of till behind is eighty-five feet higher; farther on towards the mouth of the Jacques Cartier River the two combine and present a bold cliff one hundred and eighty feet high.

Behind this region the drift is thin without marked terraces until the Canadian Pacific railway is crossed, when a sandy terrace rises Absence of terraces.

sixty-five feet from the lower clay plain of the Portneuf valley, this has an elevation on top of three hundred and twenty feet above sea level. It was traced from the east side of the Portneuf River, near its abrupt bend to the westward in the parish of St. Charles, southward parallel to the Terrebonne road, to the junction of that road with the one to St. Basile station, thence continuing southward to near Ste. Jeanne de Neuville station, where it turns northward forming a sharp point, and again crosses the St. Basile road, and sweeps round to the eastward crosses the Ste. Catherine road one-half mile to the east, and continues as a river terrace up the west side of the Jacques Cartier River. A second small terrace of twenty feet higher is passed over on the roads between the Jacques Cartier and Portneuf rivers, with cut banks facing in both directions.

Jacques Cartier Rivey valley.

Terraces on west side of Jacques Cartier River.

On the road to Ste. Catherine along the west bank of the Jacques Cartier several terraces cross the road obliquely, extending from the base of the gneiss hills, which lie to the west of the road, in a diagonal course to the Jacques Cartier River, and although laid down in the wide valley of that stream are evidently of marine origin and distinct from local river terraces. Here the next rise of thirty-five feet is passed one-quarter of a mile beyond the last, and is followed one mile farther on by another of forty-six feet with one of forty-five feet half a mile beyond the last, after this the country rises gradually to an elevation of five hundred and fifty feet near the road to Lake Sargent, on which at the rear of the fourth range of Fossambault a final terrace of thirty feet occurs along the base of the gneiss hills, which are covered by unstratified till above this level.

Continuing along the Ste. Catherine road, it has an abrupt fall of one hundred and thirty feet, where it descends to the valley at the mouth of the Rivière aux Pins, where the cut face shows a thickness of one hundred feet of grey clay overlaid by thirty feet of stratified yellow sand.

Terracesabout St. Gabriel.

On crossing this valley the road again rises to the level of the flat plain about Ste. Catherine station, where a short distance to the eastward the terrace divides into two, the upper being about thirty feet above the lower, and skirts along the base of the rocky hills on the north side of the great swamp extending to near St. Gabriel station.

Eastward from that place a wide sandy plain extends from the hills on the north to near the banks of the Jacques Cartier. This plain has an elevation of six hundred and five feet above sea level, and is flanked on its south side by a terrace of clay fifty feet below it and twenty feet above the river. The upper terrace may be traced to the bridge at Valcartier, above which it becomes very narrow and is soon

lost on the rocky hill side which here encroaches on the river. The lower terrace is somewhat wider, and continues up the river valley above the bridge, its clay being gradually replaced by sand and gravel of river origin.

East side of Jacques Cartier River.

On the east side of the river, terraces corresponding to those already mentioned, are noticeable. The lower clay terrace forms a large swamp which extends from the river margin to the foot of the second rise.

The road from Valcartier bridge to Lorette rises over escarpments of twenty-five, thirty-five, and ten feet in the first mile from the river to a sandy plain six hundred and five feet above sea level, which stretches southward between rocky hills until cut off by the high lands north of Lorette.

Valcartier plain.

The road from Valcartier to St. Ambroise first runs three-quarters of a mile over this plain and then crosses a boulder-strewn hill over one hundred feet higher, and descends again to the plain one mile further on. The descent on the west side first reaches a narrow terrace of sand at six hundred feet elevation, and then two others ten and fifteen feet lower, the latter extending to within one mile of Valcartier station where it drops by three steps of ten, twenty and ten feet to the flat sandy plain between the Bonhomme Mountain and the hills to the west of the Nelson River, which extends southward to the edge of the Archæan rocks at St. Ambroise, where it drops abruptly over the shales, which have only a thin covering of drift.

Western limit.

From the head of the St. Ambroise rise to the Jacques Cartier River at the Quebec and Lake St. John railway crossing, the rise is only thirty feet. The western limit of the plain skirts the foot of Bonhomme Mountain and crosses the road south from Ste. Catherine in the rear of the fourth range of Fossambault; its northern limit extends to within half a mile of the Jacques Cartier, descending to that stream by escarpments of seventy-five, twenty and ten feet. From the southern limit of the plain the road rises abruptly thirty feet, to a swampy plain which extends to the foot of the mountain in the third range, where a small brook has cut forty feet into the deposits, and shows ten feet of yellow sand overlying stratified greyish-blue clay. Just beyond the brook the highest terrace is seen on the flank of the mountain, at an elevation of six hundred and thirty-five feet, the road beyond as it rises over the mountain passes over unstratified till.

Section of stratified deposit.

Between Ste. Catherine and Ste. Jeanne de Neuville the rocky hills on the east side of the Jacques Cartier River lie close to the water, leaving only a narrow fringe of stratified sands and clays, with narrow and less marked terraces than on the opposite side.

Absence of drift.

As before stated, little drift material is left on the lower country south of the Archæan area, and the remains of terraces in that portion of the country east of the Jacques Cartier River are so often broken and indistinct that it is impossible to trace them in detail. East and north of St. Ambroise to the valley of the Montmorency River, the country is rough, with only a small proportion open to the St. Lawrence below the level of six hundred feet, and consequently the marine deposits are only slightly developed, as in the valley of the St. Charles River, where stratified clays overlaid by sand are found cut into terraces up to Lake St. Charles, where the highest one noted is five hundred and forty feet above sea level.

Montmorency River valley.

The road up the west side of the Montmorency River passes over flat beds of limestone, generally covered with soil, from a few inches to a few feet thick, to the middle of the first range where the road rises slowly over thirty feet of yellow sand to a terrace of that material at the second range, three hundred and fifty feet above the sea. The face of this terrace again crosses the second range road one-quarter of a mile west of the Laval road, and is lost in the driftless area to the westward.

Passing northward a terrace of forty feet is crossed before the third range is reached, where two hundred yards beyond the road climbs the steep face of a sandy terrace one hundred and forty-five feet above the last; this is immediately followed by another rise of thirty-five feet to a flat, sandy plain, which extends from the rocky hills to the west, to the edge of the river valley. This plain is five hundred and seventy-five feet above the sea, and continues northward two miles, with a few small rocky knolls covered with till projecting from it. Beyond this the high rocky hills encroach from the westward, causing the plain to gradually narrow, while the knolls are more frequent until the road crosses a small brook, when its elevation varies from five hundred and eighty to seven hundred and fifteen feet, as it passes over sandy till to a second brook half a mile beyond; this brook is crossed at an elevation of six hundred feet, and its cut banks are made up of stratified coarse sand and fine gravel, which is probably of local fluviatile origin.

Beyond this the road descends to the river valley, which it now follows closely; at its junction with the lower Lake Beauport road, the river is five hundred feet above the St. Lawrence, so that although beyond this point terraces line either bank, they have probably been laid down by running waters in the old river valley, and mark flood levels rather than old sea shore lines; their composition of sands and gravels point to the same origin, and as such they will be considered later on.

River Terraces.

Above the level of the highest marine deposits along the valleys of the rivers and their tributary streams, stratified sands and gravels have been deposited and then cut into terraces facing the water. These deposits hold a great quantity of coarse material, showing that, unlike the marine beds, they have been laid down by waters having a sufficient current to transport coarse sand and gravels from their original sources and deposit them in stratified order as at present found. Composition of deposits.

These deposits are only seen along the upper portions of the water-courses in the northern part of the area included in the map, and as these are only partly cleared it is impossible to follow them with accuracy, and at times to see them at all except along the larger streams.

Along the River Ste. Anne gravel interbedded with sand and clay is first seen a short distance above St. Raymond, the number and thickness of these beds increase as the river is ascended until, at about five miles up, the clays are entirely replaced by coarse sand and gravel. On the road to Lake Sept Iles, where it rises from the river valley, these deposits reach to a height of ninety feet above the present water level, while on the north side of the stream a short distance above, six distinct terraces are seen, the highest being 120 feet above the river. Beyond this to the Talyrade River terraces continue to flank the rocky hills on the north side, two or three being generally distinguishable, of which the highest rarely reaches seventy-five feet. From here to the east line of Gosford the terraces become less marked and are small and local. Ste. Anne River.

In the Jacques Cartier River valley similar terraces are seen above Valcartier bridge; they flank the gneiss hills on either side, but the highest never exceeds 100 feet above the water level. On the whole they are more marked and higher than those of the Ste. Anne valley; this is probably due to the narrowness of the valley, which would cause the waters to rise to higher levels during periods of flood. Jacques Cartier River.

In the Montmorency valley these terraces are especially noticeable on the point between the Bras and the main stream, where well marked terraces in stratified sand and gravel rise 120 feet above the water. On the sides of the smaller streams these deposits are seldom more than fifty feet thick, while about the shores of the various lakes similar sand and gravel deposits show that their ancient shore lines were considerably higher than at present. About Lake Beauport the terrace faces rise in places fifty feet above the present level, while at Lake Simon the stratified deposits are found from twenty-five to thirty feet above the lake. Montmorency River. Lakes Beauport and Simon.

Probable origin.

These deposits of stratified sand and gravel, in the river valleys, show that at certain times their waters rose to the level of the highest bed. This rise was probably caused by freshets from the rapid melting of ice during the close of the glacial period, and was, probably greatly augmented by dams of drift and ice, which formed temporary barriers that caused the rapid flow of water to deposit the sand and gravel at the high levels where they are at present found.

Swamps.

Iron ore and ochre.

Valuable deposits of bog iron ore and ochre are found in the extensive swamps and small lakes in the district about the St. Maurice River a short distance west of the area under consideration, and as the conditions are the same no doubt similar deposits occur in the swamps of the Ste. Anne and Jacques Cartier basins. In the third range of East and West Grondines between the higher terraces of the Ste. Anne and the limestone of the second range, is a shallow swamp of considerable extent. An extension of this swamp passes north-east through the fourth range of La Tesserie and La Chevrotière, where near the headwaters of the La Chevrotière River, it is over one mile wide and is terminated in that direction by the sandy terraces crossing from the Ste. Anne River to Deschambault. On the west side of the Ste. Anne a peaty swamp occupies the greater part of Bourg Louis south of the railway and between the river and the Jacko Branch, where it rests upon the stratified clay, and is probably rich in iron ore as the sands of the surrounding district are strongly impregnated with the peroxide, and often hold lenticular beds of the same resting on the underlying clay or interbanded with the sand. No other extensive swamps occur in the Ste. Anne basin, but all the small depressions among the Archæan hills are either occupied by small lakes or swamps. In the basin of the Jacques Cartier the swamps are more extensive, the largest is that extending from the borders of the river to the gneiss hills between Ste. Catherine and St. Gabriel stations. The line of the Quebec and Lake St. John railway passes through it and the deep ditches along the line cut out of peat show that considerable decayed vegetable matter overlies the sands and clay below. The surface of this swamp is broken by a number of small ponds, while its solid parts are covered with a thin growth of small black spruce.

East and West Grondines.

Bourg Louis.

St. Gabriel.

South of Ste. Catherine.

South of Ste. Catherine along the base of the Bonhomme Mountain swampy land occupies the greater part of the fourth range of Fossambault. The bottom lands on either side of Valcartier bridge are very low and swampy and unfit for cultivation. Much of the land along the Portneuf River to the east of St. Basile is low and swampy, the

water lodging on the tough impenetrable clay, but with a small expenditure on drainage the greater part of this land might be reclaimed.

On the road between Cap Santé and L'Enfant Jésus, there is a great bog with a breadth of half a mile. In the Grand Bois, on the west side of the Jacques Cartier River, swampy land extends for a distance of six miles, but is never very wide. Another swamp of considerable size lies to the east of Ste. Jeanne de Neuville ; the Canadian Pacific railway runs through the southern part of it ; this swamp extends eastward to the gneiss hills at the head of the River aux Pommes. Behind the rocky hills of Lorette and between the Quebec and Lake St. John railway and the St. Charles River, is another area of swampy land, which extends a couple of miles northward along the Nelson River. Other small areas of swamp are met with to the north and east of Lorette, between the Archæan hills. Jacques Cartier River.

ECONOMIC MINERALS.

With the exception of bog iron ore, ochre, building stones, brick clays and infusorial earth, no minerals of economic value are met with in the southern portions of the counties of Portneuf, Quebec and Montmorency.

Iron Ores.—Although grains and small patches of magnetite are common in the gneisses of this region, no deposit sufficiently large to be successfully worked is known. In the parishes of St. Charles, St. Paul and St. Eustache of the seigniory of Portneuf magnetite occurs freely scattered through the gneiss in grains varying from one-twelfth to one-half an inch in diameter. Large masses are found in the rocks of the mountain near the head of the Rivière aux Pins. Iron ores.

Ilmenite, as before stated, appears to be a constituent mineral of the anorthosite rocks, in the rear of Château Richer, where besides being minutely distributed through the rocks, it is found in segregated masses up to four or five inches long and over an inch thick. According to Dr. T. Sterry Hunt, this ore forms one-hundredth of the mass, and in places five-hundredths. Ilmenite.

Hæmatite was observed in the form of small crystalline masses in several of the large pegmatite veins on the Ste. Anne and Jacques Cartier rivers, and along the line of the Quebec and Lake St. John railway, between Lake St. Joseph and Lake Sargent. Hæmatite.

Bog Iron Ore.—Deposits of this mineral have for a long time been worked in the vicinity of Three Rivers, where it has been smelted in the St. Maurice Forges ; as the conditions under which it occurs there prevail in the western portion of the region under consideration, no Bog iron ore.

doubt extensive deposits of this mineral will be found in the swamps and lakes of the valleys of the Ste. Anne and Jacques Cartier rivers. In the Grand Bois, on the west side of the Jacques Cartier, there is a deposit said to extend parallel to the river, and to occur in patches for nearly six miles with a breadth of from fifty to one hundred and fifty yards. Between Portneuf and St. Basile, in the Bois d'Ail, there is a deposit extending over an area of four acres. Indications of this ore were also met with in the great swamp between Ste. Catherine and St. Gabriel, and also to the north of the Bonhomme Mountain. It occurs also, with ochre, in the swamp along the branch railway to Jackson's mill, and at the Pointe des Fourches, near St. Raymond.

Ochre.

Ochre.—Iron ochres are found in a great many localities, in fact, the stratified sand is nearly always highly impregnated with them, which gives it the dark yellow colour. The mineral often occurs in layers segregated out of the sands. These layers of ochre are most common when the sand is covered with swamp, and then often a considerable thickness of this material is found resting on the sand. Such beds are seen on the west side of the Ste. Anne River between the St. Raymond bridge and Jackson's mill, also on the Pointe des Fourches, while all the swamps before mentioned have deposits more or less extensive. In the parish of Ste. Anne de Montmorency, about a mile and a quarter above the mouth of the Ste. Anne River, there is a deposit of ochre extending over about four acres. The locality is on the top of the bank which overlooks the main road, from which it is removed about a quarter of a mile. The surface of the deposit has a slope to the south-east of about fifty feet in about one hundred and fifty yards, but the bottom of the deposit keeps nearly on a level with the lower side for some distance back, and then rises quickly up to the higher side. The thickness of the deposit is thus about seventeen feet to four feet. Three colours exist on the surface, yellow, red and blackish brown; but the lower and by far the larger part, is an ochre of whitish-green colour. In this green portion the iron is in a lower state of oxidation than in the yellow, but like it, becomes red upon ignition.

Pointe des Fourches.

Large deposit.

Bog manganese.

Bog Manganese.—On the St. Louis road, about four miles and a half from Quebec, there is a small deposit of this ore. It occurs in black honeycombed masses imbedded in sand, and occupies an area of sixty yards by five yards wide, with a thickness of one foot in the middle gradually thinning all round.

Brick clay.

Brick Clay.—The stratified clays found extensively along the St. Lawrence margin and in the lower portions of the river valleys, answer admirably for brick-making. Bricks from these clays are made at St.

Raymond, and on the east bank of the Ste. Anne River below St. Alban. Extensive brick-yards are located in the valley of the St. Charles River along the Little River road.

Building Stones.—The different outcrops of Trenton limestone afford abundant quarries of this material. The beds of the upper and lower portions are liable to contain partings of black bituminous shale which cause the quarried stone to be generally of small dimensions when free from flaws. The beds of the middle part of the formation are very free from such partings and afford stone of dimensions up to six feet in thickness. Building stone

At St. Alban bridge, the gorge of the Ste. Anne River, for half a mile above and for two miles below, passes through these rocks, and any amount of good stone might be obtained there. The stone is light grey in colour, with a yellowish tinge, and is finely granular in texture.

In the rear of the fourth and front of the fifth range of La Chevrotière, extensive quarries have been worked for a number of years in beds of nearly the same horizon as the above. The stone has a yellowish-grey colour of even tint, and is not readily discoloured by weathering. Its texture is more granular than the Montreal stone, but it does not take so fine and sharp an edge, nor does it pick out so well. This stone has been used extensively for the large public works of Quebec, and is drawn from the quarries some two miles to the railway. The quarries, owned by some seven individuals or companies, are opened on both sides of the St. Alban road for a distance of over a mile. The beds worked are only four or five in number, and as they lie nearly flat, and are near the surface, the quarries are only a few feet deep. The greatest thickness obtained here is 6 ft. 3 in., but this bed is liable to break into beds of 3 ft. 6 in. and 2 ft. 4 in.; above this is another of nearly 3 ft. thickness, overlaid by beds of 2 ft. and 15 in. in thickness. To the south of this locality, in the second range, smaller quarries have been worked in the past, but are now idle; the stone here, although hard and massive, is penetrated by thin partings of black shale, which soon weather on exposure and give the dressed stone a rough appearance. La Chevrotière quarries. Thickness of beds.

At Pointe aux Trembles, extending over several lots, there is a grey limestone in massive beds, in which quarries have been worked. It has a colder tint than the stone of La Chevrotière and is less granular; it is not soft, but can be worked to a sharp edge. The beds yield good large blocks, and the stone has been used in Quebec for the construction of the Champlain market and other public buildings. At Cap Santé the black bituminous shales of the Utica formation are at Pointe aux Trembles. Cap Santé.

intervals interstratified with calcareous layers of two to six inches thick. They are of two colours, the upper dark grey and the lower light greenish-grey; the former are the more bituminous, the later the harder and more calcareous, giving good lime when burnt. From the remarkable evenness and smoothness of these layers, they are well adapted for hearths, chimney jambs, sills and lintels, and are also excellent material for paving cellars and such like purposes. They are, however, jointed in various directions, and great weights, after the stones had been exposed to the weather for some time, might crack them in these joints. The joints are vertical to the plane of the beds, and they run chiefly in three directions, giving rise to two sets of rhomboids, one much more acute than the other. These beds are first seen about half a mile above the mouth of the Jacques Cartier, and thence extend along the beach to half a mile above Cap Santé church.

St. Ambroise. On the outcrops of limestone, from St. Ambroise eastward to Beauport, numerous small quarries have been opened and a large quantity of stone extracted for burning into quick-lime and for road metal. This stone is generally dark in colour, without a good granular texture, and is greatly divided by thin beds and partings of black bituminous shale, so that no blocks of any considerable thickness are obtainable.

Beauport. At Beauport, building stone of moderate dimensions is taken from large quarries on the hillside behind the village. This stone is of the same description as the above, and is used for private buildings in and around Quebec. In rear of Beauport to the Montmorency River, small quarries and accompanying limekilns are seen on nearly every farm lot. The limestone here is very thin bedded and greatly mixed with shale, and is useful only for lime-burning.

Château Richer. At Château Richer there are nine quarries in operation. The limestone is somewhat similar to that of Beauport, but of a better quality, being preferred by builders in the construction of private buildings in Quebec.

Gneiss. *Gneiss.*—Many of the bands of gneiss in the Archæan area would prove excellent material for the foundations of large superstructures, bridge piers, or harbour works, where superior strength and hardness are necessary.

But few attempts have been made to quarry these rocks, the abundance and good quality of the limestone leading to its employment for most purposes in which the gneiss might have been used. The cost of quarrying and dressing the gneiss is, of course, much greater than in the case of the limestone.

St. Basile. A quarry in a fine-grained, dark grey syenitic gneiss was opened at St. Basile and stone taken out for the walls of the church at that place.

This rock splits readily across the bedding in any direction, and may be obtained in blocks of fifteen inches in thickness. On the east side of the Jacques Cartier River, one mile south of the railway bridge at St. Gabriel, there is an outcrop of red, medium-grained syenitic granite, from which the stone for the railway bridge piers was obtained. This rock is an excellent building material. It works well, splitting easily into large blocks, and has a good colour when dressed. St. Gabriel.

The old dam of the Quebec waterworks, on the St. Charles River behind Lorette, was built of gneiss obtained from a quarry close by. It splits in all directions by means of wedges, and is capable of receiving fine smooth faces with sharp edges. This rock is also hornblendic with a distinct gneissic structure. Lorette.

At the St. Joachim falls, on the Ste. Anne de Montmorency River, the rock consists of micaceous gneiss, of which the stratification is most beautifully and remarkably regular, without any twists or undulations. The rock is thin bedded, and although the beds appear to adhere pretty firmly together, it is probable that by the aid of wedges, large slabs might be split off with any required thickness, down to two or three inches, and would constitute an excellent material for foot pavements. St. Joachim.

Infusorial Earth.—This substance, which is extensively used as a polishing powder, as well as for a non-conducting material and other purposes, consists of minute siliceous remains of diatoms. A considerable deposit of this earth is found on the twentieth lot of the second range of Laval settlement, which is on the right bank of the Bras, just at its junction with the Montmorency. The deposit is about fifteen feet thick and occurs in sand containing boulders, about forty feet above the river, and is overlaid by fifty feet of the same material. In colour it is partly yellowish and partly lead-grey, the colours being sometimes arranged in different layers, and sometimes irregularly intermixed in spots and patches. Infusorial earth. Laval.

Another deposit of this material occurs on the east side of the north branch of the Ste. Anne River in the ninth range of Gosford. This deposit extends over an area of half an acre in the river valley; it is of a lead-grey colour, and has been found to exceed four feet in thickness. Gosford.

APPENDIX.

Notes on the Microscopical Character of some Rocks from the Counties of Quebec and Montmorency, collected by Mr. A. P. Low, 1889-91.

By Mr. W. F. Ferrier, B.A.Sc., F.G.S.

In the following short notes on Mr. Low's rocks a scheme of classification has been adopted about which it may be desirable to add a few words of explanation.

I am indebted to Dr. F. D. Adams, of McGill University, for his kind permission to make use of this scheme, which has not yet been published, but will appear in the forthcoming number of the Neues Jahrbuch fur Mineralogie.

Dr. Adams proposes to apply the name "anorthosite," originally used by Hunt as a general term for the plagioclase rocks of the so-called Upper Laurentian, to those varieties of gabbro in which plagioclase very largely predominates. The plagioclase is, in nearly all cases observed, labradorite, but in a few instances it is andesite. This use of the term "anorthosite" has been approved of and adopted by Prof. Rosenbusch. The subdivisions of the gabbro family would then be as follows :—

Labradorite (principally)	+	*diallage*	= *Gabbro proper.*
" "	+	*rhombic pyroxene*	= *Norite.*
" "	+	*diallage + olivine*	= *Olivine Gabbro.*
" "	+	*rhombic pyroxene + olivine*	= *Olivine Norite.*
" "	+	*olivine*	= *Troktolite.*
" "		*(alone)*	= *Anorthosite.*

Then when the felspathic constituents of the rocks fail, we have :—

Pyroxene (alone)	= *Gabbro Pyroxenite.*
Diallage + olivine	= *Diallage Peridotite* = *Wehrlite.*
Bronzite + olivine	= *Bronzite Peridotite* = *Harzburgite.*
Magnetite + olivine	= *Magnetite-Olivenite.*
Olivine (alone)	= *Peridotite.*
&c., &c.	

Dr. Adams recently examined a few of the specimens from the Château Richer area, and in a communication to me calls attention to the following points noted in their examination :—

1. Plagioclase in all the specimens preponderates very largely, to the almost entire exclusion of the other constituents.
2. Most of the slides examined show excellent cataclastic structure.
3. A few of the specimens hold a very little quartz, principally in the crushed portion of the rock.
4. The coloured constituents when present consist of pyroxene, hornblende, biotite and ilmenite.

In the examination of the rocks here described untwinned grains of felspar have frequently been observed, but, as has been pointed out by G. W. Hawes*, many triclinic felspars show no twinning in thin sections, and consequently a separation of the felspars by means of a dense solution, and a chemical examination, would be necessary to determine with any degree of certainty whether these grains consist of a monoclinic or triclinic felspar.

Unfortunately there was no opportunity in the present instance to make the necessary separation, but a careful examination of typical specimens from the region is purposed with a view to the determination of the occurring felspars.

Hornblende Granite Gneiss, containing hypersthene and some biotite. —On road, east side Jacques Cartier River, 2½ miles N. of Valcartier. See Div. V., p. 18.

A rather coarse-grained indistinctly gneissic rock, which in thin sections is seen to be composed of the following minerals as essential constituents: Orthoclase, quartz, plagioclase, hornblende, a rhombic pyroxene, and biotite. Accessory minerals present are magnetite, zircon, apatite, and pleonaste (?).

That the rock has been submitted to great pressure is shown by the fact that the constituents frequently exhibit uneven extinction and in some cases are broken up into aggregates of smaller grains. Intermingled with these smaller grains, or occurring as borders around portions of the larger ones, are little areas of orthoclase and quartz intimately associated with one another in such a manner as to resemble the struc-

*On the Mineralogical Composition of the normal Mesozoic Diabase upon the Atlantic border. G. W. Hawes. Proceed. U. S. Nat. Mus., 1881, pp. 119-134. Also "On the determination of feldspar in thin sections of rocks," ibid., pp. 134-136.

ture known as *granophyr*. This may really be a structure produced by the crushing of the rock, owing to the orthoclase being cracked and the cracks infiltrated with quartz. If, however, on further study, it prove to be an original structure, this would indicate that the rock is really a crushed granite.

The orthoclase and quartz occur in irregular shaped clear grains which frequently show uneven extinction, and are sometimes broken up into smaller grains as above mentioned.

The same is true of the plagioclase felspar. It, however, as a general rule, does not show the effects of pressure to such a marked degree. It occurs twinned according to both the albite and pericline laws, the lamellæ being frequently bent and the twinning itself probably in many cases induced by pressure.

The hornblende is strongly pleochroic in green and yellow tints, exhibits good cleavages and the ordinary optical properties characteristic of that species.

A considerable amount of pyroxene, sometimes showing a decided pleochroism, is present in the sections. This has, in the two sections which have been made of this rock, invariably a parallel extinction, and is in all probability a rhombic pyroxene allied to hypersthene. It is sometimes found partially decomposed to a substance resembling serpentine.

Associated with the hornblende is a small amount of biotite in irregular shaped individuals.

The iron ore, which occurs in a few black opaque grains, is strongly magnetic and is therefore magnetite.

The zircon occurs in considerable quantity in the form of short, stout, crystals with the usual very strong double refraction, or in rounded crystalline grains.

Apatite is also found in considerable abundance in similar stout crystals.

The mineral referred to as pleonaste, only three individuals of which were found in the two sections examined, occurs in the shape of small rounded, isotropic grains, of a pale yellowish-green colour with a rather high index of refraction and showing no cleavage. No axial figure could be detected in convergent light. Its characters approach more closely to that variety of spinel known as pleonaste, than to any other mineral which commonly occurs as a rock constituent. The dull brown colour of the rock is seen in a thin section to be apparently due to the serpentine-like decomposition product of the rhombic pyroxene, which spreads all through the rock in a network of minute fissures between, and traversing the grains.

Mica Diorite Gneiss.—Road west side Sault à la Puce River, at bridge crossing west branch, three miles north of Château Richer.

This rock, which is medium-grained and greatly decomposed, consists, in the section examined, almost entirely of plagioclase felspar. Some bisilicates were originally present in the rock, but these are now so decomposed to a chlorite that it is impossible in all cases to state what the original minerals were. A small amount of biotite still remains unaltered, but it is possible that some of the chlorite was derived from hornblende. A considerable amount of ilmenite, for the most part altered to leucoxene, together with a few slender crystals and irregular fragments of a mineral having the optical characters of apatite, are also present.

The rock has evidently been much crushed. The larger individuals of plagioclase are seen to be separated by a mosaic of smaller grains, which, in most cases at least, have clearly been derived from the breaking up of larger grains. The twinning lamellæ of the plagioclase are also bent, the mineral shows an uneven extinction and is filled with little hair-like inclusions. A brown decomposition product is present in abundance, filling the minute fissures in the minerals, as in the case of the hornblende granite gneiss from the east side of the Jacques Cartier River.*

The chlorite resulting from the decomposition of the bisilicates is of two kinds, one of which, of a light green colour, corresponds to the normal variety usually observed. The other is of a yellowish-brown colour, has a somewhat stronger double refraction, and occurs in little spherulitic aggregates, which, between crossed Nichols, show the usual dark cross.

Mica Diorite Gneiss.—Road up Sault à la Puce River, three miles north of Château Richer.

This is essentially the same rock as the foregoing one, but contains a somewhat larger amount of orthoclase, and does not show cataclastic structure to such a marked degree.

No. 1. Anorthosite.—Lots 13 and 14, N.W. range of Bras, Sault à la Puce.

A fine-grained light greenish-grey rock, consisting very largely of plagioclase, although some untwinned grains of felspar are present which may possibly be monoclinic.† Evidences of pressure are seen

*See p. 74 L.

†See Introductory Remarks.

in the bending of the twinning lamellæ and in the cracking and breaking of the larger grains. The section affords a good example of Torneböhm's "mortar-structure" which is characterized by grains of felspar and quartz cemented by a fine mortar of the same materials.* Little patches of serpentine are seen in the section, resulting from the decomposition of some bisilicate, with which biotite is intimately associated. A considerable quantity of an opaque iron ore, probably ilmenite, is present, some of the grains exhibiting sharp crystal outlines. Numerous irregular grains and crystals of apatite were also observed. A very few grains of quartz occur in the section. Mr. Low states that he observed large, apparently untwinned, felspar crystals, porphyritically developed in this rock, but none are visible in the hand-specimen examined.

No. 2. Anorthosite.—Lot 18, S.W. range, Sault à la Puce, one mile further northward up the path from locality of No. 1, near the northern boundary of the anorthosite area.

This, in the hand specimen, is seen to be a rather fine-grained light yellowish-grey felspathic rock, containing only a very small proportion of bisilicates and a little iron ore. It weathers to a rusty brown colour. Mr. Low, in his notes, remarks that this is the same rock as No. 1, occurring in large loose angular fragments. Under the microscope it is seen to be composed very largely of plagioclase felspar, the extinction angle of which (measured on P) was found by several determinations to be about 8°, which would bring it under the labradorite group of the plagioclase series.† The usual evidences of pressure are seen in the section, which presents the appearance of a fine-grained mosaic of felspar through which a few larger grains are scattered. The bisilicates originally present are now almost entirely altered to a serpentine-like substance. A little biotite is present, also apatite and ilmenite.

No. 3. Anorthosite.—Lot 13, N. E. range, Sault à la Puce.

The rock is light greenish-yellow in colour and consists very largely of plagioclase, nearly all well twinned and finely granulated. A few large, twisted and broken, felspar individuals of a violet tinge lie in this granulated material. Lenticular patches of biotite occur in the hand specimen, and a few minute fragments of hornblende and apatite

*Geol. Fören. Förhandl., 1881, V., p. 233.

†Cf. Max Schuster, "Ueber die Optische Orientirung der Plagioklase." T.M.P.M. 1880, III., 117-284.

were observed in the thin section examined. Ilmenite, in small grains, is also distributed through the rock. A single grain of what is apparently quartz was detected in the fine-grained portion of the rock, but the axial figure obtained was not satisfactory enough to determine it with certainty. In his field notes Mr. Low regards this as the same rock as Nos. 1 and 2. Dr. Adams examined a fragment of this specimen, which, however, showed no coloured constituent, with the exception of a few small grains of iron ore.

No. 4. Anorthosite.—Lot 8, S. W. range, Sault à la Puce.

Essentially the same rock as No. 2, but the specimen is darker in colour, with patches of a reddish-violet tinge in it, is somewhat coarser-grained, and the thin section examined shows a larger proportion of coloured constituents, although these are far from being abundant. Torneböhm's "mortar-structure" is well shown in this rock, as in No. 2. The plagioclase is full of microlites, and in several grains beautiful examples of pressure twinning and zonal structure are seen. The bisilicates are much decomposed, in some cases entirely so, chlorite and hematite filling the spaces. Biotite appears to be the most abundant coloured constituent. Little hexagonal scales of hematite occur in the felspar, and there are also a few crystals and irregular grains of apatite distributed through the section. Ilmenite is also present in small veins and isolated grains and crystals.

NOTE.—Nos. 5 to 15 form a continuous section, going south along the road on west side of Sault à la Puce River in the Parish of Château Richer.

No. 5. Anorthosite.—Lots 63 and 64, Château Richer.

This is a fine-grained, greyish, almost purely felspathic rock, indistinctly foliated, and having larger felspar individuals disseminated through it giving to it a somewhat porphyritic appearance.

The plagioclase shows excellent cataclastic structure and perfect granulation. A few small grains of iron ore are scattered through it, and a very minute quantity of biotite and chloritic material is present.

No. 5a. Norite.—Same locality as No. 5, with which it is closely associated.

A rather fine-grained rock, with a few plagioclase crystals porphyritically developed. It weathers to a brownish-white colour. Consists of plagioclase, an untwinned felspar, hypersthene, biotite, a very small quantity of hornblende and a little iron ore probably ilmenite, and

apatite. The plagioclase presents no unusual features. The hypersthene is strongly pleochroic, in light green and pink shades. It is much cracked, the cracks being filled with a serpentinous decomposition product which also spreads all through the rock in a network of minute fissures between, and traversing the grains.

No. 6. Anorthosite.—100 yards S. of locality of Nos. 5 and 5*a*.

A fine-grained pink and green felspathic rock with gneissic structure. Under the microscope it is seen to consist very largely of plagioclase, well-twinned, but not very fresh in the specimen examined. A little biotite also occurs, but is much altered. Ilmenite is rather abundant, in grains surrounded by a dull decomposition product of some kind which does not present the usual characters of leucoxene. Apatite in rounded grains is tolerably plentiful throughout the section

No. 7. Mica Diorite Gneiss, containing some quartz.—At first forks of road up Sault à la Puce River.

In the hand specimen it presents the appearance of a coarse-grained rock which is much weathered and rusty. It consists of plagioclase, quartz, and a considerable quantity of biotite. The plagioclase is all in rather large grains, with not much crushed material between them, and is well-twinned. The quartz occurs as a few grains scattered amongst the felspar. The biotite is dark brown in colour, strongly pleochroic, and in many instances shows a partial or complete alteration to chlorite. A few grains of apatite and a little iron ore were observed.

No. 8. Biotite Norite Gneiss.—Lot 65, Château Richer.

Mr. Low states that there is some uncertainty as to whether the rock from which this specimen was taken is *in situ* at the locality. It is a rather coarse-grained, dark greenish, rusty-weathering rock with minute particles of iron pyrite distributed through it. Gneissic structure is shown in the mass. It consists of plagioclase, hypersthene, biotite, some quartz, a large amount of apatite, and a little ilmenite and iron pyrite. The plagioclase exhibits the usual effects of pressure and is finely granulated. The hypersthene is almost entirely altered to serpentine, and the biotite in many instances to chlorite. A few grains of quartz were observed in the section examined. Apatite full of inclusions is exceedingly abundant, occurring in large irregular grains.

No. 9. Granite Gneiss.—A short distance S. of No. 8.

A greenish-grey rusty-weathering rock consisting of quartz, felspar (orthoclase and plagioclase), and a small quantity of biotite and iron

pyrite. The quartz and felspar occur in large irregular grains distributed through a fine-grained mosaic derived from the crushing and breaking up of the same materials. Secondary granophyr structure is well developed in the section. The felspar is mainly untwinned (orthoclase); plagioclase, although present, being not at all abundant. The structure of the rock is granitic and it bears evidence of having been greatly crushed. A large quantity of magnetite, some iron pyrite and a little apatite are present. Decomposition products spread all through the rock, giving it a rusty appearance.* Chlorite also occurs, apparently derived from the decomposition of grains of hornblende or biotite.

No. 11. Anorthosite.—Lot 68, Château Richer.

This is an almost exclusively felspathic rock of a light greenish-grey colour tinged with light violet. Scarcely a trace of any bisilicates are discernible in the specimen furnished me. The greater proportion of the felspar grains, if not all, consist of plagioclase. Some show no twinning. The felspar occurs in layers of larger grains, with granulated felspar between them, giving to the section a banded appearance.

Some of the larger grains are much twisted and broken, and granophyric structure is developed throughout the section. A very few traces of what were once bisilicates were observed, but they are now entirely altered to chlorite, hematite, &c. Some few small clear grains of quartz were observed amongst the crushed plagioclase. Apatite is present in rather large irregular grains, also in coarse crystals. Pyrite, much decomposed to hematite, is tolerably abundant, the hematite in places giving a reddish tinge to the hand specimen. Dr. Adams examined a section from this rock and has kindly allowed me to consult his notes on it. The rock is a good example of the anorthosite division of the gabbro family, as proposed by him.

No. 12. Mica Diorite Gneiss.—Lot 70, Château Richer.

A rather fine-grained, dark green, rusty-weathering, gneissic rock, consisting of plagioclase, biotite, hornblende, hypersthene (?) and quartz, with some ilmenite accompanied by leucoxene, and apatite. The plagioclase for the most part is finely granulated, well twinned, possesses uneven extinction, and is much bent and broken. A few large grains remain scattered through the finer material. Of the bisilicates, biotite is the most abundant, but presents no unusual features. Small patches of it are scattered through the hand specimen. All the bisilicates are more or less decomposed, especially the hornblende, which is altered

*Compare No. 5a., also *Hornblende Granite Gneiss*, p. 74 L.

to serpentine and carbonates. The serpentine has a well developed spherulitic structure. A few grains of what was perhaps hypersthene were observed, but they are so badly decomposed that a satisfactory determination is impossible. Apatite is very abundant in groups and strings of large irregular grains, and a few large well-defined crystals were also seen. A little quartz and some ilmenite are present, the latter associated with leucoxene.

No. 14. Anorthosite.—Lot 71, Château Richer.

The section examined is characterized by an almost total absence of coloured constituents, the rock being composed for the most part of plagioclase felspar, although a few untwinned grains occur. In the hand specimen a few irregular patches of biotite were observed, also one or two grains of pyrrhotite and a little ilmenite. The felspar shows evidences of pressure and some fine examples of pressure twinning were seen.

No. 14a. Pyroxene Granite Gneiss.—Lot 71, Château Richer.

This and the preceding rock are intimately associated at the locality. It is a very basic gneissic rock, composed of orthoclase, plagioclase, pyroxene and quartz, with apatite and an iron ore, probably magnetite. It is granitic in structure, medium-grained, and of a dark greenish-grey colour, with parallel bands of the dark green pyroxene running through it, giving a decidedly gneissic character to the mass. The pyroxene is very abundant, of a dark green colour and quite fresh. Its pleochroism is small, green to yellowish-green. The mineral occurs mostly in irregular grains, although in a few instances it shows tolerably regular crystal outlines, and is intimately associated with the magnetite and apatite. Twinning parallel to (100) was noticed in a few grains. The apatite and iron ore are abundant, the former occurring in large crystals and rounded grains. Quartz is not very abundant in the section. A curious coarse granophyr-like structure is noticeable in this rock.

No. 15. Pyroxene Granite Gneiss.—Lot 72, Château Richer.

This section, in general, resembles No. 14*a*, but contains less plagioclase and more quartz, and holds, besides, much titanite.

No. 20. Anorthosite.—Front of 2nd range, Ste. Anne, on road in rear of church, 200 yards from contact.

Another of the fine-grained plagioclase rocks in which bisilicates are almost entirely wanting. A few grains of pyrite are visible in the

hand specimen. Under the microscope the even granulation of the plagioclase is well brought out. A very small quantity of quartz is present, also a little ilmenite accompanied by its alteration product leucoxene, and a few large irregular grains and crystals of apatite. Traces of what were originally bisilicates are to be seen, but almost entirely altered to chlorite, &c. Judging from the outlines of some of the grains they may have been originally diallage.

No. 21. Gabbro Gneiss.—Front of 2nd range, Ste. Anne, on road in rear of church, about 10 yards from contact.

A rather coarse-grained rock, which, under the microscope, is seen to consist of plagioclase, a monoclinic pyroxene, biotite and hornblende, with ilmenite and apatite. The granulation of the plagioclase is very perfect. In the hand specimen numerous small plates of a red felspar occur, together with some good-sized masses of pyroxene and ilmenite, scattered through the finer-grained, greenish-white, felspathic groundmass, giving the rock a porphyritic appearance. The pyroxene is light green and much decomposed to a fibrous yellowish-green chloritic substance, alteration proceeding along the cleavage. It has a large extinction angle and is associated with a small amount of hornblende. Ilmenite, accompanied by a little leucoxene, is rather plentiful in this section. Dr. Adams examined this rock, but observed nothing in addition to what was shown in my section. Lenticular bands of a dark green granular pyroxene, or coccolite, were observed by Mr. Low at the junction of this rock with the gneiss, sometimes interfoliated with the anorthosite rocks and again between bands of gneiss at, or near, the contact.

No. 23. Pyroxene Granite Gneiss.—Following No. 21.

A rather fine-grained, much decomposed, rusty rock, possessing distinct gneissic structure and containing much magnetite arranged in parallel bands. Under the microscope it is seen to be composed of a fine-grained mosaic of felspar and quartz, through which larger individuals are distributed of felspar, also pyroxene, hypersthene, hornblende, a little biotite, apatite and magnetite. The felspar is largely untwinned, and exhibits good examples of "schillerization."* Both monoclinic and orthorhombic pyroxene are present; the former shows the same features as in section No. 21. The latter is strongly pleochroic in pink and light green tints and has a parallel extinction. It is in all probability hypersthene. The other constituents present no unusual features. Hornblende and biotite are not abundant. Apatite and magnetite are plentifully distributed throughout the section.

* J. W. Judd, Quart. Journ. Geol. Soc. Lond., XLI., 1885, p. 383.

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

PORTIONS OF THE PROVINCE OF QUEBEC

AND ADJOINING AREAS IN

NEW BRUNSWICK AND MAINE

RELATING MORE ESPECIALLY TO THE

COUNTIES OF TEMISCOUATA AND RIMOUSKI, P.Q.

BY

L. W. BAILEY, PH.D., F.R.S.C.

AND

W. McINNES, B.A., F.G.S.A.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1893

A. R. C. Selwyn, C.M.G., LL.D., F.R.S., &c.,

Director of the Geological Survey.

Sir,—I have the honour to submit the following report of observations and explorations made by myself and Mr. W. McInnes, with the assistance of Mr. J. W. Bailey, in portions of the province of Quebec and adjacent areas in Maine and New Brunswick, chiefly during the summers of 1887 and 1888.

The report is accompanied by a quarter-sheet map, representing portions of Temiscouata and Rimouski counties, being continuous on the one hand with the series already issued of the adjoining portions of the province of New Brunswick, and on the other with those prepared by Dr. R. W. Ells in illustration of the geology of the Gaspé peninsula.

I have the honour to be, sir,

Your obedient servant,

L. W. BAILEY.

Fredericton, 25th November, 1890.

REPORT

ON

PORTIONS OF THE PROVINCE OF QUEBEC

AND ADJOINING AREAS IN

NEW BRUNSWICK AND MAINE

RELATING MORE ESPECIALLY TO THE

COUNTIES OF TEMISCOUATA AND RIMOUSKI, P.Q.

BY

L. W. Bailey, Ph.D., F.R.S.C., and W. McInnes, B.A., F.G.S.A.

Previous reports.

The rocks to which this report relates are a portion of those which have been commonly known as the Quebec group. As is well known, the latter have been the subject of much previous investigation, both by the officers of the Geological Survey and others, numerous reports and memoirs having been at various times published concerning them. The most recent of these, upon the part of the Geological Survey, are those of Dr. R. W. Ells, who in Vols. II. and III., New Series of the Survey publications, has given not only a full historical summary of the progress of the investigation, but from a minute study of the rocks in the vicinity of Quebec, supplemented by explorations extending from the Vermont boundary to the extremity of the Gaspé peninsula, has brought forward data, both of a stratigraphical and palæontological character, which, while in important particulars at variance with views previously announced, seem to place the main facts of the case beyond further controversy.

Dr. Ells's conclusions.

The most important of the conclusions thus arrived at, so far as they bear upon the region to be considered in the present report, may be briefly stated as follows:—

(1.) The larger part, if not the whole, of what was at one time known as the "altered Quebec group," is now regarded as a portion of an older and independent series of Pre-Cambrian age.

Lévis.

(2.) Of the two main groups into which the so-called Quebec group was originally divided, viz., the Sillery and Lévis (the division known as the "Lauzon" having been subsequently introduced and then abandoned), the latter or Lévis section, which up to 1888 was regarded as the older of the two, is now considered to be the more recent, the name "Lévis" being, however, restricted to the group of blackish green and gray shales which, as seen at Lévis and St. Joseph, contain characteristic graptolites of Calciferous-Chazy age, together with the associated limestones and limestone-conglomerates—the matrix of the latter also carrying typical fossils of the Calciferous formation, while the inclosed pebbles are wholly of Cambrian or Potsdam age.

Citadel rocks.

(3.) That a portion of the rocks forming the bluffs underlying the city of Quebec, as well as a portion of the Island of Orleans, and designated as the "Citadel rocks," which were at one time regarded as forming a portion of the Lévis group, are, as shown by their fossils, distinct from and more recent than the latter.

Sillery.

(4.) That the rocks of the "Sillery" formation, as thus understood and limited, contain a fauna corresponding to that of the Upper Cambrian series, its upper beds perhaps merging into those of the Lévis group, which is referred to the Lower Ordovician or Cambro-Silurian system, while at its base, and representing the Lower-Cambrian, is a series of beds in which, as yet, no fossils have been found. The Quebec citadel rocks have also been referred to the Cambro-Silurian or Ordovician system, and carry a fauna which is distinctly of Trenton-Utica aspect, and is followed upwards by fossiliferous Utica and Hudson River shales.

Potsdam.

To the above it may be added that the separation of a portion of the rocks about Quebec, as well as eastward along the Lower St. Lawrence, under the designation of "Potsdam," and its subdivision into three sections, as proposed and mapped by Mr. Richardson, is untenable, the fossils upon which this arrangement was based having been found to occur only in the pebbles of the conglomerates from which they were obtained, and not in the rock itself.

In describing the region examined by us we shall assume that these conclusions are correct, nothing having been observed by us which is in conflict with them, while they seem to afford the most satisfactory explanation of such facts as we have observed.

Region described.

The region referred to, represented in accompanying maps, lies almost wholly in the province of Quebec, having as its central and chief portion the county of Temiscouata, but including also a small part of Rimouski county, as well as portions of the counties of Madawaska and Restigouche, in the province of New Brunswick. Sheet No. 18 S.E.

lies immediately north of sheet No. 17 N.E. of the series of New Brunswick maps, and in turn is followed north by sheet No. 18 N.E. embracing chiefly the region drained by the Rimouski and Metis rivers, while sheet No. 18 S.W. embraces a similar small area about Rivière du Loup. The area thus indicated, and to be presently described, is on the eastern side continuous with that described and mapped by Dr. R. W. Ells about the headwaters of the Restigouche and Metapedia rivers (No. 3 S.W. Quebec maps); and on the west adjoins the areas in Kamouraska county, described but not yet mapped by the same author. On the north side the several sheets terminate, so far as our investigations are concerned, with the south shore of the St. Lawrence River, between Rivière du Loup and Little Metis. The rock formations included within the area above defined are, as far as known, but two in number, viz., the Silurian and the Cambrian, with possibly small unrecognized areas of Cambro-Silurian or Ordovician.

Boundaries of accompanying maps.

SILURIAN.

The rocks of this system, as found within the areas here considered, have been quite fully described in previous reports, their stratigraphy, fossils and correlations with other Silurian districts, especially in New Brunswick, Maine and Nova Scotia, having been stated in considerable detail. We have no further information concerning them, so far as they occur within the area now under discussion, but a question having arisen as to their western extension and their separation from older and lithologically similar strata about the sources of the St. John River, some particulars may here be given of an exploration of the latter having in view the more exact determination of these points.

Earlier reports.

As represented upon Lake Temiscouata the portion of the Silurian system which immediately adjoins and overlaps the Cambrian strata to be presently described, does not represent the lowest member of that system, being composed of white sandstones and overlying calcareous rocks, of which the fossils indicate an age ranging from the lower to the upper part of the Lower Helderberg horizon, while at a short distance south are heavy conglomerates followed by hard sandstones and shales containing fossils chiefly of the Niagara formation. The larger part of these beds occur only upon the eastern side of the lake, where the calcareous strata form the prominent eminence known as Mt. Wissick; but upon the western side, the only fossiliferous strata observed are a few shales, imperfectly exposed about a mile northward from the village of Cabano. The older conglomerates and sandstones of the Niagara group are, however, well exposed here and may be followed

Lake Temiscouata.

westerly for several miles along the road leading to the mills on the Cabano River. Immediately to the south of the above undoubted Silurian strata is found the great series of slates first described in the Geology of Canada in connection with the Gaspé series, and which has since been found to spread so widely over the northern portions of New Brunswick, as well as adjacent areas in Quebec and Maine. These slates, as seen along the lower half of Temiscouata Lake and on the Madawaska River, are of gray, bluish-gray and dark gray, rarely black colours, often weathering to a dull olive-green, very fine grained but including harder bands, and generally more or less calcareous. They are throughout characterized by numerous and often intricate contortions and these, with a strongly developed slaty cleavage, make any attempt to determine their thickness or relations well nigh hopeless. Neither on the Lake nor on the Madawaska have they been found to contain any fossils, these having probably been obliterated by molecular movements; but the occurrence of fossils at many different points in the resembling strata which spread so widely to the east and south, and all of which indicate a Silurian horizon, seem to justify the position first assigned them as also Silurian, and as the equivalent of the upper part of the Gaspé series. In ascending the River St. John from Edmundston, slates which are evidently the same as those of the Madawaska and Lake Temiscouata are frequently exposed upon its banks as far as the mouth of the St. Francis River. They exhibit the same alternations of fine and soft with somewhat harder, sandy beds, have the same greenish, somewhat chloritic aspect, and the same strong and nearly vertical cleavage. The dips, when recognizable, are usually low, and indicate a series of broad and open undulations. Two miles above Edmundston the dips are north-easterly, at angles of 30°; at Mecham's Rapids, six miles above, the inclination of the beds is N. 10° E. < 40°; about ten miles up it is S. 30° E. < 30°; and about half a mile below Baker River, where the beds are finely exposed, it is about N. 80° E. < 15°. At the Narrows, about five miles above Fort Kent, the slates, here finely banded, dip S. 40° E. < 85°, a dip which is repeated, or nearly so, two miles further up. At Connors's Landing, ten miles above Fort Kent, the dip is N. 20° E. < 70°.

Silurian slates.

Upper St. John River.

St. Francis River.

On the St. Francis River the exposures are but few, but such as occur are quite similar to those on the main St. John, and have similar low inclinations, mostly to the southward, and the same peculiar greenish tint. No trace either of the limestones or the conglomerates of Lake Temiscouata could be found on this stream, but blocks of whitish-weathering sandstone, similar to those found at the base of Mount Wissick, which occur a little below the foot of Pohenegamook,

or Boundary Lake, appear to indicate that the northern boundary of the Silurian is not far from this place. In the map of Mr. Richardson, the country on either side of the lake to its head is represented as Silurian, but the earlier description given in the Geology of Canada, 1863, is, without doubt, the correct one; the only strata visible being hard glossy slates of the Cambrian system. Above the St. Francis, the main river lies wholly in American territory, and presents much the same aspect as in the portion already described, the bluish, greenish-weathering slates showing frequent outcrops, which are often characterized by short and sharp foldings of the strata, the latter being, at the same time, cut by strong and highly inclined cleavage planes. The scenery of this portion of the St. John is very striking, the bordering hills, which are quite high, sometimes exhibiting strongly serrated outlines, while between them and the river are belts of terraced flats and intervales, most of which are cultivated. Access to the upper farms is, however, difficult, there being no roads whatever, while communication by water, effected in summer by canoes or tow-boats, and in the winter on the ice, is impeded by the numerous and sometimes dangerous rapids. These are, in some instances, due to ledges, but not unfrequently also to accumulations of boulders, which cross the river in trains, and by their grouping and character, suggest that they are of morainic origin.

Pohenegamook Lake.

Description of Upper St. John River.

Ascending the Little Black River, which joins the St. John about twenty miles above the mouth of the St. Francis, only one exposure, of blue slates, was observed in the first eight miles, the stream being exceedingly tortuous, and bordered either by extensive low flats or by banks of stratified clay or gravel. In some places the clays have an observed thickness of ten or twelve feet, and are covered by thirty or forty feet of sand, with from three to four feet of coarse gravel between the two. About twelve miles up, the still-waters cease, and about fifteen miles up, occurs strata, which, probably, mark the limit of the Silurian in this direction. They occur about the junction with the north-east branch, and consist, in part, of black slates, which are somewhat graphitic, and with which are associated purplish-gray, red-weathering slates, and partly of a hard gray grit and conglomerate, containing pebbles of black slate and white quartz. Their dip is S. 40° E. < 60. These were at first believed to belong to, and represent the base of, the Silurian system, but comparisons since made, lead us to think that they belong rather to the Cambrian system, of which undoubted strata occur a short distance farther up the stream.

Little Black River.

Between Little and Big Black rivers, upon the main St. John, gray, bluish and greenish-weathering argillites, continue to be the only rocks

seen *in situ*, though boulders of metamorphic rocks, including hard sandstones, red slates and conglomerates, become abundant, and by their accumulation at certain points, cause long and dangerous rapids.

Geology of Upper St. John.

In the report of the Geological Survey of Maine, and in an accompanying map, all this portion of the valley of the river, and for many miles above it, is represented as composed of talcose schists, but we looked in vain for anything to which that name could fairly be applied. Some of the slates found here are glossy, and, perhaps, a little unctuous, and they often contain scattered scales of mica, but to no greater extent than do many of the slates on Lake Temiscouata and in northern New Brunswick, which are certainly nothing more than ordinary argillites. They exhibit also the same greenish-chloritic aspect, becoming brownish-red under the influence of water, already noted as characterizing the slates to the eastward. The best exposures are at Big Black Rapids, and outcrops occur at intervals from this point to Hunter's, ten miles below the Seven Islands. Their strike is almost uniformly S. W., and the dip north-westerly, at high angles. The land on either side of the river is here much lower than further down the stream, the hills being few and of slight elevation; while the stream itself, though broad, is much encumbered with boulders, which, as below, appear to cross its course in trains, and are the cause of numerous and difficult rapids.

Settlement at Seven Islands.

From Hunter's to the Seven Islands, the navigation is easier, with more still-water and fewer ledges and boulders, while at the "Islands," the stream divides into numerous channels, intersecting an extensive alluvial flat, which, although almost entirely isolated from communication with the outside world, has, for many years, been the seat of a small but very prosperous farming community. The ordinary means of access to the settlement is by a very rough and often almost impassable winter-road from St. Pamphile, in Quebec, a distance of about fourteen miles; but, understanding that this road showed little or nothing of the underlying rocks, our exploratory route was chosen by way of the Big Black River, which, passing near St. Pamphile, joins the St. John, fifteen miles below the Seven Islands. Reaching St. Pamphile by the Elgin Road, the rocks of this settlement were found to be hard dark gray grits, interstratified with black slates, probably belonging to the Sillery division of the Cambrian system, and the extension of those seen on the Little Black River. Two miles west of St. Pamphile church, they form a high hill on the road to Seven Islands, but are here much

Conglomerate.

coarser, becoming a somewhat schistose conglomerate, holding pebbles up to a foot in diameter, chiefly of black quartzite, with included beds, usually thin, of very lustrous black slate, the conglomerate being much veined with white quartz. Their dip is N. 15° W. < 75°—80°. The

finer beds are quite similar to some to be hereafter noticed as occurring along the line of the Temiscouata Railway at St. Louis de Ha! Ha!, and are certainly Lower rather than Upper Silurian, as represented in the map of Mr. Richardson. Conglomerates and slates, similar to the above, are again seen on Big Black River, where this is crossed by the Seven Islands road, and for a quarter of a mile below. About half a mile north of the boundary, these are followed by other slates of dark gray colour and weathering bluish, which are also well exposed directly on the boundary, showing a regular and distinct dip N. < 80°—90°. These slates are without conglomerates, are even-bedded and fissile, with thin layers of sandstone, and might readily be taken for Silurian strata; but, after prolonged search, we failed to find any fossils in them, and are, therefore, uncertain whether they should be referred to this or to some older horizon.

Big Black River.

The difficulty here referred to of distinguishing between Silurian and older rocks in this section, and which was the main object of its exploration, is the same as that found in the Eastern Townships, and which originally led in that section to the reference of large areas, including important gold bearing districts, to the Silurian, whereas, as has been shown by Dr. Ells, these are largely, if not wholly, of Cambro-Silurian and Cambrian age. In our further exploration of the Upper St. John, having this separation in view, the route followed was by way of the Big Black to its junction with the St. John, the ascent of the latter to the Seven Islands and beyond to the Forks, the ascent from this point of the South-west Branch for twenty-five miles to Baker Lake, and after returning to the Forks, a similar ascent of the North-west Branch, whence, by way of its main tributary, the Daaquam, access was had to the settlement of St. Magloire in Quebec.

Similarity between Silurian and older rocks.

Route followed.

The Big Black River, south of the boundary, shows but few exposures, such as occur being of slates, apparently of Silurian age. The rocks occurring between the mouth of this stream and the Seven Islands have already been described. Two miles above the Islands, gray, bluish-weathering and somewhat sandy slates occur, with a south-west strike and nearly vertical dip, and thence follow the course of the river for several miles, forming low bluffs upon its shores. Six miles above the Islands the slates are more micaceous than below, though never assuming the aspect of true mica-schists. Their dip here is S. 5° E. <70°. Ten miles above the Islands alternating slates and fine sandstones, here only slightly micaceous, dip S. 25° E. <70°. Passing Burnt Land Brook, which is eighteen miles above Seven Islands, the land becomes low and the ledges fewer, but such as occur present no noticeable difference as compared with those seen lower

Geology of Upper St. John River.

down, except perhaps in the fact of their frequently holding white quartz veins. Five miles below the Forks the right bank shows ledges of hard, gray, micaceous sandstones, alternating with fine, fissile, dark-gray slates, and having a regular dip S. 12° E. <80°. Approaching the Forks the stream becomes more rapid, and is filled with large boulders, one of them thirty feet long by thirty feet high, of greenish serpentinic rock, with others of conglomerate and hard sandstone. Above the Forks, on the South-west Branch, the stream for several miles shows only dead-water, and no exposures occur as far as the mouth of Baker Brook. On this latter stream an exposure is found three miles up, of bluish-gray slates and sandstones of the ordinary Silurian type, dipping S. 25° E. <80°, but with this exception no rocks *in situ* are visible as far as the outlet of Baker Lake, the limit of our exploration in this direction.

Baker Brook.

N. W. Branch St. John River.

Returning from Baker Lake to the mouth of the North-west Branch, the latter was then ascended, with the opportune aid of heavy rains, to its forks or point of confluence with the Rivière Noire, a small stream flowing south from Lac de la Frontière. This stream we ascended, but with great difficulty, to a point about one mile below its first falls, and three below the lake and boundary. Here occur good exposures of fine-grained, gray sandstones, slightly micaceous and alternating with slates, and in these were found the only fossils met with in any portion of this region. These consist of long, coarsely and longitudinally furrowed stems of plants; but though occurring in considerable numbers they are not sufficiently preserved, or of such a character as to throw much light upon the age of the containing beds. These strata have a distinct and regular dip S. 10° E. <80°, and their general aspect is not unlike that of many Silurian beds, but in view of the observations made by others in this vicinity (See Report for 1887, part K, page 13) we are not prepared to say that they may not be older. In an examination of this region made by Mr. A. Webster, formerly of the staff of the Geological Survey, and referred to in the report last cited, similar slates and sandstones are described as having associated with them beds of dark gray graphitic limestone, but these are situated somewhat nearer to Lac de la Frontière, and owing to want of water, were not reached by us. The whole series is regarded by Dr. Ells as Cambro-Silurian. On the Daaquam, as far as ascended, viz., to a point where this is touched by the clearings eight miles south-west of St. Magloire, no exposures of any kind were observed.

Fossils.

Earlier examination.

It will appear from the above observations that so far as the main issue is concerned, viz., the separation of the Silurian and older strata,

these show nothing of a decisive character by which the question may be determined. Admitting that the beds observed upon the Rivière Noire, and possibly those near the boundary upon the Big Black River, are older than Silurian, though the character of the plant remains upon the former is rather unfavourable to this view, we cannot but think that the exposures in the main valley of the St. John, and as far up as Baker Brook, are of Silurian age. At least they do not differ essentially in character from those which occur so widely lower down in the same valley, and which all the facts in our possession tend to refer to that horizon. It may here be observed that the character and relations of these latter rocks are strongly marked in the physical features of the region, as strikingly seen in ascending from the valley of the Daaquam to the settlements south-west of St. Magloire. The land here rises rapidly and from a high hill, two miles and a half from the river, one may look back over the valley and for many miles follow its course north-easterly and south-westerly as a low tract of nearly level land, along the southern side of which, at a distance of ten or fifteen miles, is another chain of somewhat prominent hills, probably the westward extension of the Aroostook Mts. from the sources of the Alleguash River. It may be added that as a matter of practical cartography the question, so far as Canada is concerned, is, after all, of little importance, as it is probable that the Silurian rocks, if such they are, are almost wholly confined to the region south of the Canadian boundary.

General conclusions.

Aroostook Mtns.

CAMBRO-SILURIAN.

According to the arrangement of Dr. Ells, referred to in the introduction, and which has been here adopted, the rocks regarded as Cambro-Silurian embrace (1) those which, as best exhibited in the vicinity of Point Lévis, consist of blackish green and gray shales, carrying a characteristic Ordovician fauna, with which are associated dolomitic limestones and limestone conglomerates, the whole described as resting in synclinals of the underlying Sillery or Cambrian formation; and (2) the overlying black bituminous shales and limestones, including the rocks of the Citadel of Quebec, which carry faunas ranging from the Trenton, through the Utica formation, to the age of the Hudson River or Lorraine shales.

Description of rocks of Cambro-Silurian age.

Of these several groups of rocks we are unable to say with certainty that any occur within the district to which this report relates. As regards the fossiliferous limestones and shales, however, of the Trenton-Utica formation, which are so conspicuously developed upon the north shore of the St. Lawrence at Montmorenci and elsewhere, it may be

Trenton-Utica probably absent.

considered as quite certain that nothing resembling these is to be met with on the south shore, at least within the settled portions of the area examined by us. The fact, however, that such strata do occur, only a few miles farther east on the Gaspé shore, near the mouth of the Tartigo River (see Report of 1880-81-82, page 30 DD) where they are infolded among the Cambrian strata, would make us hesitate to say that such beds, similarly infolded, may not occur over the large and to a great extent uncleared tract embraced in this report. It may, however, be observed that these rocks, whose nature, when present, is so readily recognized, are equally absent from the drift, a circumstance which renders the fact of their occurrence extremely improbable.

Quebec Citadel rocks.

As regards what has been termed the Quebec Citadel series, also consisting of black bituminous shales and limestones, with some conglomerates, but holding a fauna in some respects distinct from the typical Trenton-Utica formation, we have also failed to recognize its presence over any portion of the area examined by us. The occurrence, however, of some of its peculiar forms in the strata revealed in the valley of the Beccaguimic River in New Brunswick would seem to indicate that the group is more than a local one, and that similar remains may yet be found at some points over the wide area by which these two localities are separated.

Lévis group nowhere recognized.

The lowest rocks of the Ordovician or Cambro-Silurian, as here classified, are those of the Lévis group proper. Of their occurrence or absence within the area under discussion, we feel unable to speak with any great degrée of confidence, for although particular groups of strata are sometimes there met with, which in lithological aspect might well be compared with the typical beds as seen at Lévis and the south-west end of the Island of Orleans, careful search has as yet failed to reveal any fossils which are sufficient to establish their identity, while the extreme complexity of arrangement, as revealed along the coast, together with the want of good exposures in the interior, make the study of the stratigraphy, and the identification of particular horizons exceedingly difficult. Under these circumstances it only remains for us to describe the various formations of the entire area, as they have been actually observed, which may be most conveniently done in connection with the consideration of the Cambrian system, to which undoubtedly the great bulk of the strata belongs.

CAMBRIAN.

Prior to the publication of the present report, the most important references to the area now to be described are those contained in the "Geology of Canada, 1863," and the subsequent report of Mr. Richard-

son in 1868. In the first of these publications the references are almost entirely confined to the settled areas, immediately adjacent to the St. Lawrence; but in the latter the various groups distinguished in the vicinity of Quebec are traced eastwardly, and both described and mapped as to their supposed relations along the section afforded by the Temiscouata Portage road. The subdivisions recognized included not only the Sillery, Lauzon and Lévis of the earlier reports, the latter being regarded as the lowest, but also a group referred to the Potsdam, and further subdivided into three divisions. The reasons for this latter view, and for its abandonment by later observers, are fully given in the report of Dr. Ells for 1887-88 (part II., page 42 K), and will be further noticed here. Previous reports.

The Temiscouata section is by far the most complete of any to be found in the district. Indeed, with the exception of that afforded by the Intercolonial Railway between Metapedia Lake and Metis, and that of the Pohenegamook road, it is the only accessible line of traverse across the entire belt of Cambrian rocks in this part of Quebec. While, however, that of the Intercolonial covers a breadth of only about eight or ten miles, that of the Temiscouata road embraces a distance of over forty. The recent opening also of the Temiscouata Railway having afforded, in its cuttings, admirable facilities for the examination of the rocks which it intersects, these have been carefully studied, and will be here made the basis of comparison for the entire region. Temiscouata road and railway.

The north-eastern part of Lake Temiscouata is occupied by a series of rocks, briefly referred to in the Geology of Canada, 1863, as belonging to the base, *i. e.*, to the "Lévis" division of the Quebec group, as then understood. As seen on the south-east shore of the lake, above Mt. Wissick, they consist of gray and dark gray fissile clay slates, holding thin interlaminated beds, from two to four inches thick, of hard gray sandstone and, at the foot of the eminence named, are (as described in the Report of 1887-88, part II., page 29 M) covered unconformably by the fossiliferous limestones and sandstones of the Silurian system. In these slates, which, in contrast with the rocks of the mountain, are highly tilted and corrugated, we have, during the last summer, succeeded in finding fossils which, for the first time, afford definite evidence as to the age of the beds containing them. These, in addition to obscure Lingulae, include undoubted specimens of *Obolella* (or *Linnarsonia*) *pretiosa*, Billings. As this species is not only characteristic of the Sillery group, as here understood, but confined to it, its occurrence may be regarded as showing the equivalency of these beds to those which on the Chaudière, Cambrian of Lake Temiscouata. Sillery fossils.

at St. Michel, on the St. Lawrence, and elsewhere, contain the same form, and which are regarded as representing the upper member of the Cambrian system. Some portions of the slates are banded with numerous thin layers, from one to four inches wide, of light gray, yellowish-weathering limestone, having a peculiar transverse fibrous structure, and from this feature have been compared (Geology of Canada, 1863) with the rocks of the Chatte River, on the north side of the Gaspé peninsula. They are thought by Dr. Ells, who has personally examined them, to probably represent Divisions 2 and 3, of the section given by him as occurring at Cap Rouge, near Quebec.

Fibrous limestone bands.

It should be added that in Cabano village, at the foot of the northern section of the lake, and in the line of strike of these beds, is exposed a heavy mass of white vitreous sandstone, which may be a part of the same series. It is, however, completely surrounded by fossiliferous Silurian slates, and it has been found impossible to determine whether it pertains to the older series, protruding through these slates, or is the equivalent of very similar sandstones, which at Mt. Wissick occur near the base of the Silurian.

White sandstones.

Strata similar to the above occur for some distance along the south-eastern side of the lake, corresponding approximately to its course, and again upon its north-west side; but here, as seen just above Sandy Point, the included limestones are flaggy, breaking in broad slabs, the fracture of which is conchoidal, while the unequal hardness of the calcareous and slaty layers gives, by weathering, to some of the beds, a gnarled or ribbanded appearance. The dips are irregular, in some places north-westerly, in others south-easterly, at varying angles. It is probable that they occupy the whole of the low ground, a mile or so wide, on the north-west side of the lake, and in their westerly extension underlie the similar low tract crossing the Temiscouata Railway and Portage road, between Cabano and the 37th mile post. Further west, the same beds have been observed on the Cabano River, three miles above its mouth, whence they probably cross to the foot of Boundary or Pohenegamook Lake. In an easterly direction, owing to the uncleared state of the country, it has been impossible to trace them; but it is probable that they are at no great distance overlapped by the Silurian strata which in this direction sweep northwards towards the St. Lawrence.

Flaggy limestones.

Where the Temiscouata road crosses Little River or Rivière du Lac, near the 38th mile post, are fine, gray and dark gray, somewhat plumbaginous slates, seamed with spar, which probably form a part of the belt last described. Just north of this the land begins to rise, and on the slope of the hill between the 37th and 38th mile-posts,

Plumbaginous slates.

beds of reddish-gray and purplish-gray sandstone, associated with bright red and gray, sometimes greenish slates, come into view, dipping south-easterly at a high angle; beyond which are broad ledges of gray, very silicious white-weathering sandstones, also dipping southerly, though with some irregularity. The slates are supposed to represent Divisions 2 and 3 of the Cap Rouge section, or Lower Sillery, while the quartzites, which are in two or more bands, separated by belts of slate, are referred to Division 4.

Slates and sandstones of the Sillery.

From the 37th mile-post the road, for half a mile, runs on the strike of the sandstones, now dipping north-westerly, beyond which more bright red slates (2-3) appear. The quartzites thus mark an anticlinal, flanked on either side by the red slates. To these succeeds a broad belt of dark gray to black crumpled slates, which occupy the greater part of the space to the church of St. Louis de Ha! Ha! Here another great ridge of white-weathering quartzite comes into view, dipping S. 60° E. < 50°, while at the base of the ridge on the northern side are found large, loose blocks of limestone-conglomerate, of which the pebbles in some instances resemble corals, but appear to be only concretionary. These are the only rocks met with in the interior which bear any resemblance to the limestone-conglomerates, so strikingly represented on the shores of the St. Lawrence, but the beds from which they were derived could not be discovered, and their precise relations are therefore unknown.

Anticlinal.

Blocks of limestone conglomerate

The rocks last described occur in the valley of the Rivière des Savannes, half a mile south of mile-post 34. It may here be remarked that it is at this point that, in the map of Mr. Richardson, the rocks of the Quebec group are represented as followed by the Silurian system, occupying all the area above described; but from the descriptions given it will be evident that the true southern limit of the Cambrian is several miles further south, or about the Cabano River. In the same map the rocks from the 34th to the 26th mile-post are represented as belonging to the Lévis group. As first seen to the north of the 34th mile-post they consist of dark gray, glossy slates and slaty sandstones, which are much corrugated and seamed with white quartz. They rise into very prominent hills, including White Mountain, Mount Paradis and others, and from the summit of these may be seen to form a well marked ridge, extending eastwardly towards the head of Temiscouata Lake. Some of the slates are greenish, others purplish and black, with seams of quartz and chlorite, and their dip, as seen on the northern side of the ridge, is N. 25°, W. < 70°. Very similar beds have also been observed on the shores of Boundary or Pohenegamook Lake, eighteen miles to the westward, and it is probable that the

Geological boundary changed.

Prominent hills.

Small areas possibly Pre-Cambrian.

ridge is continuous in that direction. In some respects these rocks appear to be older than any seen elsewhere in this section, and recall some of the strata which in southern New Brunswick underlie the lowest Cambrian rocks, as they do also contain other beds which, near St. Magloire, in Quebec, have been similarly referred to a Pre-Cambrian horizon. They cannot, however, here be clearly separated from the undoubted Cambrian strata, and apparently form one series with the latter.

The slates or schists referred to have a width of something over two miles, but owing to the course of the road, which follows the valley of Blue River, occupy most of the space between the 34th and 29th mile-posts. Near the latter the cuttings on the railway are partly through slates of gray, green, purple and black colours, which are very glossy and unctuous, and partly through gray quartzoze sandstones and grits, which sometimes become fine conglomerates, and are filled with numerous fragments of black, glossy slates. The latter rocks are in all probability representatives of Division 4 of the Sillery group, and forcibly recall the grits of the latter as seen near the forts in the rear of Lévis.

Fine conglomerates.

Blue River valley.

At the mill on Blue River heavy beds of white-weathering quartzite again come into view, and are seen to inclose thin beds of fine, fissile, glossy slate, while above them are about one hundred feet of black slate, containing thin beds of quartzite, from one to two feet thick, the dip of the whole series being N. 20° W. < 65°. Beds of similar character appear on the slope of the hill south of St. Honoré, and form also conspicuous ridges for several miles, both east and west of the Blue River valley.

Highest land.

Water-shed.

The church and settlement of St. Honoré mark the highest point on the traverse from the valley of the St. John to that of the St Lawrence, and have an elevation above the sea level of 1,400 feet. The actual water-shed, however, as indicated by the position of Lake St. Francis, whence the stream of the same name flows to the St. John, is nearly nine miles further west, or is within twelve miles of the St. Lawrence. The country about St. Honoré though high, is comparatively flat, showing only gentle undulations, and is covered with a clayey soil containing but few boulders. Rock exposures are also few, and their character indecisive. Near the southern part of the plateau and settlement are gray white-weathering sandstones, resting on black slates, similar to those in the valley of Blue River; while at the 26th mile-post, are dark gray glossy slates, with a high dip, but much corrugated. These latter have been regarded by Dr. Ells, from their lithological aspect, as being below the quartzites and associated strata, and

Anticlinal.

as marking a Lower Cambrian anticlinal. It is quite probable that this may be the case, but the exposures, which are only a few yards in extent, are not sufficient to allow of their relations being determined with certainty.

The descent from St. Honoré, on the northern side, is less rapid than upon the southern, and for the most part, the country is less rugged. For three miles and a half from the station there are no exposures, either on the road or railway. Half way between the 23rd and 22nd mile posts, the latter intersects the former, and just beyond the crossing, are cuttings in black, shining flaggy slates, holding thinner bands of green and purple slates. Their dip is distinct, N. 33° W. < 70°—80°. A quarter of a mile further on is another cutting in dark gray grits, dipping S. 30° E. < 80°. These latter contain little black grains of quartz, together with fragments of black slate, and are supposed to be a repetition of the rocks already noticed at Blue River, and like the latter to represent Division 4, or the Upper Sillery of the Cap Rouge section. From this point on, for several miles, or as far as the St. Francis River, the railway cuttings are frequent, the prevailing rocks being slates, some of them bright green, purple or red, while others are dark gray to black, and glossy. They include, however, some beds of dark gray grits, and one small ridge of white-weathering sandstone. The dips are, as usual, irregular, but mostly to the southward, varying from S. 30° E. < 80° to S. 10° E. < 90°. They are the strata which, on Richardson's map, are referred to the "Lauzon," forming a portion of a belt extending, with great uniformity, and with an average width of about four miles, all the way from the Chaudière River; but in the classification here followed, are referred to Divisions 2 and 3, of the Sillery group. Lauzon of Richardson.

To the above belt succeeds a tract, nearly six miles in width, being the greater part of the space included between the St. Francis and the head of Rivière Verte, in which there are but few exposures, but where such as occur, are very generally of a dark green grit, the characteristic rock of the Sillery, large loose blocks of which are also thickly strewed over the entire area. This belt is also continuous for many miles to the westward, and on the Pohenegamook road, according to Richardson, has a breadth of about eleven miles. To the eastward, its distribution is limited, and in a traverse made by one of the authors by way of Trois Pistoles to Lake Temiscouata, it was found that no continuous belt of these sandstones crossed the line of section.* Belt of dark green grit.

To the eastward the nearest section to that of the Temiscouata road is afforded by the road to St. Hubert which leads by St. Epiphane and

*Annual Report, vol. III., pp. 26, 27, 28 M.

St. Francis between which two points, if prolonged on its strike, this band of Sillery grits would pass. Though the distance across to the Temiscouata Road, where the band has a width as already indicated of about six miles and a half, is only ten miles, no trace of this broad band of grits is to be found. It is true that isolated exposures of the greenish grit are seen, but these seem to represent here as over the whole eastern portion of the area under consideration, only lenticular patches inclosed in the prevailing red, green and gray slates. The band, therefore, must rapidly diminish in width as it is followed eastward from the Temiscouata Road, until at a point a little to the east of the eastern end of Lake St. Francis, it entirely disappears as a distinct band and is only represented by the small inclosed areas already alluded to. On several of the roads and streams further to the east good sections across the strata may be seen and in each of these, though the general structure is the same, the details are quite different so that no general division of the strata into well-defined bands is possible. In fact it would be only on a large scale, lithologically coloured map that any divisions could be mapped in the whole complex of rocks stretching from the St. Lawrence southwards to the overlying edge of the Silurian system. In the case of these Sillery sandstones, as seen over the whole of this easterly area the prevalence of southerly dips is noticeable and would seem to indicate that the strata have been effected by a thrust acting from the south-east and buckling up the beds towards the north-west in overturned anticlinals. These overturns form ridges whose steep northerly sides represent in many cases the lines of local thrust faults, the beds having been pushed from the south-east and overlapping by a short slide. A fault on a larger scale, but of similar character to these small local thrusts would explain the structure at Mount Wissick on Lake Temiscouata, where the heavy beds of Silurian sandstone which make up the main body of the mountain, and which hold a fauna indicating for them a Lower Helderberg age, are found overlying at a comparatively low angle the highly contorted and twisted slates of the Sillery and succeeding the steeply inclined beds of conglomerate and shale of Black Point and its vicinity, whose fossils indicate that they are of about Niagara age. A thrust fault of the character above indicated would very well account for this structure, and the moderate dips of the overlying beds contrasted with the almost vertical position of those of Black Point is perhaps to be more easily explained in this way than by supposing that we have here an unconformity between two parts of the Silurian, with an upthrow fault.*

Band of Sillery grits terminates.

Complexity of general structure.

Thrust faults.

Structure at Mt. Wissick.

*Cf. Annual Report, vol. III., part II., page 35 M.

These overturn folds with prevailing southerly dips, are very common in the case of the Sillery sandstones all over the area now being considered, and presumably the slates have been effected in the same manner, though, owing to their being more profoundly crumpled, and often locally bent and twisted, the structure is not so well defined in them as in the more resistent sandstones. The sandstone exposures cannot be traced in continuous belts for any great distance, partially owing to the profound folding to which the strata have been subjected, but more, probably, to the fact that the sandstones have been originally deposited only in lenticular areas alternating with patches of slates, the sandstones being laid down only where the conditions were favourable for their deposition, these conditions being the same as those which, along the present coast line, cause the alternation of long sandy beaches and extensive mud flats. About twelve or thirteen miles from Rivière du Loup, the band of green Sillery sandstones, last described, is followed by another belt of red, purple and green slates, well exposed near a fall and lumber dam on a branch of the Rivière Verte. They are evidently members of Divisions 2 and 3, being a repetition of the beds at the head of the St. Francis, and mark the northern side of a synclinal, of which the sandstones (Division 4) occupy the centre. The dips, as usual, are southerly, but very variable in their angles sometimes not exceeding 8° or 10°. Half a mile beyond the crossing of the Rivière Verte, rocks, similar to the above, occur, but, at the 8th mile-post, are succeeded by black rusty-weathering slates, which are the only rocks visible for over a mile. These, on the map of Mr. Richardson, are represented as the second division of the Potsdam, while to Division 3, of the same group, is referred a series of grits and sandstones which, in the neighbourhood of the 6th and 7th mile-posts, border these slates on their northern side, being well exposed at a mill on another branch of Rivière Verte. We were unable to find any fossils in the slates, but there is certainly nothing about the sandstones which would indicate that they are others than those which, at so many points, form a characteristic member of the Sillery series. They probably mark another anticlinal, similar to those of St. Louis and Blue River, and, as at the latter, are immediately followed northward, at St. Antoine, by another wide belt of (Lauzon) red shales. This is about five miles from Rivière du Loup station, within which distance the country is flat and largely covered with barrens.

Structure.

Lenticular areas of sandstone.

Rivière Verte.

Anticlinal.

The general arrangement of the rocks along the line of the Temiscouata Portage, above described, will be better understood by reference to the accompanying plan, in which, however, all minor details are omitted.

Plan.

Earlier reports.

The rocks about Rivière du Loup have been prettly fully described in the Geology of Canada (1863) and again in Mr. Richardson's report (1867). To these descriptions we have but little to add, except to say that we are quite unable to see any reason for the separation of any of these beds, as Potsdam, from other portions of the Cambrian series. The extremely complicated, not to say unnatural arrangement of the strata caused by the introduction of this designation, with its subdivision into three distinct groups, as made by Mr. Richardson, will be very greatly simplified if only we admit the identity of the sandstones and grits of Frazerville with those of the Sillery formation, as already described along the Temiscouata section, and as they occur in the vicinity of Lévis. Certainly they cannot be distinguished lithologically from the latter, and their relations to the associated strata would seem to be quite the same. These, as seen at Rivière du Loup station and at the High Falls, are dark gray green and red shales, with bands of gray quartzose sandstone and gray arenaceous limestone, representing Division 3 or the Upper Cambrian; and the strata of limestones and shales, of similar character and colour which appear at Rivière du Loup Point and along the road to Cacouna, and which were described by Richardson as Division 3 of the Potsdam, are, no doubt, these same beds coming up from beneath the quartzites on their north-west side. Thus the sandstones and grits of Rivière du Loup, or rather of Frazerville, represent another synclinal, and as such extend eastwardly to the mouth of Isle Verte. Outside of the red and gray slate belt which extends through Cacouna to the mouth of the same river, another broad synclinal is represented in the rocks of Cacouna Island. The principal features of difference in the rocks of the Cambrian system as seen along the coast, in comparison with those of the interior, is the occurrence here of limestone conglomerates, interstratified with the red and green shales, and which like the associated limestones, are more or less fossiliferous. During the past summers a re-examination of the localities observed by Mr. Richardson, as well as others, have been made by us, but without adding any new information to that obtained by him. The following notes upon this subject and upon the rocks occurring along the coast eastward to St. Fabien are based on observations of Mr. McInnes. As above observed, the rocks which seem most worthy of a special description in connection with the Cambrian of this region are the extensive deposits of limestone conglomerate.

Frazerville grits probably Sillery.

Synclinal.

Limestone conglomerate

These conglomerates occupy a comparatively narrow belt along the present coast line. They are nowhere found at any considerable distance inland, but form long ridges parallel to one another and to the trend of the shore. These ridges are often the sides of long

synclinal axes or the crests of anticlinals, and sometimes merely small whale-back areas protruding through the inclosing slates. They can perhaps be best seen about the village of Bic and westerly along the coast between that point and Trois Pistoles. The irregular coast line, so striking a feature along this part of the south shore, and, indeed, the harbour of Bic, are due to the occurrence of these hard conglomerates alternating with the softer Sillery slates. The tides and currents of the river have washed deeply into the soft shales, and left the hard conglomerates projecting in bold points with irregular and striking outlines. A short description of the rocks seen along the shore from Rimouski south-westerly up the coast will perhaps best give an idea of the mode of occurrence of these beds. Occupying the shore all along as far as a point about three miles above Sacré Cœur de Jésus are gray slates, cleaved obliquely to the bedding, and showing prominent bandings of red, green and purple. The strike of these slates, though showing considerable local curving and twisting, yet follows one general direction parallel with the coast line, the rocks standing at angles of from 70° to 90°. Above this point the coast is bordered by high bluffs of conglomerate, rising in bold cliffs, often almost perpendicularly from the shore. These conglomerates immediately overlie the slates already described, which still continue to form the flat shore at the base of the cliffs. The cliffs are formed of a coarse conglomerate, which is overlaid by a finer conglomerate and sandstone, which passes upwards into a still finer sandstone or quartzite. This general order of beds is preserved all along the shore the coarse conglomerate, whose nature is calcareous and sandy, and among whose pebbles are many of a tolerably pure limestone, occupying a middle place between the overlying finer conglomerate and sandstone and the variously coloured slates below. These underlying beds are the typical Sillery slates which, at different points along the coast, hold *Obolella pretiosa*, etc.* These conglomerates are remarkable, particularly for the interesting assemblage of pebbles which they contain, which are for the most part of a character quite distinct from any rocks occurring in place anywhere in the neighbourhood. One of the commonly occurring pebbles, often found of very large size, is of a bright gray or drab, fine, even-grained limestone of fair purity—pure enough to have been burned successfully for lime. A limestone very similar to that forming these boulders occurs at Lake Mistassini and about the shores of Hudson's Bay, but as far as our knowledge goes at no point nearer.*

Bic conglomerates.

Coast section.

Conglomerates overlying Sillery slates.

Variety of pebbles.

*Annual Report, 1885, p. 32 D.

Fossiliferous pebbles.

Pebbles of a very distinctive limestone, literally crowded with comminuted fossil remains. *Obolella*, *Lingulella*, etc., also occur in considerable numbers. No limestone of a similar character is known nearer at hand than at the Straits of Belleisle, but there beds of so remarkably similar a character are found that it seems probable that the pebbles under consideration have been derived from these beds or rather from a former westerly extension of them.

Diorite and conglomerate pebbles.

There occur also pebbles of a hard amygdaloidal diorite which differs from anything known to occur in the district, and representatives of an older conglomerate, sandstones and quartzites with occasional schists whose derivation does not seem to be so remarkable, though even they are not represented in the neighbourhood by rocks of an exactly similar character.

Derivation of pebbles.

That the beds from which the bulk of these pebbles have been derived nowhere underlie the conglomerates in this district is fairly certain. The complicated folding which has affected all the strata of the region must bring into view at some point representatives of all of the immediately underlying rocks, and beds so conspicuous in their macroscopical character as the two limestones above referred to could hardly have been passed over in a district which is now largely cultivated back nearly to the overlap of the Silurian system.

Absence of Laurentian pebbles.

Another point of interest in reference to these conglomerates in addition to the peculiar assemblage of boulders above referred to, is the absence in them of characteristic Laurentian pebbles. This condition of affairs is in great contrast with the state of things obtaining at the present day. The gravel beds now in process of formation along this part of the St. Lawrence coast are made up in the main from the hard conglomerates and sandstones bordering the shore, but contain in conspicuous numbers, boulders of typical Laurentian gneiss.

Pre-Cambrian conditions.

That none occur in these earlier gravel beds, would go to show that, at the time of their formation, the vast area of Laurentian to the north was covered by other beds. And this view is strengthened by the occurrence of limestone pebbles, already mentioned, which must have been broken from their parent rock at a time when the beds now seen only at Mistassini, Hudson's Bay, and Belleisle, extended widely over the present Laurentian floor.

Early Laurentian floor.

It has been noted by various observers that the Laurentian is found with approximately its present surface contours, wherever the earliest overlying beds are seen overlapping it.*

*Note on the Pre-Palæozoic surface of the Archæan terranes of Canada, by Andrew C. Lawson, Bull. Geol. Soc. of America, vol. I., pp. 163-174.

It had then suffered very considerable denudation even at that early date, and boulders must have been formed in great numbers by the uneven decay of the rock. These boulders should be largely represented in the conglomerates we have been considering, if the Laurentian was then bare of overlying rock, for, from the widely different character of its contained pebbles and boulders, it is to be inferred that this conglomerate was not formed only of material accumulated at the base of some cliff and derived from its decay, but rather has resulted from the gathering together of materials from various beds, probably widely separated. It seems then, probable, that these conglomerates were originally laid down along an extended shore line, defined, approximately, by their present distribution, for the formation of which the materials were carried down from the north by streams and rivers, which cut early Cambrian strata, which covered the present valley of the St. Lawrence and spread widely over the northern area, now denuded down to the bare gneissic hills of Laurentian.

Formation of boulders.

Origin of conglomerates.

The region between St. Fabien and Bic, and extending back to the edge of the overlying Silurian, is occupied, generally, by strata, which are quite characteristic of the Sillery, as defined in this report. There is one notable exception, however, in the case of a small area of sandstones, which occurs at Lac St. Simon, about five miles back from the coast, the exact age of which has not been determined. The following brief description of these rocks is based partly upon observations by Mr. Ord, in 1878.

Lac St. Simon sandstones.

To the south-east of Lac St. Simon and forming bluffs of moderate height along its southern shore lies a small, synclinal basin of a rather hard, quartzose, red sandstone which overlies unconformably the red and gray, highly tilted slates and sandstones of the Sillery. The basin is a very shallow one, the rocks dipping, at its western and south-western edges, east and north-east respectively at angles of 15° to 20° and all along its southern edge, north to north-west at the same low angles. The area has a width of only about a mile and a half with a length of three miles and a half. As no fossils have yet been found in the sandstone and as it overlies unconformably, in the form of a shallow synclinal basin, the Sillery formation, the only inference yet possible as to its age is that it is newer than Middle Cambrian.

Synclinal basin.

Probable age.

That it is not Silurian seems also probable as no rocks of a similar character have been found in the Silurian which is well exposed at no great distance where it overlaps the Sillery both to the east and west. Some of the Silurian white sandstone of the basal beds of Mount Wissick are, however, near enough in character to those now under consideration to make it possible that they may represent these beds. The

Temiscouata beds, though they do not show the deep red colour which is characteristic of large portions of these sandstone, often have their generally white colour tinged strongly with pink or light red.

Building stone.

At the time of the building of the Intercolonial Railway this rock was quarried quite extensively for bridge-building purposes and seems to have served admirably this object and it may be considered both from its texture and colour as a building-stone of value. Though an actual contact between these sandstones and the underlying Sillery was nowhere seen by the writer, yet there can be little doubt about the structure. The hard Sillery quartzites which run under the sandstones in east and west trending ridges have a general dip varying from 45° to 90°, while the sandstones themselves in no case show a higher dip than 20° and flatten out from that attitude to horizontal.

Fossils.

The interval between St. Fabien and Bic is especially remarkable for the great development of the limestone conglomerates. The pebbles of these conglomerates contain fossils of Primordial age, especially *Olenellus Thompsoni*, and the associated shales which are of various colours hold obolellas and graptolites, but these latter do not appear to include any Lévis forms, and are regarded as marking a Lower or Upper Cambrian (Sillery) zone. The conglomerates are conspicuously exposed along the railway, between three and four miles west of Bic station and again on either side of the entrance of Bic Harbour, in each case resting on the shales, and themselves covered, at least on the southern side, by beds of white-weathering quartzite. The dips are very irregular and low undulations are sometimes seen, while in addition to the main belts of conglomerate other smaller and lenticular bands occur at various points around Bic Harbour.

Width of Cambrian belt

Near Rimouski the width of the Cambrian belt becomes greatly reduced, the overlapping Silurian approaching on the Rimouski River within a distance of seven miles from the St. Lawrence, and then sweeping around by St. Blondin and the valley of the Neigette to the Grand Metis River. As seen on the road to St. Blondin and at the lower falls of the Rimouski, the rocks are similar to those of Rivière du Loup, consisting chiefly of slates of red and gray colours, sometimes beautifully ribbanded, and holding thin bands of limestone. Similar beds also skirt the shore in front of the town of Rimouski,

Northern edge of Silurian at Neigette River.

and thence towards St. Anaclet and Father Point. In this vicinity the width of the Cambrian belt is still quite narrow, the distance from the shore to the Silurian escarpment overlooking the valley of the Neigette on the southern side being not more than eight miles, but a short distance to the west it rapidly widens, and embracing the western extremity of Mount Commis sweeps around to the Rivière

Rouge, a branch of the Metis, near where this is crossed by the Taché road. Mount Commis itself is partly composed of trap (dark gray and purplish epidotic and vesicular diorite) and in part of coarse grits and quartzites resembling those of the Sillery. The latter are a part of a belt which crosses the Rouge and reappears on the Taché road, just west of Ste. Angèle; while both north and south of this sandstone belt are belts of red and green slates, with thin bands of limestone and limestone conglomerate, the characteristic rocks of Division 3. Another wide belt of these Upper Cambrian Sillery sandstones runs south of and parallel to the Neigette River and crosses the Grand Metis not far above where this is crossed by the Intercolonial Railway, being largely used in the construction of the culverts and bridges of the latter. Still farther south, near the mouth of the Grand Metis, are at least two other belts of Sillery sandstone, extending westward in the direction of Ste. Flavie, and separated by parallel belts of very coarse limestone conglomerate and dark gray shales. The breadth of the entire group upon the Grand Metis is about sixteen miles.

Grand Metis River.

The last point to which our examinations upon the coast have extended is that of Little Metis Bay. For several miles from Grand Metis the shore shows only Quaternary deposits and is strewed with Laurentian boulders, mingled with a few of fossiliferous Silurian limestone, but, beyond this point, gray shales, banded with purple, come into view, and may be followed for a considerable distance, their general dip being southerly at high angles. Approaching the Lighthouse heavy beds of gray sandstone come into view, often with reversed dips, and run out to the promontory on which the Lighthouse stands. From this point to the mouth of the Little Metis the trend of the shore is nearly at right angles to that of the measures, and hence a section is revealed which is one of the most complete to be met with anywhere along the coast. It is also very interesting as containing the beds in which the remains of fossil sponges were found by Dr. Harrington in 1887, and subsequently more fully collected and determined by Sir William Dawson. As the section, with its contained organic remains (including, besides the several species of sponges, shells of *Obolella pretiosa*, Billings, fucoids of the genus *Buthotrephis*) and (in the sandstones, *Astropolithon*, *Retiolites* and *Arenicolites*) has been very fully described by the last named author in the Transactions of the Royal Society and elsewhere, it is not considered necessary to reproduce the details here. It may, however, be said in general that both the aspect and the arrangement of the rocks, which include limestone conglomerates, shales and sandstones, are

Little Metis Bay Quaternary deposits.

Fossils.

Probable age.

much like those of the beds at Grand Metis and again at Bic, and probably occupy about the same horizon.

Railway cuttings examined.

In the rear of the district last noticed, and about the sources of the Little Metis River, the Cambrian area is traversed by the Intercolonial Railway; and between Little Metis Station and that of Saint Moïse, long and deep cuttings have been made. Unfortunately for their present examination the greater part of these are covered with snow-sheds which almost completely exclude the light, and a satisfactory examination of them is difficult. The longest cutting, exceeding a

Little Metis.

mile, occurs at and just south of Little Metis Station, and is chiefly in dark gray slates, dipping southerly. A quarter of a mile further south another cutting shows gray glossy slates and shales exhibiting several archings, but also for the most part dipping southerly. The next long cutting is also in shales, mostly gray, but including others of purple colour. Still another shows purplish red shales, often splintery and with alternating beds of gray, the whole lying in a succession of low folds. To these succeeds a band of coarse gray grit containing numerous pebbles of white quartz, mingled with many of black slate, and which no doubt, represent the Sillery sandstones of Division 4, the beds previously mentioned being those of Divisions 2 and 3. The dip of the sandstones is northerly, and on their southern side they are immediately underlaid by bright red slates, showing beautiful archings. A quarter of a mile further south more bright red slates occur, alternating with coarse gray grits, and showing great irregularity of attitude, and then after a similar distance a long cutting in dark gray to black slates and shales, probably a repetition of those at Little Metis

Berniers to St. Moïse.

Station. This cutting is about one mile north of Berniers, within which interval there are no exposures; but south of Berniers, which is five miles south of Little Metis, and thence to St. Moïse, bright red beds again predominate, mingled with others of gray and dark gray tints.

St. Moïse to Sayabec.

Between St. Moise and Sayabec the Cambrian is unconformably overlapped by the Silurian and the area examined by us meets that of the Gaspé region explored and mapped by Dr. Ells.

GEOLOGICAL SURVEY OF CANADA

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

ANNUAL REPORT

(NEW SERIES)

VOLUME V

PART II

REPORTS P, Q, R, S, SS

1890-91

OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY

1893

NOTE.

The four plates inclosed herewith (erroneously marked as belonging to Part F.) are intended to accompany Part G. Vol. V. of the Annual Report of the Geological Survey of Canada, 1890-91. It is requested that those who have received Vol V. will have these plates placed in proper position.

Plates 1 and 2 face page 61, Pt. G.

Plate 3 " 62, "

Plate 4 " 74, "

TABLE OF CONTENTS

PART II.

REPORT P.

ON GEOLOGICAL SURVEYS AND EXPLORATIONS IN THE COUNTIES OF PICTOU AND COLCHESTER, NOVA SCOTIA, BY H. FLETCHER.

	(P.) PAGE.
Introduction	5
Geology	6
Cambro-Silurian	8
Silurian	10
Devonian	17
Middle	18
Upper	34
Carboniferous	73
Carboniferous Conglomerate	73
Carboniferous Limestone	85
Millstone Grit	102
Coal Measures	105
Permian	108
New Glasgow Conglomerate	109
Middle Group	120
Upper Group	131
Triassic	141
Surface geology	144
Igneous rocks	147
Scenery, Climate, Timber, Productions, etc	167
Economic Minerals	170

REPORT Q.

ON NATURAL GAS AND PETROLEUM IN ONTARIO PRIOR TO 1891, BY H. P. H. BRUMELL.

	(Q.) PAGE.
Introduction	5
I.—Extracts on Origin of the Hydrocarbons	10
II.—Record of Boring Operations and Notes on the Distribution of Natural Gas and Petroleum	21
Eastern Ontario	21

(Q)
PAGE

II.—Record of Boring Operations, &c.—Con.

York County ... 24
Simcoe County ... 26
Grey County ... 29
Halton and Wentworth Counties ... 30
Lincoln County ... 32
Welland County ... 33
Waterloo County ... 41
Wellington County ... 42
Brant County ... 43
Oxford County ... 45
Norfolk and Elgin Counties ... 48
Middlesex County ... 49
Salt Region ... 53
Perth County ... 60
Lambton County ... 61
Kent County ... 70
Essex County ... 76

APPENDIX A.

TABLE OF BEAUMÉ'S HYDROMETER WITH CORRESPONDING SPECIFIC GRAVITIES ... 87

APPENDIX B.

COST OF "DRILLING RIG" AT PETROLEA ... 89

APPENDIX C.

BIBLIOGRAPHY ... 91

REPORT R.

CHEMICAL CONTRIBUTIONS TO THE GEOLOGY OF CANADA FROM THE LABORATORY OF THE SURVEY, BY G. C. HOFFMANN.

(R.)
PAGE.

Table of Contents ... 5
Miscellaneous Minerals ... 11
Natural Waters ... 22
Brief Outline of the Methods pursued in the Manufacture of Salt ... 36
Iron Ores ... 38
Nickel and Cobalt Ores ... 39
Gold and Silver Assays ... 48
Mineralogical Notes ... 65
Miscellaneous Examinations ... 70

REPORT S.

DIVISION OF MINERAL STATISTICS AND MINES, BY E. D. INGALL AND H. P. H. BRUMELL.

	(S.) PAGE.
Summaries of Production, Exports and Imports	6
Abrasive Materials	9
"*Amber*"	14
Antimony	16
Arsenic	17
Asbestus	19
Coal	31
Coke	50
Copper	51
Gold	54
Graphite	72
Gypsum	76
Iron	81
Lead	90
Manganese	92
Mica	101
Mineral Pigments	105
Mineral Water	108
Miscellaneous	111
Natural Gas	117
Nickel	121
Treatment of Ore	132
Petroleum	143
Phosphate	153
[redacted]	161
[redacted]	162
Silver	167
Structural Materials	182
Index	201

REPORT SS.

DIVISION OF MINERAL STATISTICS AND MINES, BY E. D. INGALL AND H. P. H. BRUMELL.

	(SS.) PAGE.
Mineral Products, 1886 to 1891	4
Summaries of Exports and Imports	5
Abrasive Materials	6

Antimony 1
Arsenic 1
Asbestus 1
The Canadian Asbestus Industry, by L. A. Klein 1
Coal 2
Coke 6
Copper 60
Graphite 70
Gypsum 74
Iron 78
Lead 88
Manganese 90
Mica, Mineral Pigments 93
Mineral Water 96
Miscellaneous 98
Natural Gas 102
Nickel 110
Petroleum 120
Phosphate 133
The Precious Metals 135
Gold 135
Silver 139
Discovery and Development 140
Pyrites 1
Salt 1
Structural Materials 1
Index 1

MAPS AND ILLUSTRATIONS

VOL. V. PART II.

		Page
29.	Sketch plan of the Niagara Peninsula	32 Q
30.	Sketch plan of Essex County, Ont.	76 Q
31.	Section, Whitby, Ont., to Fredonia, N.Y.	Q
32.	Section, Whitby, Ont., to Courtright, Ont.	Q
33.	Sketch map of South-western Ontario	Q
34.	Section from Port Colborne, Ont., to Kincardine, Ont.	Q

(Statistical Diagrams.)

35.	(I.)	*Asbestus*—Production, quantities and values, 1880–1890	18 S
	(II.)	*Coal*—Production, quantities and values, 1886–1890	30 S
		do Production by provinces, quantities and values, 1890	
		do Men employed, &c., 1890	
	(III.)	*do* Nova Scotia, production, quantities, 1870–1890	
		do British Columbia, production, quantities, 1874–1890	
	(IV.)	*do* Exports, quantities, 1873–1890	
	(V.)	*Copper*—Prices current for 1890	52 S
	(V.)	*Gold*—British Columbia, production, values, labour, 1858–1890	54 S
	Gypsum	*do* Nova Scotia, production, values, yield of gold per ton of ore crushed, 1862–1890	56 S
	Salt	*do* Quebec, production, values, 1877–1890	
42.	(V.)	*Iron*—Production, values, 1886–1890	80 S
43.	(VI.)	*Petroleum*—Prices current, 1886–1890	150 S
	(VII.)	*Phosphate*—Exports, quantities and value, 1878–1890	154 S
	(VIII.)	*Salt*—Imports, quantities, 1880–1890	166 S
	(IX.)	*Silver*—Prices current, 1890	182 S
		Asbestus—Production, quantities and values, 1880–1891	12 SS
48.	(II.)	*Coal*—Production, quantities and values, 1886–1891	24 SS
		do Production by provinces, quantities and values, 1891	
		do Men employed, &c., 1891	
49.	(III.)	*do* Nova Scotia, production, quantities, 1870–1891	
		do British Columbia, production, quantities, 1874–1891	
50.	(IV.)	*do* Exports, quantities, 1873–1891	

(Statistical Diagrams.)

			PAGE
51.	(V.)	*Copper*—Prices current for 1891	68 SS
52.	(VI.)	*Gold*—British Columbia, production, values, labour, 1858–1891	136 SS
53.	(VII.)	*do* Nova Scotia, production, values, yield of gold per ton of ore crushed, 1862–1880	
		do Quebec, production, values, 1877–1891	
54.	(VIII.)	*Iron*—Production, values, 1886–1891	78 SS
55.	(IX.)	*Petroleum*—Prices current, 1886–1891	132 SS
56.	(X.)	*Phosphate*—Exports, quantities and values, 1878–1891	134 SS
57.	(XI.)	*Salt*—Imports, quantities, 1880–1891	182 SS
58.	(XII.)	*Silver*—Prices current, 1891	140 SS

ERRATA.

Page 19 R, side note, line 3, *omit* "Con."

Page 31 R, side note, line 2, *read* "of" *instead of* "on."

Page 44 R, side note, line 2, *insert at end* "Con."

Page 141 S, line 9, *after* "where no allowance is made by the buyers" *insert* "for the copper."

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

GEOLOGICAL SURVEYS AND EXPLORATIONS

IN THE

COUNTIES OF PICTOU AND COLCHESTER, NOVA SCOTIA

BY HUGH FLETCHER, B.A.

OTTAWA:
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S
MOST EXCELLENT MAJESTY.
1892

To ALFRED R. C. SELWYN, C.M.G., L.L.D., F.R.S.,
Deputy Head and Director of the Geological Survey of Canada.

SIR,—I have the honour to submit herewith a report on work done during the summers of 1887 to 1891 in the counties of Pictou, Colchester, Hants and Cumberland, as described in the Summary Reports of the department for these years.

As in previous years, detailed surveys were made, plotted on a scale of forty chains to an inch and used with supplementary surveys obtained from the Admiralty, the Department of Railways and Canals, the Department of Crown Lands of Nova Scotia and Church's county maps, for the construction of a map on a scale of one mile to an inch on a projection laid down by Mr. Scott Barlow, and, west of Great Village River, mostly drawn by him from his own surveys. Map.

My assistants in different parts of the field work have been Messrs. M. H. McLeod, J. A. Robert, D. I. V. Eaton, A. Cameron, John McMillan, W. B. Almon, Fred. Coldwell and Prof. Coldwell; and in preparing the map, Messrs. Robert, Eaton and B. A. L. Huntsman. Assistants.

To enumerate all those from whom we have received kindness, hospitality, assistance and information would be impossible, but the following gentlemen may be especially mentioned: Henry S. Poole, John Rutherford, J. G. Rutherford and Robert Drummond, of Stellarton; William B. Moore, W. P. McNeil, Jeffrey McColl, H. V. Jennison, Harvey Graham and James F. McLean, of New Glasgow; R. P. Fraser, James Hudson and Robert Simpson, of Pictou; Alex. McBean and T. M. Turnbull, of the Vale; A. McG. Barton, of Pine Tree; James Maxwell, John William Sutherland, James Fraser (Moose), Wm. Maddin and Charles Fergie, of Westville; John A. McKenzie of Lower Caribou River; James Wm. Hogg, of Pictou Island; R. E. Chambers, John Dunbar and Henry McLean, of Hopewell; Donald Fraser of Springville; John A. Cameron, of Bridgeville; Graham Fraser, of Trenton; A. McKimmie and A. Bain, of Riversdale; James Pitblado and J. K. Blair, of Truro; Gilbert Sutherland, of the Falls, Waugh River; John McKay (Ross), Robert Murray and Duncan McKenzie, of Earltown; Timothy McLennan and Dr. E. Roach, of Tatamagouche; Peter McIntosh and Hugh McKay, of

New Annan; G. W. Densmore, of Brookfield; Dr. W. D. McKenzie, Dr. A. S. Townshend, C. E. Day and W. F. Jones, of Parrsboro'; A H. McKay, James H. Austen, E. Gilpin, Martin Murphy, W. A. Hendry, A. F. Church, T. J. Ritchie, Charles J. McDonald and F. W. W. Doane, of Halifax; R. G. Leckie, W. F. Jennison and Wm. Smaill, of Londonderry Mines; P. S. Archibald and Wm. B. McKenzie, of Moncton; R. G. E. Leckie, of Middleton; Professor H. Y. Hind, of Windsor; Sir J. W. Dawson, of Montreal.

I have the honour to be, sir,

Your obedient servant,

HUGH FLETCHER.

REPORT

ON

GEOLOGICAL SURVEYS AND EXPLORATIONS

IN THE

COUNTIES OF PICTOU AND COLCHESTER, NOVA SCOTIA.

INTRODUCTION.

The geology of that part of Nova Scotia which lies in the counties of Pictou and Colchester, west of the district to which Report P for 1886 relates is described in this report. It embraces the basins of the rivers of Pictou and Caribou, Toney River, River John, Waugh and French Rivers, which flow into Northumberland Strait; Salmon, North, Stewiacke and Shubenacadie (in part) which flow into the head of Cobequid Bay; Chiganois, Debert, Folly, Great Village, Portapique, Economy, Five Islands, Moose, Parrsboro' and other rivers that empty into Minas Basin. The northern portion of this district is made accessible by the Oxford and Pictou branch of the Intercolonial railway, the southern portions by the main lines of this railway. The district is all well settled, with the exception of two tracts of mountainous country. The first of these forms the Cobequid Hills which extend from Cape Chignecto to Mount Thom in a belt about ten miles wide which crosses the Intercolonial railway between Greenville and Folly Mountain. In places these hills rise to a height of 1,050 feet above the sea, being probably more than 400 feet lower than the highest summits of northern Cape Breton. The second tract of uninhabited country, from the Pictou branch of the Intercolonial railway between Valley and Glengarry stations south as far as the Stewiacke River settlements is an extension of that between East River of Pictou and the West River of St. Mary's.

District described.

Rivers.

Railways.

Mountains.

The district displays great variety of surface features accompanied by differences in the structure and constitution of its rocks. On Cobequid Bay and Minas Basin there are about 20,000 acres of rich

Character of the soil.

meadowland reclaimed by dykes from the high tides of the Bay of Fundy. Along the rivers and brooks there are large belts of excellent intervale; while the upland, even to the summits of the hills, is fertile.

Harbours.

On the north side is the excellent harbour of Pictou and the smaller harbours of Caribou, River John, Brulé and Tatamagouche, Boat and Little Harbours. Besides the Caribou Islands and several smaller islands near the mainland, Pictou Island, which is about five miles long and a mile wide, lies nine miles from Pictou light. The land

Scenery

along the shores is generally low, but views of great beauty are presented in several places, whilst the hills "exhibit prospects which in richness and variety of sea and land, hill and dale, river and shore, field and forest will compare with any in America."* Lakes add "in some places a pleasing variety to the landscape" and on some of the streams are beautiful cascades and pools.

GEOLOGY.

Geological formations.

The geological formations found in this district are for the most part the same as, and an extension of, those described in the Report P for 1886, above mentioned. Of the large areas of Pre-Carboni-

Metamorphic rocks.

ferous metamorphic rocks by far the greater part consists of Devonian strata. The Cambro-Silurian is confined to the hills east and north of the valley of the East River of Pictou and between Sunnybrae and Plymouth at the south-eastern corner of the Pictou coalfield where the Silurian also occupies small areas and is not met with again except in limited patches at and near Earltown and in Waugh River. Devonian fossiliferous rocks are largely developed south of the East River of Pictou and thence without interruption run far to the westward of Truro on the south side of Cobequid Bay and Minas Basin. They appear again in Waters Hill, McCulloch's Brook and Mount Thom, and form, with the series of igneous rocks which are everywhere found to cut and alter them, the axis of the Cobequid Hills. They include the iron ore series of Londonderry and are similar to the metamorphic rocks of Antigonish and Guysboro' counties.

Carboniferous rocks.

Carboniferous limestone occupies a considerable portion of the basin of Stewiacke and Shubenacadie Rivers. Outliers are also found on Minas Basin, on Penny's Mountain, on the East Mountain of Onslow, resting in small unconformable patches on the Devonian rocks, also underlying the coal measures and millstone grit of the Pictou coalfield. The coal measures occupy an irregular area

*Patterson's History of the county of Pictou, Dawson Bros., 1877.

between the Middle River of Pictou and Sutherland River. A considerable area of Carboniferous rock skirts the south side of the Cobequid Hills; by Dr. Ells it is supposed to be Lower Carboniferous, while Mr. Barlow considers it millstone grit, and Sir William Dawson, coal measures.

Along the northern part of Pictou and Colchester counties, from Big Island, Merigomish, to Brulé and Tatamagouche, there is a wide belt of Permian rocks, the conglomerate at the base forming Fraser's Mountain, Green Hill, Roger's Hill, Fitzpatrick's Mountain, Dalhousie Mountain, the Biorachin and other highlands on its course. The conglomerate is overlaid by grey sandstones, like those of Pictou and West River, containing one or more thin coal seams; and these are succeeded in turn by brownish and red sandstones and marls with thin layers of limestone. Dark red, crumbly, Triassic sandstone and conglomerate, generally in nearly horizontal attitude, occupy a basin which extends westward from near Valley station, one rim fringing the south side of Minas Basin, the other reaching much further inland on the north side. Two principal intrusions of igneous rock have been determined within the area. In one red syenite, diorite, felsite and similar rocks cut no strata newer than the Devonian, in the other Triassic sandstones are intersected and intermixed with great masses of basalt and amygdaloid which furnish the celebrated trap minerals of the Bay of Fundy.

Permian.

Triassic.

Igneous rocks.

These strata may be classified as in the following tabular view :— Classification of rocks.

M. Post-Tertiary.

H. Triassic.

G. 4. Permian.....
1—Upper red sandstone and shale group, with thin bands of limestone.
2—Middle grey sandstone and shale group, with small coal seams.
3—New Glasgow conglomerate.

G. Carboniferous....
G. 3—Coal measures.
G. 2—Millstone grit.
G. 1—Carboniferous limestone.
G. 1m—Carboniferous conglomerate.

F. Devonian.....
Upper red slate and sandstone group. Red rocks of Union, on the Truro and Pictou railway.
Middle grey slate and sandstone group. Riversdale and McKay Head rocks.

E. Silurian.....
E. 6—Lower Helderberg.
E. 3—Niagara.
E. 2—Clinton.
E. 1—Medina.

D. Cambro-Silurian..
Upper sandstone and conglomerate of Bear's Brook.
Middle shale and sandstone of Baxter's Brook.
Lower flinty shale and sandstone of James River and Eigg Mountain.

Igneous Rocks..... { Of Triassic or Post-Triassic age.
Of Devonian age.
Of Cambro-Silurian age.

D.—Cambro-Silurian.

Constant association of the Cambro-Silurian with igneous rocks.

That within the areas marked Cambro-Silurian on the map there may be rocks of Silurian age, and that the boundaries in some cases may be vague, or that greatly altered patches of Silurian may have been mistaken for Cambro-Silurian is quite possible; but there is apparently a distinct series of these lower rocks, often so closely associated with Silurian strata and also with igneous rocks that it is difficult to determine whether they may not be Silurian indurated along the line of contact with igneous intrusions. They belong chiefly to the lower subdivisions especially to the Baxter Brook group. Most of the details regarding them were collected by Mr. Robert.

Park's mills and falls.

The rocks of Park's Falls with associated masses of diorite, have already been described. At twenty paces above the bridge on the most westerly of the two brooks above the mill-dam, they are succeeded by Medina, quite unaltered, which are well exposed higher up the brook. South of the St. Mary's road hereabout are greenish and reddish, rubbly, flinty slates, like those of Baxter Brook, with red flinty grits and siliceous sandstones, succeed the coal measures or Carboniferous limestone, in some of the brooks and include a great variety of trappean rocks. In McLellan's Brook, at and below the falls, one mile below Brookville, trap and diorite, are followed down stream by slightly altered greenish-grey fossiliferous rocks, succeeded, further down stream, by greatly altered grits and bright greenish and reddish slaty argillites, probably Cambro-Silurian. The dip gives no key to the relation of the two series. In the brook which flows from the mountain church into McLellan's Brook, Silurian rocks are succeeded by greenish argillite and fine sandstone, having a much more flinty aspect, splintery, ringing and rubbly, veined with quartz. At the mountain church and on the road towards Brookville are light green, white-weathering, quartz-veined slates, almost certainly of this age. At the foot of the hill, however, and on the road towards Bridgeville, past James Seivright's they are succeeded, as elsewhere stated, by the Silurian; but further south white-weathering, scaly or schistose, fine, granular, felsitic rocks reappear, the Silurian lying, however, not far to the westward. In Mr. Thomas McMillan's fields, white quartzite is largely exposed with reddish grit and green slate. The quartzite contains veins of limonite and is in contact with

Contacts of Silurian and Cambro-Silurian, McLellan's Brook.

Bridgeville.

Iron ore.

greenish felsite and other igneous rocks. The road thence towards East River shows only Silurian. The other rocks of the neighbourhood of Mount Horeb are whitish sandstone, light greenish-grey, soapy, ribbanded slates, cut by diorite, and underlying Medina. At the head of the west branch of Sam Cameron's brook, underlying Clinton slates, are matted or felted, cleaved, greenish slates, but most of the rocks are volcanic. Mount Horeb.

At Blue Mountain church is a purplish grit; green grit and slate are under the post office, while north of the school is a green flinty slate. Near McLellan's Mountain church are outcrops of greenish, fine, rubbly sandstone and slate, perhaps belonging to the Baxter Brook series; they underlie the Carboniferous limestone and are cut by greenish and dark grey diorite. Below the bridge, half a mile below the cemetery on McLellan's Brook, greenish, thick-bedded argillaceous sandstone, probably Medina, is succeeded by greenish calcareous rocks underlaid by red, massive, soft argillite, breaking into irregular pieces. The lowest green beds are nodular or brecciated, and sometimes splintery, associated with greenish, massive, flinty, fine sandstone and with layers of the peculiar breccia of Hartsborn Brook and Barney's River. A little lower down are outcrops of reddish grit, succeeded again by greenish, well-bedded argillaceous sandstone, sometimes brecciated and nodular, crowded with Silurian fossils; below this, the reddish and greenish rubbly rocks and reddish flinty, coarse grit with quartz veins and blotches, extending to the contact of the Carboniferous. Near McPherson's mill, green, somewhat soft, soapy slate contains yellowish-grey flinty bands. On the road from the head of Cross Brook to Brookville, succeeding Silurian fossiliferous rocks which extend to the north of the brook is a mass of diorite and, close by, white soapy slates. South of the road, the rocks seem to be Silurian, but along it for some distance reddish, flinty grit is close on the left and a diorite hill beyond. The grit is netted with veins of quartz and associated with reddish, flinty, compact slate. In proceeding down McLellan's Brook towarks Brookville, the hill recedes on the left leaving the road in Silurian rock as far as the bridge. A little beyond it, however, are masses of Cambro-Silurian grit and conglomerate. McLellan's Brook. Intimate mixture of Cambro-Silurian and Silurian.

On the East River immediately opposite the mouth of Ogg Brook, the rocks in the road are greenish slates with red layers, probably of the Baxter Brook group, and this is, perhaps, also, the age of the red and green, papery, soft slates cut in mining the iron ore in the tunnel on the west side of William Grant's Brook and also at Fraser's (saddler), although possibly these may represent East River of Pictou. Iron ore of Grant's Brook

altered members of the Lower Helderberg. The ore taken out 60 years ago is said to have come from beneath this red slate. On the left bank of Grant's Brook, a short distance higher, dark grey Arisaig slates are well exposed for some distance. At the upper mine level on the hill, the west wall shows greenish, soft, Silurian rock dipping westward at a low angle, whereas the east wall is a compact, flinty, white quartzite like that of McMillan's and probably Cambro-Silurian. This would seem to indicate a tongue of Cambro-Silurian perhaps joined with that of McMillan's between which and the Silurian the ore has been filled into a fissure ; but small veins of limonite also cut the quartzite. A tunnel driven at a lower level into the hill struck a face of light-greenish, earthy, shelly, Silurian rock from which the ore turned sharply to the eastward probably along the contact with the Carboniferous.

Glencoe Brook

In Glencoe Brook, immediately above the school, reddish, flinty rocks, perhaps Cambro-Silurian are followed by cliffs of Silurian as far as the falls. One bed is a flinty, quartz-veined quartzite not unlike that of McMillan's and also like the rocks associated with red hematite at Webster's. Not far above the falls, however, Cambro-Silurian rocks reappear, and it may be that for some distance the brook forms the boundary. The fossils collected from the fall by Mr. Robert and examined by Mr. Ami were Medina. Near the source of the brook, veins of ankerite are found in flinty, splintery, ribbanded slates, associated with reddish-grey and greenish, soft, soapy slates. Lower down are rocks which may be newer and represent those found in the East River above Sunnybrae bridge—greenish and reddish, mottled, flinty rocks with joints full of films and small veins of hematite. They are associated with mottled, micaceous, soapy argillite, followed up stream by rocks more closely resembling the typical Medina. In the gorge, blackish, flinty, pyritous, massive rocks and greenish-grey rusty sandstones holding encrinites and brachiopods are succeeded by the rocks described above.

Silurian rocks.

Blanchard Brook.

In the west branch of Blanchard Brook, near its head, are outcrops of Cambro-Silurian near the Silurian. Quartzites and slates, perhaps of this age, are found also on Irish Mountain, and at the head of Holmes Brook, in Corrimony, greenish compact slates are associated with traps.

E.—Silurian.

Description of Silurian rocks

Numerous details concerning nearly all the Silurian localities referred to in this report have been given by Dr. Honeyman and Sir

J. William Dawson in the Transactions of the Nova Scotia Institute of Science, the Canadian Naturalist and Acadian Geology. The subdivisions are those adopted in the report for 1866. No continuous sections like those of Arisaig have been measured, the outcrops being, as a rule, too much disturbed, although many good exposures occur. by Honeyman and Dawson.

E. 1.—Medina.

The best exposures of this group, nearly always associated with Clinton and higher strata, are found on McLellan's Mountain, in Sutherland River, Cameron Brook, Holmes Brook, on the St. Mary's road and at Springville* some of which have been already referred to. Areas of Medina.

In some of the brooks the alternations of Silurian and Cambro-Silurian are very numerous and the breadth of the various groups of Silurian is necessarily narrow.

In the basin of French River, near Blue Mountain and in the neighbourhood of McPherson's mills there are outcrops of Medina and Clinton rocks. In Glencoe Brook, as already remarked, many of the rocks hold Medina fossils. The whitish fine grit or quartzite, veined with quartz, is, perhaps, of this age and runs out to William Grant's. Other outcrops, some distance above the road in this brook, consist of light grey slate and rusty-weathering sandstone, holding brachiopods and cut by threads of spathic iron. The flinty grit is probably that found at Sunnybrae; it passes near the head of Holmes Brook, not far from the Corrimony road, occurs some distance north of the fork of the roads, is found between McPherson's grist mill and Murdoch Lake and runs towards Blanchard. From McPherson's mills, for some distance on the road towards Glencoe school, the rocks are fragmental felsites. Then, in a steep hill on the right there are exposures of flinty quartzite, like that of Grant's, but a short distance beyond and immediately opposite the first bridge on the brook flowing southward into Glencoe Brook are rocks evidently Silurian. French River. Glencoe Brook to Murdock Lake.

The greenish, rusty-weathering, earthy, micaceous shale and massive rock at the head of Campbell Brook and towards Mount Horeb consist of Medina and Clinton overlying the Cambro-Silurian. On the southern slope of Mount Horeb siliceous Medina rocks are succeeded by black Clinton shales.

---

* Trans. N.S. Inst. Sc., vol. III., pp. 62, 69, 70, 108; vol. IV., p. 464; vol. V., pp. 67, 72, 202, 207, 209, 293.

Iron mines.

At the Blanchard iron mines good outcrops of Silurian slate are found at Ross's and McDonald's and again near Glencoe Brook, at a knoll of diorite containing specular iron, in the unsettled land between the iron mine and Blanchard road and on that towards Webster's. The iron mine at Webster's* occurs among greenish-grey, tough, siliceous rocks associated with a whitish quartzose grit, doubtfully Niagara or Medina, their relation to the neighbouring Clinton slates being obscure. The grit on the east side of the road is possibly Silurian rather than Cambro-Silurian as at first supposed; but at Archibald Fraser's, in the Wentworth Grant, on Sutherland's River† an ore bed forty feet thick seems again to separate the Silurian from the fragmental slates which lie to the north, and at Angus Fraser's the ore is in white quartzite, perhaps also Cambro-Silurian. Again near the little lake at Archie Fraser's greenish, fragmental slate is associated with the ore, which is apparently, therefore, inclosed in Medina rocks overturned. It has been supposed that all these outcrops of red hematite are connected, but this is very doubtful. Between the ore at Webster's and the road to the school at Blanchard road, Clinton slates are found, and still more abundantly in the road. Some of the Silurian rocks of Earltown are, perhaps, Medina, but as they are chiefly higher they will not here be described.

E. 2.—Clinton.

Descriptions of the Clinton.

Rocks of this formation occur chiefly at Sutherland River, Blanchard, McLellan's Brook, Cross Brook, Cameron Brook, Simon Fraser's Mountain, on the St. Mary's road, and at Earltown.‡ They resemble, lithologically, the rocks of this age already described at Arisaig, presenting dark and light coloured shales with characteristic fossils.

Search for coal.

Among the dark slates of the neighbourhood of Blue Mountain are crumbly beds, which have been uselessly prospected for coal.

Cross Brook igneous rocks.

In Cross Brook|| above the track between Churchville and Johnston's, greenish and dark grey slates of this age are well exposed with a very variable dip, although blocks of trap are in the brook, rolled from the hill to eastward. Higher up, the rocks are more altered and contain quartz veins. On the road to eastward towards Brookville from the head of the brook, greenish Silurian rock is in contact with large masses of diorite, beyond which are slates, pro-

* Trans. N.S. Inst. Sc., vol. V., p. 201.

† Trans. N.S. Inst. Sc., vol. IV., p. 140.

‡ Trans. N.S. Inst. Sc., vol. III., pp. 70, 108, 258, 393; vol. IV., p. 464; vol. V., pp. 64, 65, 205, 207; Acadian Geology, pp. 560, 568.

|| Trans. N.S. Inst. Sc., vol. III., p. 66.

bably Cambro-Silurian; and on the road eastward from Brookville the contact of the Silurian and Cambro-Silurian is again well seen.

Webster's iron mine.

In the neighbourhood of Webster's iron mine, Clinton slates are apparently overlaid by greenish arenaceous rocks like the Niagara; and according to Sir J. W. Dawson it is in rocks overlying the Clinton that the iron ores occur.* The slates again appear on the road to the bridge on McLellan's Brook; and for a considerable distance below the mills at this bridge banks of dark bluish-grey, pearly, papery slates with harder lenticular bands carry quartz veins which have been mined. They extend nearly to the road at the cemetery, where they appear to be in contact with Cambro-Silurian, with the intervention of a band of Medina. The light grey, micaceous, earthy shales in the brook below Webster's and in other brooks of this neighbourhood, are perhaps also of this age.

Quartz veins prospected.

Sam Cameron's Brook.

Immediately above the bridge at St. Paul's church, Sam Cameron's Brook passes between cliffs of dark, crumbly, rusty-weathering slate, overlying rocks of igneous origin, probably Cambro-Silurian. They are cut by quartz veins, two inches thick and downward, show many fucoidal markings, ferruginous veins and nodules of compact grey limestone. In the little tributary from the eastward are twisted, micaceous, graphitic slates.

William Grant's Brook.

In William Grant's Brook, bluish-grey, rusty-weathering slates, shiny and graphitic, showing little variety, except that in places they hold thin pyritous bands or veins and yield graphitized markings of plants, perhaps fucoids. In Holmes Brook, near the Corrimony road, twisted black slates contain minute quartz veins and numerous graphitized markings of minute branching plants.

Earltown and Salmon River.

The Silurian rocks of Earltown and the head of Salmon River† may here be described, although many of them are undoubtedly higher. They are everywhere unconformably overlaid by Permian conglomerate. In the neighbourhood of East Earltown and Spiedel Hill they consist of grey, greenish and bluish-grey slates full of fossils. In Waugh River above Gilbert Sutherland's, the bluish-grey, flinty, splintery, compact quartzites, with threads of quartz and calcspar, first seen in irregular, nearly vertical bedding, are succeeded up stream by dark bluish-grey, more argillaceous, rusty-weathering rocks, greatly contorted, exposed nearly to the bridge on the road to Baillie's.

Igneous rocks.

The cliffs of the brook above the hotel at the village of Earltown show dioritic rock in contact with grey, rusty-weathering, fine

* Canadian Naturalist, vol. IX., No. 6.

† Dawson's Acadian Geol., p. 270; Supplement, pp. 75 and 76; Trans. N.S. Inst. Sc., vol. III., pp. 346 and 393.

massive slate, full of shells. In one of the brooks running into Waugh River, some miles below Earltown, are siliceous, greenish and bluish-grey, fossiliferous slates, with quartz veins and blotches. Fine ledges are also found on the road which runs north-west from the post road at Earltown mills of rusty-weathering, massive, grey, argillaceous and siliceous rocks, full of threads of quartz. On the road west from Earltown church, Silurian debris is abundant. At the old mill-dam near John McKay's (Ross) is an outcrop of bluish-grey flaggy argillite which makes good whetstones and is full of shells. Beyond it, however, are outcrops of flinty, red argillite sandstone and conglomerate succeeded by the Permian conglomerate of Matheson Brook. The relation of the red rocks to the Silurian is somewhat obscure. They may be above or below it, but have in the meantime been included in the Devonian. At the cross roads in the Biorachin are greenish, compact, quartzo-feldspathic sandstones and bluish-grey, rubbly, striped slates, perhaps Lower Helderberg, in contact with black diorite. Further west are dark slates full of fossils; and on the road from Earltown towards Kemptown are other outcrops. On that which runs west from the county line near William Ferguson's, bluish-grey flinty rock is seen near the Permian conglomerate of the neighbourhood, which is largely composed of its debris. In some places it contains shells which are clearly Silurian, in others it is brecciated, slaty and compact, evidently altered by the igneous rocks of the vicinity so that it might be mistaken for the rocks which have been called Cambro-Silurian at the East River of Pictou. Associated with the hard rocks and bluish-grey slates, are others probably higher, which contain fossils resembling Niagara and Lower Helderberg. Towards Nuttby certain outcrops were found, containing fossils which may perhaps point to the contact of the Silurian with the Devonian of that neighbourhood; but these require further examination.

Whetstones.

Contact with Permian.

Metamorphism by igneous rocks.

Wentworth.

The Silurian rocks of Wentworth and the vicinity on the north side of the Cobequid Hills have been fully described by Dr. Ells,* who refers also to a list of fossils determined by Mr. Ami from a part of the series. In the cuttings immediately west of the station, dark green, fine diabase cuts and alters rubbly Clinton slates. In the next cuttings the rocks resemble more closely the siliceous Medina, those first seen being cut by a mixture of dark diorite and reddish syenite or granular quartz-felsite. The sedimentary rocks here are very massive and, near the dykes, rubbly. At the tunnel on Whetstone Brook, between two cuttings, these siliceous

Igneous dykes

* An. Rept. Geol. Surv., vol. I., 1885, Part E, p. 51; Cf. also Supplement to Acadian Geol., pp. 75 and 92; Trans. N.S. Inst. Sc., vol. III., p. 351; vol. IV., p. 478.

rocks are on the upper side, while at the mouth of the tunnel a mass of granular and fine dark diabase has to north of it a siliceous Medina rock, succeeded immediately by dark Clinton slates. Down stream and overlying come greenish flags, full of shells, probably Upper Clinton, which present a considerable thickness before they are interrupted by Permian? sandstone at the fork of a branch from the south-east. At the tunnel over the branch immediately west of Wentworth the brook shows large outcrops of dark, friable, altered slates. Up stream, dark diorite is succeeded immediately by siliceous Medina, finely exposed in cliffs near the head of the brook.

Other small detached outcrops of sedimentary rocks occur among the igneous rocks of the mountains west of Wentworth, in the Second River, in Bulmer Brook and other streams. From dark shales in a little brook at the road near Farmington, discovered by Mr. Scott Barlow in 1876, were obtained the following fossils determined by Mr. Ami:—

Fossils discovered by Mr. Barlow in River Philip.

PLANTÆ.

1. *Palæophycus sp.* or *Palæochorda* sp.

GRAPTOLITHIDÆ.

2. *Cyrtograptus Grayiæ*, Lapworth, or a very closely related species.

BRACHIOPODA.

3. *Lingula lamellata*, Hall (*Cf. Lingula striata*, Sowerby).
4. *Leptæna transversalis*, Dalman.
5. *Rhynchonella nucula?* Sowerby, or *R. cuneata*, Dalman.
6. *Leptocœlia hemispherica?* Sowerby, or allied species.

This is the first time that the genus *Cyrtograptus* has been recorded in America. It is eminently characteristic of the lower half of the Silurian system.

E. 3. Niagara, and E. 6. Lower Helderberg.

Rocks of these formations overlie the Clinton in most of the Silurian areas and are well exposed at Springville, in Sutherland River, Blanchard and other localities.* A list of these is given by Dr. Honeyman in the Transactions of the Nova Scotia Institute of Science, vol. III., p. 393; and a list of the fossils in vol. V., p. 210.

Upper Silurian areas.

* Trans. N.S. Inst. Sc., vol. III., pp. 8, 63, 66, 68, 71, 107, 393; vol. IV., p. 465; vol. V., pp. 200, 201, 202, 209, 223.

McLellan's Brook.

In McLellan's Brook, not far above the contact of the Carboniferous limestone, are outcrops of mottled, reddish and greenish Silurian rocks apparently of this age. Higher up in a little brook from the eastward and also in the main stream at a mill and fall, the diorite of the fall (against which the Silurian rocks come nearly or quite unaltered) extends for a little distance and is then succeeded by greenish, massive Silurian rock, rusty-weathering and perhaps Niagara; followed up stream by greenish-grey and bluish massive rocks, and bright red and green, calcareous, slaty, argillite and limestone, dipping steeply down stream and holding Lower Helderberg fossils. Higher still are reddish, grey and greenish flags, crowded with fossils. Immediately above the first clearing on this brook, however, these rocks are succeeded by Cambro-Silurian.

East River of Pictou.

The earthy, rusty-weathering, micaceous rocks in Campbell Brook east of William Grant's on the East River of Pictou, are perhaps Niagara. The ledges which appear in the fields north of David's Lake are said by Dr. Honeyman to be Lower Helderberg; and similar rocks occur on the hill between that lake and the road. East of the post road between Springville and Bridgeville are great blocks and outcrops of apparently horizontal strata also of this age. On the right bank of the East River of Pictou for some distance above Bridgeville the higher Silurian rocks are exposed. In Holmes Brook, earthy, micaceous flags, containing Niagara brachiopods, are overlaid by Carboniferous limestone, under which the brook runs to appear again at the Sluice. A short distance above the contact, fine bluish-grey rocks, spotted with ankerite, are crowded with *Avicula Honeymani;* and, higher still, are succeeded by grey and greenish sandstones. On Irish Mountain, steel-grey, rusty sandstones and slates of Lower Helderberg age also occur.

Overlap of Carboniferous

McGregor's Mountain.

The Silurian strata of McGregor's or Weaver's Mountain* are in part at least Niagara and Lower Helderberg—reddish and greenish, calcareous, mottled, metamorphic slates and limestones, associated with blackish, graphitic beds, veined and blotched with calcspar and passing into limestones.

North Earltown.

The rocks that underlie the Permian conglomerate of North Earltown contain, among others, beds of fine calcareo-argillaceous sandstone, in one place nearly pure limestone, greatly resembling Niagara. The outcrops, however, are not extensive, the more common exposures in this district being of flinty reddish argillite and conglomerate, apparently Devonian.†

* Geological Survey Report for 1866–69, p. 5.

† Acadian Geology, Supplement, 1878, p. 76.

F.—Devonian.

As already stated, most of the metamorphic areas of the hills of Antigonish, Pictou and Colchester counties consist of rocks whose geological position is between the group containing marine fossils of Lower Helderberg age and the Carboniferous or Mountain limestone, also characterized by the occurrence of marine types, whereas all the fossils found in the intervening Devonian consist of shells indicative of a shallow-water origin and of plants both drifted and erect indicating land conditions. Between this series and those underlying and overlying there is everywhere the clearest evidence of enormous unconformity, and although from the abundance of their plant-remains they have sometimes been confounded with millstone grit and even higher strata* their relations to the Carboniferous limestone at the East Mountain of Onslow and Penny's Mountain, at Shubenacadie, Stewiacke, Walton, Cheverie, Parrsboro' and wherever the two series are in contact, and the ease with which they can be traced from point to point, shows that they are to be compared rather with the Mispeck and Little River groups of New Brunswick and that the Carboniferous limestone rests unconformably on the slates.

The metamorphic rocks of the mountains, chiefly Devonian.

Plants.

Relation to Carboniferous

Comparison with New Brunswick.

Some particulars have already been given† regarding the character and thickness of these rocks on the line of the Intercolonial railway between Valley and Hopewell. A close examination of the country both north and south of the railway has since been made.

Intercolonial railway

The conglomerate, or lowest of the three groups into which this series has been subdivided, is here absent. A broad belt of the upper or red slate series lies north of the railway between Glengarry and Riversdale, the boundary passing thence south nearly to the Stewiacke River and the rocks appearing on both sides of Minas Basin; while the grey slate series occupies a large area at the head of the Stewiacke; and areas of both are found in the Cobequid Hills, where they have been examined by Mr. Scott Barlow and Dr. Ells.‡ The iron ore of the Londonderry mines appears to occur in rocks identical with the reddish, green and rusty slates which in Antigonish, Guysboro' and Pictou counties contain such a large quantity of specular iron ore which is worked at several places§

Londonderry iron mines

* Acadian Geol., p. 283, line 17, and p. 561; Supplement, 1878, p. 48; Fossil Plants of the Lower Carboniferous and Millstone Grit, 1873, pp. 9, 29, 33.

† An. Rept. Geol. Surv., vol. II., 1886, Part P, p. 64.

‡ An. Rept. Geo. Surv., vol. I., 1885, Part E, pp. 48–51.

§ An. Rept. Geol. Surv., vol. II., 1886, Part P, p. 49.

a horizon intermediate between the two groups. It will be best perhaps to include them with the upper group, as the red strata are characteristic. Like the Cambro-Silurian and Silurian these rocks, generally situated in the mountains, are so contorted that their relations to one another are not always easy to make out.

F. 2.—Middle Devonian.

Character and distribution of the middle group.

This group is characterized by the occurrence of grey sandstone and slate, yielding fossil plants even when nearly in contact with syenite and diorite as so frequently happens. Its general characters have been described in the Report for 1886, Part P, p. 55. It is most largely developed south of the East River of Pictou and the Pictou branch of the Intercolonial railway as far as Riversdale, where it is succeeded by the red rocks. With regard to both this group and that succeeding, we are met by a difficulty in determining the minute geological structure in the absence of distinct layers and in the crumpled and faulted condition of their beds; but, as outcrops are generally abundant, a close examination will usually effect this.

Sunnybrae.

Near Black Taylor's Lake south of Sunnybrae are beds of steel-grey and greyish flinty grit and conglomerate or quartzite and slate. John Macdonald's (Ogg) Brook, above East River road and above a small branch from the west, is occupied by dark graphitic

Igneous rocks.

slates, cut by greenish, massive, felsitic, trappean and granitoid rocks and blotched with veins of quartz and ankerite. In the east branch are interstratifications of the Guysboro' quartzites and flags, including bands of flinty nut-conglomerate, the surrounding country

Iron ores.

being as usual barren or half barren. At several points small veins of limonite and red hematite have been found.

Maple Lake.

Near the head of the Black Brook of Centredale and on the wood roads to Maple Lake are light bluish-grey quartzite and slate. The track to the lake from James McKenzie's passes first over black slates, but nearer the lake the slates alternate with quartzites. Similar rocks occupy the upper part of Maple Brook, while above Sam Cameron's mill-dam are fine exposures of black twisted graphitic slate with harder siliceous slate and quartzite.

West Branch, East River of Pictou.

On the Trafalgar road near Donald Fraser's, black slates are in place, succeeded, near the road to Elgin, by flinty, Upper Devonian rocks, which are also well exposed in the river. But the West Branch below the lake presents only a few small narrow outcrops of dark slates, quartzites and massive flinty pyritous grits, the river being bouldery and hard to follow. From this formation the slates

quarried in this district are obtained. Some of them are rippled; in the cliffs at the mill near Angus McIntosh's they hold plants. In the rocky barrens bordering West Branch Lake, Speid Lakes, Hood's Lake and other lakes of the vicinity are ledges of Devonian slate and quartzite.

Cullen's iron mine.

On the road from Lorne to the iron mine at Cullen's, occasional outcrops of black slate are met with succeeding the dark shales of the valley. In the Drug (Truagh) Brook, bluish-grey Devonian slates, rusty-weathering, graphitic and twisted, are well exposed and contain, at the old dam, veins of limonite. In Cross Brook, succeeding the softer rocks near the road, are blackish slates and light grey flinty quartzites, alternations of which are seen to the head of the brook. In the Big Brook these rocks begin immediately below Thomas McDonald's mill, and can be traced along the road from this mill towards Glengarry.

Middle River of Pictou

Above the railway bridge in Middle River are interstratified bluish-grey regularly bedded flags and slates. Below the fork of the two branches are greenish and grey, fine, ripple-marked, evenly bedded shales and sandstones, breaking into large rectangular blocks which may belong to this horizon, but are succeeded down stream by indian-red, soft, crumbly shales, containing patches of pea-green shale apparently of the upper group. On the roads from Glengarry and Lansdowne towards Stewiacke, black shales are interstratified with white-weathering quartzites as far as John Robert McKay's.

Lansdowne and Glengarry to Stewiacke.

The first rocks seen in the branch of Middle River which crosses the railway at the big embankment immediately west of Lansdowne are greatly altered slates, interstratified with more quartzose rocks, full of quartz veins. The exposure, however, is small and the other rocks of the neighbourhood look like those of Riversdale and less altered than those of the railway, while in texture and composition they are identical. The grey slates in the fields near the head of this branch of the river hold plants, and their resemblance to those of the railway is remarkable. The Rocky Brook at the head of Stewiacke River, which crosses the road about two miles from the station, falls over cliffs of considerable beauty, composed of more or less sandy slates, dark grey, micaceous, and like certain rocks of Landsburg's. On the whole dark slates predominate, as at Sunnybrae, Drug Brook and Mount Misery. Near the shore of Dryden Lake, however, a quantity of reddish slate debris perhaps indicates an outlier or extension of the upper series to this point. From the fork at the county line at McKay's, dark rocks extend nearly to the head of the settlement of Eastville.

On the old road which runs southward from Gordon Summit, flaggy sandstones, slaty, veined with quartz and interstratified with dark bluish micaceous slates, marked with carbonized plants, extend far towards Stewiacke.

West River, Pictou.

Above the railway, in the first little brook east of Baillie's Brook at West River station, are dark slates which are again exposed in the next brook near the shanty at the railway. On the road south from the station are blocks of greenish, flinty sandstone; above the bridge on the brook is a quartzite that cannot be distinguished from that of the Stewiacke road, and further out are black slates. In Baillie's Brook, above the railway, grey, fine, soft sandstone and coarse grit, easily split in the bedding, flaggy or thick bedded, perhaps represent the rocks which include the coal. It is possibly Carboniferous, but more probably a portion of the Devonian.

West of West River, the boundary between the red and grey rocks seems to cross the railway about Campbell's Siding and has been already described.* By Dr. Honeyman these rocks seem to be regarded as Clinton.† The grey flags of the barrens north of the railway are associated with quartz-veined quartzites. In the little brook south of the railway at Landsburg's are light grey flinty flags also veined with quartz, and on the blueberry barrens in the neighbourhood of Williamson's Meadow Brook, among low conical hills interspersed with large hay marshes and wet barrens covered with a scanty growth of bushes and a few poplars and spruces, the rocks are apparently also those of the railway.

Riversdale.

In the brook, one mile east of Riversdale, the dark slates, grey, micaceous, somewhat soft sandstones and light greenish-grey and grey, compact, flinty sandstone are veined with quartz containing specks of pyrite, which has, no doubt, led to the search made here for gold. East of this brook another, crossing this railway, shows up stream cliffs of light grey, rust-spotted, rusty-weathering, flinty quartzite. In the large brook opposite, which enters Black River from the north-west, grey and reddish, fine, flaggy sandstone and crumbly argillite, marked with fossil plants, either represent the rocks of Campbell's Siding or are possibly higher. The head of this brook comes near the Riversdale road, and near it another rises which crosses this road but shows no rocks.

Search for gold.

Fossils.

The flags and slates of the railway immediately east of Riversdale contain *Stigmaria* and the fossil plants collected by Messrs. Weston and Robert.‡ They do not in any respect resemble the

* An. Rept. Geol. Surv., vol. II., 1886, Part P, p. 64; Trans. N.S. Inst. Sc., vol. II., part III., p. 169.

† Op. cit., vol. II., part I., p. 118; vol. III., p. 39.

‡ An. Rept. Geol. Surv., vol. II., 1886, Part P, p. 64.

Carboniferous, but rather, as already stated, the quartzite series of Guysboro'. Even the black shales are slaty and resemble the Pre-Carboniferous rocks of other localities. In Salmon River, above the confluence of Black River, dark shales are apparently overlaid by massive, grey, flinty quartzite or sandstone, and by broken flags.

Calvary Brook.

Although most of the rocks of Calvary Brook belong to the upper and intermediate groups, some of them are dark slates, alternating with whitish, flinty, Guysboro' quartzites indistinguishable from those of the railway cuttings. The dip being very changeable, the separation of the two groups requires the closest examination. The black slates contain nodules of ironstone and are veined with quartz and calcspar. The coarse grits include patches of conglomerate. A short distance above the railway bridge, limestone has been dug.

In Baillie's clearing, south of West River Station, and in other clearings nearer the station, dark slate is found, although blocks of grit occur near the brook. Further south, in Anderson's old clearing, are bluish-grey slate and white weathering, quartz-veined quartzite. In Calvary Brook, near the track from a hay meadow to this clearing, are outcrops of greenish-grey, rusty-weathering, fine, flinty sandstone or quartzite, interrupted down stream by a concealed interval, at the end of which are whitish-grey flinty sandstones or quartzites, with druses of quartz, sometimes in flags which break into brick-shaped pieces, interstratified with coherent, splintery argillite, breaking into knife-shaped splinters, sometimes 18 inches long. Alternations of flags and shales extend some distance down stream and are overlaid by a thick band of rusty-weathering, whitish, pyritous, Guysboro' quartzite, succeeded near the driving-dam by the red and green rocks.

Above the track in Calvary Brook outcrops are not numerous. They consist of grey, rusty-weathering, flinty shales and flags like those of the railway; of blackish graphitic shales and flags, showing markings of *Cordaites* and other fossil plants; and of whitish-grey sandstone with bright indian-red patches like that of Sutherland Brook on the East River of St. Mary's. Blocks of grey, flinty Devonian sandstone occur on the wood-roads running to West River and in the barrens and rocky woodland between these and the head of Stewiacke River, in all the headwaters of which light grey, slaty sandstone and shale, dark, blackish-grey, massive quartzite or flinty sandstone, micaceous, sometimes netted with veins of crystalline quartz, light and dark grey argillites, in part papery and graphitic and like the Devonian rocks of Sunnybrae, are equally abundant. There is, however, little variety. The more flinty rocks

Fossil plants.

form barrens covered with pieces of stone broken like road metal. In the branch of Calvary Brook from the south, above the driving-dam, flaggy, rippled sandstone or quartzite is overlaid by grey, soft shales, while higher up are cliffs of whitish, brown-spotted quartzite like that of the barrens of Grand River and Guysboro'.

South of the track to Island Lake, the Pembroke road shows grey and reddish, flinty, glistening, red-spotted quartzite, associated with grey argillite or slate like that of the Big Brook of Stewiacke; flaggy sandstone, rubbly, flinty and micaceous, holding plants, and like that north of Riversdale.

Salmon River. Black River below Riversdale exposes rocks which are again seen far up Salmon River. The first of these are greenish-grey argillite, somewhat crumbly shales and sandstone with ironstone, alternating with very flinty flags. Down stream are grey, rusty-weathering, flinty sandstones and a great thickness of black, polished, twisted slates, with a few hard, siliceous bands and intercalated lenticular layers of limestone, one of them eighteen inches thick. Greenish and dark grey, rusty-weathering argillite and sandstone, coarse and very flinty, breaking into irregular bricks, are next succeeded by black shale or slate, with flinty, flaggy bands and irregular layers of rusty limestone, overlaid, near the confluence of Salmon River, by red argillites of the higher series, with lighter reddish and whitish quartzite in great cliffs. Similar alternations occupy Salmon River for some distance above the fork, dipping down stream.

Stewiacke River. These rocks are well exposed in many of the brooks flowing into Stewiacke River, but in most of them do not seem to require special mention, the outcrops being indicated on the map. In the Black Brook, from the crossing of the old Stewiacke road, they comprise dark bluish-grey flags and flinty slates, twisted and blotched with lenticular veins of quartz. The dip is always high, often vertical. In the upper part of the brook the slates predominate, while lower down there is a larger proportion of the coarse whitish quartzite of Guysboro'. Similar rocks are exposed to the head of the settlement near Eastville. In the river, about a mile above the first settler, a micaceous, quartz-veined, coarse sandstone or quartzite seen in high cliffs, probably represents the rocks of the Guysboro' barrens and of Speid Lake, is on the horizon of those of Rocky Mountain, and also perhaps of those of Salmon River near the fork of Black River. It shows large hematite-red blotches; certain beds are shaly or flaggy, but it is for the most part thick-bedded; it is full of broken

Fossil plants. carbonized plants and of impressions of *Cordaites*. Among the finer beds is a band of quartz-veined conglomerate with pebbles three inches in length. A short distance below the bridge a thin band of

dark bluish-grey shale is full of stipes and broken leaves of ferns and of *Psilophyton*. Down stream they are succeeded by the upper series.

In the cliffs and fine reefs of Salmon River below the red bridge on the road west of Riversdale, the rocks belong largely to this group, consisting of alternations of dark shales and flags like those of Riversdale. Higher up are blackish splintery shales and thick-bedded sandstones, with dirty greenish-grey argillite, including a band, at least 15 inches thick, of black, coaly, *Cordaite* shale, which perhaps represents the coal seam of Kemptown. Light grey, fine, flinty, micaceous sandstone, with small quartz veins, in one of which a speck of copper pyrites was found, dirty greenish-grey, rusty-weathering sandstone and shale, light grey, fine, flinty sandstone and dark bluish-grey shale are then found to the saw-mill, above which are dirty greenish-grey argillites and light grey sandstone full of carbonized plants. At the Telegraph road the rocks include red bands. Up stream they are not so well exposed, but grey, flinty, fine sandstones extend to Jacob Fenton's, resembling those of the south branch of North River. Dark bluish-grey shale and flinty sandstone occupy the road from Kemptown to the red bridge, the road from this bridge to Riversdale and all the other roads in the vicinity. Salmon River. Coal. Copper ore.

McKenzie Brook, which flows into Salmon River above Valley, exposes, not far above Philip Archibald's house, greenish-grey shales, grey, somewhat flinty, quartzose sandstone, and sandy flags covered with markings of *Calamites*. North of these lie grey, rusty-weathering, coherent slates and papery shales, with alternations of grey fine sandstone, probably of the Riversdale series, with a very high northerly dip. Blocks of grey sandstone are found as far as Abner McNutt's house and also on the road through to the Telegraph road, about a mile to the south-westward. In the west branch, from this road down stream to the fork of a branch from the left, are outcrops of greenish-grey and grey, flinty, jointed sandstone and dark bluish-grey shale; while above the fork in the left branch, and also down stream, are the red rocks of Union. McKenzie Brook.

In Mingo's intervale on the south branch of North River the first rocks seen are dirty greenish-grey crumbly argillite, with bands of grey sandstone very quartzose and more or less flinty, full of rusty spots and resembling the Devonian rocks of Loch Lomond. Below Mingo's house the dip becomes nearly vertical and sandy flags are succeeded by a great breadth of black shales, succeeded again down stream by grey and greenish-grey, nearly compact, jointed, flinty sandstone, in thick and in flaggy beds. These extend to an old mill- North River of Onslow.

Coal.

dam, near which traces of coal have been discovered; and frequent outcrops of the flinty sandstone extend down to a bridge on the river, where they comprise flinty, jointed, flaggy sandstone with bands of dirty greenish-grey argillite. Thus far the river seems to show a descending section from the red and green rocks, altered by contact with the syenite, to the massive flinty sandstone of Mingo's, which may be that of the west branch of West River. The sandstone follows thence for a great distance nearly on the strike, the dip being very steep and perhaps indicating a fault complicating the anticlinal. Overlying the sandy flags, below a large brook from the right, appear again greenish and grey and blackish argillites, very ferruginous, including a few flinty bands and followed by massive somewhat argillaceous sandstone. Then, at the head of a piece of good interval, rise cliffs of reddish and greenish shale and sandstone or quartzite of the upper series, striking vertically 211°; but 200 paces to northward the dip is 3° < 80°. The river then turns to the south-westward, showing dark shales and rusty flags, which, 50 yards lower, dip 76° < 65°, indicating how much these strata are faulted or broken. Grey crumbly shales and red and grey sandstones and shales, lower down, dip 38° < 40°; then alternations of dark grey shales with harder bands, blackish shales with ferruginous plates and nodules, like the black shales of West River, extend to the Jollytown road. On this road to the left, these rocks probably extend to the top of the hill at the road to the left, beyond which the soil is Carboniferous. Most of the rocks of the river from Mingo's to the fork thus seem to be of the lower series.

Iron ore.

Contact with Carboniferous

On the Mingo road, grey flinty rocks continue to the Telegraph road, along which towards Salmon River are large outcrops of massive grey sandstone with a steep dip.

In the brook which crosses the Tatamagouche road about two miles north of the iron bridge at North River, greatly contorted grey and greenish-grey broken shales, containing *Naiadites*, probably the same as that of Riversdale, are succeeded higher up by grey flaggy sandstone, rusty-weathering argillite, and greenish, soft, smooth shales, showing indistinct markings of *Stigmaria*. Some of the grey shales have a purplish tinge. More flinty sandstones are seen higher up the brook, and similar rocks, with layers of ironstone and limestone, extend down the adjacent branch of McCurdy's Brook to the road at the contact of the Triassic. In the west branch of this brook—Turner Whidden's Brook—immediately underlying the Triassic, are, however, purple and greenish, mottled, somewhat sandy shales of the upper series, containing minute fragments of plants, interstratified with compact, thick-bedded sandstones, under-

Fossil shells and plants.

Ironstone and limestone.

laid by light grey and cream-coloured, rusty-weathering, more argillaceous rocks, with the structure of underclay, holding rootlets and plants. In the joints is a film of blackish, shiny limonite; and in one layer of flinty sandstone a *vugg*, one inch in diameter, contains a mixture of red and brown hematite with the characteristic papillæ of the latter; but the rocks are much less altered than most of the iron ore belt. A half inch parting of blackish shale at the top might pass for coal. Up stream are banks of greenish-grey, crumbly, rusty-weathering argillite and flinty sandstone; and above the house, dirty-greenish and grey argillite, reddish, crumbly argillite, containing spherical concretions, and many blocks of light grey somewhat coarse sandstone, resembling Carboniferous rocks. Similar grey sandstones and shales occupy Baird's and Beaver Brooks.

Iron ore and coal.

North of Penny's Mountain the brooks show rocks belonging to both the subdivisions of the Devonian, indian-red soapy shales, dark bluish-grey, contorted, soft shales and rubbly, micaceous, flaggy sandstone producing a barren, rocky country like that north of Riversdale. The shales, as usual, contain rusty-weathering nodules and are sometimes ripple-marked. The contacts of these rocks with the Triassic and the Carboniferous limestone can best be studied from the map.

Penny's Mountain.

Contact with Carboniferous and Triassic.

In the river above the village of North River, greenish and grey, jointed sandstone is succeeded by a great thickness of black shale. Below the confluence of the south branch greenish-grey shales and sandstones with rusty-weathering nodular bands, marked with plants and containing thin layers of ironstone, alternate with dark shales to the confluence of the west branch, below which greatly contorted red rocks are occasionally seen, although the dark shales predominate to the Triassic. Similar rocks are found higher up the river, and below the bridge on the post road, dark shales containing rusty, hard bands of grey flinty sandstone which breaks into small pieces, are full of nodules and thin layers of limestone and ironstone and of shells like *Naiadites*. The dark contorted shales predominate and extend in great cliffs for some distance.

Black shales.

Fossil shells.

The sandstones associated with the coal are strikingly like those associated with the coal of West River and Kemptown, seem to be beneath the dark shales further down the river and to be inseparable from them. The limestone of the neighbourhood occupies the same position, apparently, with relation to the other rocks as that of Riversdale and Chiganois.

Coal and limestone.

Nuttby and New Annan.

On the road from Nuttby, past Tom McNutt's to Waugh River, rocks of this group are found. Near the fork of the road to New Annan the brook shows red argillite, with veins of ferruginous calc-spar and calcareous concretionary masses. Further out are blocks of the grey quartzite of Riversdale. Then, at an old steam mill, grey fine grit is succeeded by coarse syenite and reddish, flinty porphyry, which occupy a considerable breadth and are then followed by a grey and blackish trap of Waugh River and Ferguson Brook.

Igneous rocks.

Middle Branch of North River.

Falling Brook is mostly occupied by red syenite and falls into the middle branch of North River over a cliff of that rock 40 or 50 feet high. In the river, sixty yards above the confluence, blackish or dark grey Devonian slates are closely pasted to the syenite, which is mixed with a bottle-green diorite, sometimes the syenite, sometimes the diorite predominating. About eight yards down stream black slate is seen among syenite and diorite which then occupy the river for more than half a mile to a little brook from the west. Here another direct contact is seen. At sixty-five yards above the little brook are the first outcrops of syenite and diorite, some of the latter being coarse breccia or conglomerate, perhaps mixed with sedimentary rock. Sixty-five yards below the little brook is a cliff of massive, grey, rusty-weathering conglomerate and grit, composed of syenite and felsitic debris, with a few layers of grey and dark shale full of minute plants. Dark grey and greenish-grey crumbly shale, with bands of grey sandstone, occur lower down, with others like those of the Coalmine Brook, certain flags being full of rootlets and of broken plants. The rocks are as rubbly as those of Riversdale and are cut by veins of white and dark calcite with siliceous matter like those of Tom McNutt's. Then follow alternations of flinty sandstone or quartzite and dark graphitic shale. There is here, perhaps, an intermixture of slaty rock and soft Carboniferous sandstone folded in among the faults, one band of conglomerate containing pebbles of blackish argillite. Near the head of the intervale, at the settlement, the dark grey and greenish, compact, flinty rocks contain specular iron which has been worked to a small extent. These rocks are unconformably overlaid by Carboniferous conglomerate.

Contact of Carboniferous.

Up the west branch of North River from the fork, dark grey or blackish, rusty-weathering shales, with light grey sandstones and a few coherent bands of ironstone or limestone, are interstratified with red beds, with a very high, often vertical, dip, and greatly contorted, and extend nearly to the bridge at the church on the Tatamagouche road. Near this bridge are cliffs of light grey, flinty, rubbly sandstone.

Following the Devonian rocks to the Chiganois River*, they are exposed below the sandstones and conglomerates of the Staples Brook and Delaney settlements. From the Higgins road down Old Sam's Brook to the river, reddish and brownish sandstones and marls, with layers of grey sandstone, are similar to those which overlie the conglomerate in Great Village and Folly Rivers. These extend down the river from the mouth of this brook to the cliff beyond an old barn on the left bank. At the next cliff, however, are rocks from which they appear to be separated by a fault. Those first seen consist of a dirty, greenish-grey, crumbly shale or argillite, like that of Landsburg's; then four feet coherent, greenish-grey sandstone; then greenish-grey more shaly rock; then a faulted band of four feet coherent, greenish-grey sandstone; above which lie twelve feet of dark grey and blackish shales, holding *Cordaites*, and other fossils; then four feet and under of dark grey, compact limestone, the upper surface of which is covered with plants—*Naiadites*, *Coprolites* and other fossils; then about three feet blackish calcareous shales; then only indistinct outcrops of reddish crumbly sandstone. The limestone is like that cut by igneous rocks in North River, and among the dark shales are other thin bands of limestone. The next reefs consist of red and grey sandstone and crumbly shales which seem to overlie the grey rocks. They include at the base a band of greenish and grey, coherent sandstone, weathering rusty and marked with plants. Reddish, flaggy, jointed sandstone and shale occur again immediately below a large branch into the river from the left; and further down are long reefs of rubbly, reddish-grey sandstone and shale, followed by coherent flags showing green and grey spots marked with carbonized plants. The grey, coherent, fine flags beyond are overturned. A short distance below, at a reef and pool at a sharp bend, is a rock even more flinty than the above, underlaid by dark grey and greenish-grey shales, succeeded below by red and greenish, rubbly argillite, full of rusty nodules, and these by a great cliff of greenish flags full of *Lepidodendron* and other plants. These shales and flags are finely rippled on a great sloping cliff face. The upper part of the flinty band is an underclay. Blackish and dark grey, fine shales overlie it for a thickness of fifteen to twenty feet and are full of plants and *Cythere*. Down stream, and apparently overlying the last, come reddish, coherent shales and argillites, in no way resembling the Carboniferous, and in all probability representing the red rocks of Union. Beneath them are grey and greenish, coherent rocks; then a concealed interval, beyond which the flinty band above described forms a long

Devonian and Carboniferous rocks of Ishgonish.

Fossils in limestone.

Fossil plants and shells.

*An. Rept. Geol. Surv., vol. I., 1885, Part E, p. 46.

wall on the left, passes the river on a reef and rises on the right bank. Down stream and underlying is a great thickness of blackish, greenish and bluish-grey argillite. With these at a dam are many layers of flinty, greenish-grey sandstone. Below the dam the cliffs show blackish, papery, rusty-weathering *Naiadites* shale, with nodules and layers of limestone, one of which, two inches thick, has cone-in-cone structure. Then come cliffs of dirty red, rubbly, flinty sandstone and argillite, with a northerly high dip, underlaid by a strong band of reddish-grey sandstone, with *Calamites* and other carbonized plants; then reddish, flinty flags to the end of the cliffs. Beyond are reefs, chiefly of grey, coherent sandstone; then a long stretch of reefs of red rocks dipping nearly vertically and rising into a cliff on the left near the head of the clearings. To confound these flinty, fine, rubbly rocks with the coarse, flaggy, soft, evenly-bedded strata of the neighbourhood of Old Sam's Brook would be impossible. But that the lower series is equivalent to that classed as Lower Carboniferous at Hastings on the Strait of Canso is almost equally certain. The undulations of these rocks may be seen on the map. After an interruption of Triassic rock of about a quarter of a mile, similar rocks again appear in the river and exhibit a thickness of about 800 feet about a mile and a half above the railway bridge. They consist of dark grey, greenish and reddish, rubbly argillites, with spots of hematite, including a black, bituminous layer, one or two inches thick, containing traces of good coal, overlying a *Stigmaria* underclay, and associated with light grey, fine, flinty, jointed sandstone, with small veins and films of hematite, and bluish-grey, crumbly shales, with layers of light grey shale and dirty greenish-grey sandstone, with another layer of three inches of black shale largely composed of *Naiadites* and *Cythere*, with flinty, rubbly sandstone veined with hematite. There is a red band among the greenish and grey shales, and in one place five black bands in a width of ten feet, the more carbonaceous shales being crushed, polished and shiny.

Cone-in-cone limestone.

Coal and iron ore.

Above Higgins' mill, near the igneous rocks which form the celebrated fall of this river, is a compact grit or quartzite, a light grey, fine, flinty sandstone and a reddish, crumbly, fine sandstone with rubbly, flinty rocks, having an obscure dip, in contact with dark reddish, somewhat compact trap, succeeded by coarse syenite. In Higgins' Brook only two small outcrops of sedimentary rock are found among the felsites.

Contact with igneous rocks in Chiganois River.

The syenite and associated diorites extend to a point more than a mile below Patterson's old mill. We have then a breadth of a mile of slates. Those nearest the syenite on the south side of the belt

are greenish and bluish-grey, having sometimes a fine tinge of red, papery, flinty and associated with greenish, flinty, felspathic sandstone like one of the gold-bearing series, full of reticulations of quartz and interbedded with whitish, massive, quartz-veined quartzite, so compact that the veins can be distinguished only by a slight difference of colour. Higher up are red, purple and green slates, with layers of crystalline limestone. White, rubbly, banded quartzites are the last of these rocks seen in contact with a pale flesh-coloured porphyritic or obscurely granular quartz-felsite or syenite at Patterson's mill and on the road from this mill eastward to the main road.

Crystalline limestone.

Dr. Ells has described as Devonian* a belt of rocks 434 yards wide immediately beneath the Triassic in Debert River and unconformably overlaid up stream by the Lower Carboniferous. The Triassic rocks near the contact seem to be nearly horizontal, although down stream, near a spring on the right bank, nearly vertical. They are often more coherent than usual and have been used for building. On the left bank of the river, 110 paces above the last of the Triassic, are indefinite exposures of grey and reddish calcareous rock of somewhat coarse texture. On the right bank, 173 paces from the contact, are light grey, rubbly, coherent and heavy quartzose sandstones. On the left bank, about 200 paces from the contact, are similar flinty sandstones with dark bluish-grey shales, resembling rocks of Riversdale, well exposed for thirty-two paces. Then for 175 paces are occasional outcrops of grey and red rocks, nearly vertical, followed by a cliff of dark bluish-grey argillite, full of markings of stems of plants, rusty in the joints; rising, at nineteen paces, into a cliff ten feet high and, at 197 paces to a cliff twenty feet high, which shows layers of nodular ironstone and underclay. How these come against the red rocks seen at 212 paces is not very clear. They dip near the junction $143° < 50°$, while the red rocks dip $354° < 50°$ and are slickensided. They may perhaps be cut off by an east and west fault which has also displaced them a little among their own beds. The red rocks resemble Carboniferous in colour and texture, comprising indian-red, fine sandstone and marl, with layers or patches of conglomerate in which the pebbles are sometimes larger than a hen's egg. A few paces up stream, a greenish-grey soft layer is full of carbonized plants; and higher up are reddish-grey, somewhat coherent sandstone and shale. The fault is about 100 paces below the mouth of Totten's or Graham's Brook. The coherent red strata extend up the river to a point less than three-quarters of a

Debert River Devonian described by Dr. Ells.

Fault at contact with Carboniferous.

Coal of Cottam settlement.

* An. Rept. Geol. Surv., vol. I., 1885, Part E, p. 43.

mile above the bridge at the Cottam settlement and include the coal seams. Above Totten's Brook they include patches of concretionary grit and certain flaggy layers have been quarried. One of the slabs showed, in addition to fucoids, tracks of *Sauropus*. The lower rocks resemble those of Turner Whidden's and the vicinity. When they again appear above Cottam settlement* blackish graphitic slates are in contact with greenish and grey, soft, slaty, volcanic breccia and massive felsite, containing films of red hematite in the joints, succeeded by greenish and grey flinty, porcellanous flags with ironstone bands, followed by gneissic rock and by light grey, granular, fine and coarse diorite or diabase.

Fossil footprints.

Igneous rocks.

In the Millbrook that comes into the river from the eastward at Cottam settlement, dark bluish-grey, light grey and greenish-grey, flinty, quartz-veined sandstone or quartzite, rusty-weathering, whitish, compact quartzite and argillites are associated with dioritic and grey syenitic rocks.

Carboniferous and Devonian rocks of Totten's Brook.

The rocks of Totten's Brook, from the confluence with the river to a short distance above the road through the back settlements, are, like those of the river, Carboniferous. At their contact with the iron ore rocks they are brecciated as if at a fault. These latter consist of light grey sandstone, with rusty-weathering patches and greatly veined with quartz; of black, slaty, rubbly, graphitic argillite, with small veins and lenticular patches of ankerite. Then follow outcrops of igneous rock, above which are the sedimentary rocks holding the iron mine of the Peter Totten meadow†. These extend nearly to the head of the brook and consist of grey, rusty-weathering, rubbly, flinty sandstone, massive or flaggy, with layers of reddish, bluish-grey and greenish, flinty argillite, presenting numerous graphitized markings of minute plants. In the east branch, north-east of the iron mine, greenish and grey, massive and flaggy, rubbly, fine sandstone or quartzite, with minute plates and veins of ankerite and of spathic iron, films of limonite and hematite, like that of Grand Lake and Guysboro', is exposed in fine cliffs. In one place among the sandstones is a spot as if a tree had grown there; no rootlets, however, could be definitely made out, although in certain dark rocks surrounding it fragments of carbonized plants, apparently *Cordaites*, abound; and even in the flinty, micaceous flags, where they are not too much felted together or veined, minute plants are observed. Above the quartzite come dark slates and pyritous argillite veined with calcspar, followed up stream by syenite and diorite.

Iron mine.

Plants.

Erect tree.

Syenite and diorite.

* An. Rept. Geol. Surv., vol. I., 1885, Part E, p. 45.

† Geol. Surv. Progress Rept., 1872-73, p. 22.

The rocks of Pine Brook, from the Triassic up to and for half a mile above the Base-line road, are described by Dr. Ells as Lower Carboniferous*. Succeeding them are blackish and dark grey, curly, papery, silky, graphitic slates with nodular or lenticular masses of siliceous and calcareous rock. They closely resemble the slates of North River, but are much more altered. Above a mass of volcanic rock a short distance up stream are light grey and cream-coloured siliceous and argillaceous, massive and compact rocks, intersected in all directions by veins of ankerite sometimes two feet thick, on the surface of and in cracks of which specular iron is found in masses six inches thick and downward. Specular ore is also found in separate veins and films in rock precisely like that of Cook's Brook, of which the less metamorphic portions have a strong resemblance to underclay. Higher up are larger veins of ankerite and specular iron; and pieces of limestone like that of Tom McNutt's are found in the slates. Though grey and greenish and cream-coloured rock are associated with purple and greenish porcellanites, certain sandy micaceous flags and argillites show markings of *Cordaites* and other plants which are somewhat obscure; but in the bed of a little brook from the west is an underclay full of rootlets and of impressions of *Calamites* which leave no doubt of the age of these Devonian metamorphic rocks.

Pine Brook.

Specular iron ore near contact with dykes.

Underclay full of rootlets.

Higher up, at the contact of red and green slates with greenish breccia, is an opening on a band two feet thick impregnated with specular iron, the ore having, in one place, a thickness of seven inches, but being lenticular. Above these volcanic rocks, which are of some breadth, sedimentary rocks again appear.

Iron mine.

In Weatherbe, Gory, Slack and other brooks of East Folly Mountain similar rocks yield the iron ores of the East Mines, but they require no special mention. Folly River† next exposes fine alternations of Devonian in contact with igneous rocks. A deep railway cutting at the snowshed immediately south of the siding at the foot of Folly Lake shows whitish and dark fine flags and striped quartzites, with a layer of conglomerate, very greatly altered and resembling the metamorphic rocks of James River and the Atlantic coast. Intermixed with the massive igneous rocks is a chloritic slate or schist. Soon, however, diorites occupy most of the cuttings, and only small patches of sedimentary strata are met with. In Folly River, before the railway leaves it, not far above the east branch, they are again, however, seen full of layers and reticulations of

Londonderry East Mines.

Folly River.

* An. Rept. Geol. Surv., vol. I., 1885, Part E, page 45.

† An. Rept. Geol. Surv., vol. I., 1885, Part E, pp. 47-53 and 56.

quartz. Below the diorite at the fork of the east branch, the rocks are massive, light greenish-grey, quartz-veined sandstones, containing veins of rusty-weathering spathic iron, overlaid by flinty quartzite. Lower down, the river is wide and shows light-coloured quartzose rocks, veined with quartz and ankerite, some of the quartz veins holding also traces of specular iron. Down stream occur grey slates, like the Devonian rock which carries the specular iron in Guysboro' and Antigonish counties, overlaid by black graphitic slates, with threads or plates and masses of ferruginous calcspar, interstratified with red and green, mottled, soft, soapy argillite. Succeeding these slates almost immediately on the left bank is a cliff of reddish coarse conglomerate, with pebbles of the flaggy, flinty quartzites and of light-coloured diorite and syenite, belonging to the Carboniferous. By a fault on unconformity the slates are sent to the right, up a small brook from the river, while immediately north-east of them is a slickensided felsitic rock.

Contact with Carboniferous

Railway between Folly Lake and Londonderry.

Following the railway, banded, altered argillites succeed a greenish fine diorite, and about 115 yards south of the school near the foot of Folly Lake, are associated with light grey, flaggy quartzite. Mixtures of slate and diorite then extend for some distance, certain whitish quartzose flags including quartz veins supposed to contain gold. In one of the cuttings light-coloured strata are interstratified with blackish, coarse hornblende rock or fine diorite, which follows in the bedding for some distance. The quartzites end at a dyke of red compact quartz-felsite or syenite, five feet wide, which runs up eight feet vertically to meet this diorite. Blackish diorite then comes below the syenite; one of the lenticular veins in it is ten feet wide. The whole section from the siding to the contact with the Carboniferous is about three miles long. For thirty-five chains from the school, sedimentary rocks predominate; then for more than three-quarters of a mile none but igneous rock; then nearly a mile with occasional bands of sedimentary rock among diorites; then twenty-nine chains of sedimentary rock to the 82nd mile-post, where the Lower Carboniferous begins. The sedimentary rocks among the diorite are greenish-grey, rusty-weathering, but with some bands of red argillites, quartzites and flags; greenish-grey and dark grey argillite; fine grits with ankerite in the joints. Certain rusty, shaly layers show abundant traces of graphitic or anthracitic matter; one bed shows obscure rootlets, graphitized marks of plants and stains of copper. Near the 82nd mile-post the rocks are very ferruginous, light grey, cream-coloured, quartzose and soft. The last seen in the little brook at the con-

Dykes.

Obscure plants.

tact are blackish, soft, crumbly, graphitic slates with light-coloured calcareous and ferruginous nodules and lenticular beds of light grey compact sandstone or quartzite, unconformably overlaid by conglomerate holding pebbles of all these rocks. Contact of Carboniferous

McElman Brook empties into Folly River from the west immediately above the high bridge on the railway, displaying, at and for three-quarters of a mile above the river, Triassic coarse sandstone and conglomerate. Up the east branch (Urquhart Brook) for about half a mile are somewhat flinty, red and rusty-grey sandstones and shales, full of fossil plants, rubbly and slickensided, veined by calcite and with films of limonite, of doubtful age, but perhaps Carboniferous, succeeded up stream by coarse beds, undoubtedly Carboniferous. Not far above the railway these give place to dark and light greenish-grey, flinty, brecciated, greatly altered rocks, with nodules and veins of bluish-grey, rusty-weathering calcite, precisely like the Devonian slates on the left bank of the East River at Sunnybrae. They are graphitic and twisted, and are succeeded by light greenish or cream-coloured, rusty, fine rocks and by flinty sandstones and argillite, cut by many rusty veins. Next comes massive quartzite, with dark, plant-bearing flags and occasional purple beds, broken by igneous rocks, above which greatly altered quartzose flags and argillites, apparently underclays with intercalated layers of blackish shale, show markings of plants. Whitish, compact, slaty quartzite, greenish micaceous rock, light grey, flinty and dark grey porcellanous argillite extend to the head of the brook, but are interrupted in many places by diorite. McElman Brook. Trias and Carboniferous. Devonian. Fossil plants. Diorite dykes.

The Triassic rocks of the west branch of McElman Brook (Phillips Brook) come vertically against reddish and greenish-grey strata, probably Carboniferous, holding streaks of coal derived from trunks of trees. They are, however, immediately succeeded by more flinty rocks, which may be lower, but are again succeeded by Carboniferous, at the base of which is a conglomerate, in contact, above the railway, with greenish and bluish-grey Devonian slates, including a lenticular mass of grey, flinty quartzite, interstratified with rusty-weathering quartzite, very like underclay, holding obscure, carbonized plants. Up stream, greenish, soft, papery slates, mottled, purple and greenish or cream-coloured slates, with stains of specular iron, light and dark grey slates veined with ankerite, and flinty, fine sandstone, with a large proportion of red—not unlike the rocks of the other branch, but without igneous intrusions—extend to the head of the brook. Great masses of spathic iron ore have been taken from an opening in this brook. Fault at contact of Trias and Carboniferous. Iron mine.

Saltspring Brook.

Above the Base-line road on Saltspring Brook, Carboniferous conglomerate is again seen in contact with grey, flinty sandstone or quartzite, dark shale or slate, with a large proportion of bright red argillite with grey and black blotches, at a little brook from the eastward. Higher up the main branch are good exposures of dark grey and greenish, contorted, flinty and soapy shale and quartzite, with patches of red and purple argillite, of greenish and cream-coloured argillite and of grey, thick-bedded, compact sandstone or quartzite, rusty-weathering and sometimes veined. These extend to a fall, 30 feet high, over greenish, soft and hard chloritic trap or diorite, containing films of red hematite and succeeded by grey or blackish, crystalline diorite, intermixed again with rusty slates and quartzite at the head of the brook. In the pasture lands to the northward are dark, dioritic rocks, associated here and there with patches of sedimentary strata. From these clearings, down the brook which runs westward to Great Village River, nearly all the exposures are of massive, dark, crystalline diorite, red quartz-felsite or syenite, more or less compact, with only one or two patches of obscurely-bedded, flinty rock, which may be sedimentary. The diorite is interrupted by dykes or masses of reddish, compact syenite or quartz-felsite, with blotches or little lenticular veins of quartz.

Sedimentary and igneous rocks.

Great Village River.

F. 3.—Upper Devonian.

Distribution.

The upper beds of this formation are most widely distributed in a tract which lies north of Stewiacke River and south of the railway between Riversdale and Truro stations, and in the country south of Cobequid Bay.

Iron ore belt.

A narrow belt of rocks of a lower horizon, including green and rusty ferriferous slates, extends from Sunnybrae to join the large area along the Middle River of Pictou. These will be first described.

Bridgeville.

In Archibald Brook, unconformably underlying the Carboniferous rocks near Bridgeville, are greenish slates cut by soft trap, followed up stream by dark grey twisted slates, veined with calcspar and interstratified with yellowish-grey brecciated quartzite, full of blotches of ankerite. Certain red flinty quartzites and argillites of the neighbourhood are, perhaps, equivalent to those of Union. Running in the bedding of reddish and greenish-grey, flinty, micaceous sandstone or quartzite, twisted slates, greenish and cream-coloured, porcellanous, flinty, ferruginous rocks higher up the brook, are lenticular veins of ankerite sometimes ten inches thick. Greenish and grey, very flinty, rocks just below the road at Archibald's mill resemble those of

Iron ore.

Roman Valley, while immediately above the mill is a bank of black graphitic slate worked for coal; and up stream the bluish-grey slates of the Mira Falls, like which they are supposed to be fit for roofing*.

Slates prospected for coal.

Roofing slate.

Similar rocks occur in the lower part of John McDonald's (Ogg) Brook, the bluish-grey soft shales of the post-road being succeeded up stream by reddish and greenish calcareous slates, and, 210 yards above the bridge, by dark slates, containing thread-like markings of plants, cut by dykes of trap and diorite and by rusty bands of ankerite, with grey quartzite and other rocks of the lower group, veined with quartz and calcite. The openings in iron ore on the east side of the brook are in grey, rusty-weathering, flinty, quartzose rock. In the brook south of the openings dark slates are well exposed and contain an immense quantity of ankerite in irregular veins, sometimes of great thickness. The rock containing the specular iron ore at John McDonald's (weaver)† is very like the flinty and soft rocks of Londonderry. In the brook above mentioned, at a little brook from the west, rusty rocks of this description on both banks contain small pockets of specular iron among veins of ankerite, and in contact with igneous rock.

Dykes and veins.

Mines of specular iron ore

At the Centredale school, whitish quartzite and black slate succeed the Carboniferous. In a little brook which flows into the East River, between St. Paul's and Bridgeville, red rocks belonging to this group are associated with very flinty, grey quartzite and with grey, fine, calcareous flags and shales, veined with threads of calc-spar, which extend to the road up the river. Near the fork of the Centredale Brook and that from Maple Lake, the purplish argillite and sandstone, grey, greenish and dark, jointed, splintery argillites and quartzites are probably of this age, as well as the reddish and greenish siliceous sandstones and argillites of Elgin, which hold minute ferruginous veins. Here, as in the west branch, they are overlaid by Carboniferous limestone.

In the West Branch, above the bridge at Elgin, are reddish, flinty, jointed rocks; sparkling, fine quartzite, with layers of greenish and purplish, slaty argillite; dark slates; greenish, soapy slates veined with quartz; blackish, graphitic slates, sometimes flaggy, including bands three inches thick and downward of ferruginous limestone or ankerite; greenish-grey and reddish, soapy, papery shales. Red argillite predominates. Occasionally a greenish quartzite, tinged with red, has rippled surfaces and pyritous lenticular layers, and

West Branch of East River Pictou.

* An. Rep. Geol. Surv., vol. II., 1886, Part P, p. 56.

† Trans. N.S. Inst. Sc., vol. II., p. 67; vol. III., p. 171; vol. V., p. 206; Progress Report Geol. Surv., 1866–69, p. 408.

the grey and greenish flags resemble those of Big Brook. Up stream they are succeeded by the grey slates of the Middle Devonian.

Big Brook. The rocks of Lorne, south of the gypsum, are shown both on the Big Brook road and on that to Trafalgar. From Kenneth McKenzie's to the Glengarry railway station, by way of John McDonald's, all the debris points to the country being underlaid by Carboniferous and by the red Devonian rocks. From the bridge over Big Brook on the Trafalgar road, to the road on the left to Elgin, the dark, coherent argillites are, no doubt, equivalent to those on the road near Kenneth McKenzie's. South of the plaster land are outcrops of red and green slate, like that of the west branch above Elgin. Above the fork of Cross Brook, Big Brook exposes greenish-grey, fine, pyritous, flinty sandstone and argillaceous shale, succeeded up stream by light greenish, soft argillite, blackish argillite or soft slate, with nodules and lenticular bands of black calcveined limestone, very much broken and associated with diorite, followed by reddish, fine, rubbly, argillaceous sandstone, and near the mill by the Middle Devonian slates.

Cross Brook The rocks of Cross Brook, like those described above, are perhaps equivalent to the coaly strata of west branch and Kemptown. Above the road they consist of light grey, rusty-weathering, fine, micaceous, flinty sandstone, or quartzite and argillite, sometimes slaty, of blackish and light grey argillaceous shale, with bands of micaceous sandstone, well-bedded, but jointed and sometimes slaty.

Black shales. Some of the graphitic shales have been mined. Immediately succeeding these rocks are dark slates and quartzites.

Middle River of Pictou. From Lorne to West River the railway seems to follow closely a band of Upper Devonian. In the fields south of Glengarry railway station, reddish, purple and greenish, flinty argillites and quartzites are in place to the back road, and on this road westward along the

Igneous rocks. railway are associated with traps. To the north, reddish-grey argillite and sandstone, in thick beds veined with quartz, appear in the Middle River, and similar rocks, resembling also those of Big Brook, abound on the roads towards Whitehill and Marshdale. On the road from Lorne to Glengarry the rocks are no doubt also of this age, the huge blocks of veined diorite indicating the igneous rock so often seen in the same position, cutting no higher rocks than Upper Devonian; and the black slate mined at Jesse Grant's is perhaps the same as that of Cross Brook, of the Big Brook and other places. The rough land east of Glengarry is covered with blocks of white-weathering, flinty sandstone. About one hundred yards west of the station, a cutting shows purplish slaty argillite, and on the road to the northward are grey and purplish coherent

rocks. Near the railway tank are grey, coarse sandstones and bluish-grey shales, not unlike Carboniferous. Other cuttings show greenish and grey, coarse, flinty grit, dirty greenish-grey, bluish-grey, red and green crumbly shales; and black shales, which would seem to be about the horizon of the coal of West River, have been dug for coal in a shaft and several pits in this neighbourhood. Some of the associated sandstones are very siliceous and resemble the Guysboro' quartzites and rocks of the Salmon River west of Riversdale, which underlie the red and green rock of Calvary Stream. Search for coal.

On the road from Glengarry to the fork of the Middle River, the green slates are Devonian, as well as rocks associated with the trap below the bridge. Some distance above the bridge, a flinty quartzite is in contact with greenish coarse diorite, among which is a breccia containing pebbles of the cream-coloured siliceous rocks and argillites.

Apparently most of the rocks of the magnificent outcrops above the fork of Middle River in the west branch, as far as the railway crossing at Lansdowne, belong to the horizon between the Middle and Upper Devonian. Those first seen comprise greenish-grey, fine, flinty, argillaceous sandstone, in shales and flags, with layers of polished graphitic slate and of flinty quartzite. They are traversed by veins of ankerite, and by minute veins of quartz, one of which yielded specks of copper pyrites. Up stream are red, slaty argillites, with bands of green, and a greenish grit, perhaps Carboniferous; succeeded by cliffs of purplish, flinty, splintery, massive, jointed, micaceous, argillaceous sandstone or quartzite, cut by threads of quartz and spotted with rusty grains and bright green blotches, sometimes calcareous, and in one place passing into impure limestone; and still higher, fine outcrops of purplish, coherent argillite and sandstone, with bands and reticulations of green, veined or blotched with quartz, and ripple-marked, followed by greenish and cream-coloured argillites, purplish rocks with plates of spathic iron and large cream-coloured blotches, greenish and light grey, flinty, argillaceous and siliceous rocks, with light grey, very pyritous, rusty-weathering bands, most thick-bedded, also a greenish and grey, massive, rubbly, rusty-weathering siliceous rock, with ferruginous veins. Specular iron accompanies a band similar to that of the iron-bearing rock at the Roman Valley, Caledonia Mills, South River and elsewhere. Reddish, greenish and grey rocks extend to Matheson's Mills. Copper ore. Iron ores.

Good exposures of the red and green rocks occur in the brook from the mill-pond immediately north-east of Lansdowne station and on many of the roads of the neighbourhood. The first rocks seen Lansdowne

below the pond are greenish, rusty-weathering, somewhat massive, rubbly, ferruginous, siliceous and argillaceous, containing a quantity of specular iron and ankerite. Lower down the greenish are associated with purplish beds, also containing veins of specular iron ore, one of which, one inch thick, cuts across the bedding, and of ankerite, sometimes more than a foot wide, in part converted into specular ore.

Gordon's Summit.

On the railway near the 29th mile-post are blackish graphitic slates, and light grey, crumbly, granular, quartz-felspathic grit, dug from iron. At Gordon's Summit, rusty-weathering, siliceous rocks are followed by flaggy, and by a greenish-grey and grey argillite and quartzite to Matheson's Mills, sometimes associated with volcanic material. At the head of a branch of Middle River, near Gordon's Summit, purplish, bluish-grey and grey argillite and compact sandstone, the latter containing many veins of specular iron, are associated with greenish and grey slates. At the fork of Dan Matheson's Brook the river exposes red sandstone and argillite, together with grey rocks like those of Roman Valley.

Igneous rock.

West River, Pictou.

The rocks near Campbell's siding, include a great thickness of red, crumbly argillite; but a large portion are of rubbly, flinty, slaty argillite at a little brook further east. The dirty greenish rocks further east have among them layers of flinty sandstone or quartzite, and also of black *Cordaite* shale and crumbly, greenish and reddish argillites, of which there is a great thickness near Landsburg's. The cuttings near the county line, and those near Jonah Langille's show red and green flinty flags. On the road from Langille's to the main road at Landsburg's, the debris seems to indicate greenish and purple slates, and along the main road eastward the grey rocks of Riversdale, numerous blocks of which are seen near the West River road. To left, down the river, the land on the right and left is very rocky as far as a little cemetery, the grey, flinty, quartz-veined quartzites show as far as the river bank. Then the land is better as far as the ford and foot-bridge, below which, grey, rusty-weathering, flinty rocks are again apparently in place as far as a small brook near a house on the left, where the hill turns to westward and the overlying conglomerate begins.

Fossil plants.

Contact of Carboniferous

On the east bank of West River the debris hereabout is of blue-purple rock, not of the colour of the rocks of Union. If as seems probable the rocks of the left bank are beneath those of the right, this would imply either a great bend of the strike from east to south, or a great fault carrying the purple and green rocks of the east side far south past the grey underlying series. The road

on the east side shows the grey rocks only at the end near the station.

Riversdale and Stewiacke

The Riversdale rocks almost certainly underlie those of Union, and a great tract of the intermediate series seems to occupy the country north of the railway, being spread over a great area by frequent folds and faults, some of which can be indicated with considerable accuracy; a great area of black slates seems then to succeed that of the Riversdale rocks and to be repeated in the same manner at the head of Stewiacke River and south of the East River of Pictou.

Devonian of Mount Thom.

On the track north from Campbell's Siding, about a quarter of a mile south of John McKay's, Devonian rocks are found which connect those of the south with the rocks of Mount Thom and the east end of the Cobequid Hills. They comprise green, light grey and purple pearly slates, with whitish quartzites, intersected by dykes of diorite. On the road to the west end of Mount Thom, are reddish and cream-coloured argillite and rusty-weathering quartzite, veined with ankerite; and similar slates are everywhere in the vicinity.

Dykes.

Carboniferous rocks north of the railway.

The rocks of this track south of the crossing of a branch of Black River, consist of grey and reddish fine sandstone and grit, very shaly, associated with coarser rocks and probably belonging to the Carboniferous series to the northward. Near the railway they are rusty-weathering, finer and argillaceous. From where the track strikes the railway, the first cuttings to the eastward show dirty greenish-grey and grey, rusty-weathering, crumbly, argillaceous sandstone and shale; underlaid by reddish marly rocks resembling those below the fork of Middle River, and succeeded, further east on the railway, by dirty, greenish and grey rocks and black carbonaceous *Cordaite* shales, containing layers of slaty bituminous coal which have been dug and which appear in two of the cuttings to the eastward.

Coal.

Calvary Stream.

Nearly all the rocks of Calvary Stream below the driving-dam, three miles above the railway, lie between the grey rocks of Riversdale and the red rocks of Union. Near the dam they are massive, full of iron pyrites, and veined with quartz and ankerite; certain bands of light grey, often flaggy, sandstone show bright red blotches. The greenish and grey, wrinkled, shaly rocks of the cliffs at the dam, at the iron mine, are much more flinty than the rocks above it, perhaps because of the proximity of volcanic rock. Below the dam is a white-weathering, green slate and a wrinkled, scaly, graphitic, polished slate, full of quartz veins, succeeded down stream by cream-coloured slate, ribbanded flags and a small outcrop of trap. Below, are grey, rusty-weathering, crumbly shales, underlaid by light grey Guysboro' quartzite, again underlaid by flags, breaking into bricks.

Iron mine.

Dyke.

Limestone.

These lie at the mouth of Johnny's Brook (which flows from Island Lake) up which are the red rocks of Union. A band of five feet of impure limestone is found in Calvary Brook, not far above the railway, * among light-coloured flinty sandstone and shale, veined with milky quartz. Then come, up stream, red rocks with green blotches, with minute veins of ankerite and calcite, and a patch of greenish conglomerate. Black slates with lenticular patches of grey sandstone are interstratified, near the mouth of Brown's Brook, with whitish, very flinty, coarse quartzite or grit, veined with quartz, of great thickness, with greenish, grey and reddish, ripple-marked, flinty flags, veined with quartz and ankerite, and with blackish shales with a few nodules of ironstone. Outcrops are nearly continuous to the driving-dam and are also found in the tributaries. The dip is very high and the strike along the brook perhaps indicates a large fault which may be an extension of that which follows the East River of Pictou.

In Johnny's Brook, near the river, are dark bluish-grey graphitic slates, overlaid by whitish, quartz-veined quartzite. Up stream are cliffs of light grey, fine, somewhat soft, micaceous sandstone and greenish compact quartzite, overlaid by a reddish, massive, quartz-veined quartzite; and, at a track from the driving-dam, by reddish and greenish, somewhat crumbly, argillite. Above the track the dip is up stream at angles varying from 50° to 80°, and the rocks are those of Union—reddish and whitish spotted sandstone or quartzite and argillite, veined with quartz. Greenish and grey slaty argillite and quartzite occur with the red rocks near Island Lake, and on the hauling road to the Pembroke road, on which, towards Riversdale, red rocks show occasional green layers. In Brown's Brook are light grey and greenish quartz-veined quartzite, in thick beds with red and light grey, glistening, coarse, flinty, quartz-veined, quartzose sandstone, resembling that of the main brook.

Stewiacke River.

Beneath an unconformable covering of gypsum which occurs on both sides of Stewiacke River near Crockett's at Eastville, lie red and purplish strata like those of Union, veined with quartz, containing bands of greenish sandstone, and probably overlying the grey rocks seen higher up stream, as they do at Salmon River, although the steep dip renders this difficult of determination. At

Carboniferous conglomerate.

Cox Brook is another outcrop of red rocks, probably of this age, underlying a conglomerate which seems to be identical with that

*Sir J. W. Dawson states that he has collected at Riversdale [Lower Carboniferous Plants, pp. 29-34] *Calamites Cistii, C. cannæformis, Odontopteris antiqua, Cardiopteris?, Hymenophyllites furcatus.*

which overlies grey quartzites and slates of the gold-bearing series at the Newton Mills iron mine. The exposure of these upper rocks in the river is narrow, but on some of the lower tributaries larger areas of them come from beneath the Carboniferous limestone, as at Glenbervie, where the latter is succeeded by the red rocks of Union, and on the parallel road from the Smithfield lead mine, where red argillites alternate with grey, rusty-weathering rock, often coarse and pebbly, and with whitish, massive quartzite. On the road near Harmony and also at Manganese Mines, precisely similar rocks underlie the Triassic, and will again be referred to.

Carboniferous limestone and gypsum.

In the Little River of Stewiacke, at and near a fork above the head of the settlement, red Devonian rocks are exposed, and, about two hundred and ten paces below the fork, are in contact with grey and dark flaggy Carboniferous limestone, dipping 277° $<43°$. Lower down near a bridge, are great outcrops of gypsum, north of which lie grey flaggy sandstones, like those of the Goldmine Brook, succeeded almost immediately by the red rocks of Union, including a grey rusty-weathering sandstone and coherent flags, with many markings of plants, which extend northward to a branch, and down this branch to the river at the two bridges near Leander Nelson's. On the road up the river from these bridges, flaggy sandstone and whitish quartzose grit, like those of the Goldmine Brook, perhaps indicate that these latter belong to the limestone and gypsum series. Along the most southerly of the two roads at Brookfield iron mine a strongly marked valley runs 254° towards Little River. In and immediately north of this hollow lies the iron ore, the rocks of both hills being those of Union, including, next the ore, a grey spotted, flaggy sandstone. Down Little River, Devonian rocks extend for thirty-five paces below the road to the iron mine, and are then succeeded by grey bituminous Carboniferous limestone, dipping 174° $<60°$, and overlaid by grey, soft, rusty-weathering sandstone and gypsum. The boundary closely follows the river for a great distance down stream.

Brookfield iron mine.

Salmon River.

The almost unbroken section in Salmon River is clearly a descending one from the rocks of Union to the mouth of Black River, the red of the strata being interrupted by only a few little bands of dirty green. About 200 paces above the mouth of Black River they are succeeded by massive, rusty-weathering sandstone, underlaid by whitish, fine and coarse quartzite, veined with limonite, including thick beds of very flinty conglomerate with pebbles, as large as a hen's egg, of quartz, syenite and green slate, which

Iron ore

Fault. may possibly indicate unconformity between these and the lower rocks; the dip, however, is nearly vertical and the bedding-planes are finely polished or slickensided. The rocks of this vicinity strikingly resemble those of Grand River and Guysboro', and the country underlaid by both is precisely the same. Higher up, alternating with red beds, vertical or overturned, are whitish red-spotted quartzites, like those of Johnny's Brook; bright green and purplish, fine quartz-veined argillite and greenish rusty-weathering or cream-coloured flinty quartzite, precisely like those of Londonderry mines, with darker grey and greenish bands, very much

Specular iron ore at a dyke. altered, containing specular iron and ankerite, and succeeded immediately by a small dyke of diorite. Up stream from the diorite are cliffs of dirty greenish, grey and dark bluish-grey argillite and flags, with bands of grey rusty-weathering sandstone, perhaps equivalent to the rocks of Riversdale, but succeeded immediately below the Telegraph road by the red rocks. There is no doubt that these rocks are frequently repeated by faults. Strata of the

Carboniferous and Devonian of Steel's Run. intermediate series are abundant in Steele's Run, but those first seen above the mouth are argillite and flinty sandstone of the Union series, overlaid by a conglomerate in detached masses, and evidently newer than Devonian. Beyond the conglomerate, are red or purple argillite and quartzite, succeeded by light cream-coloured,

Iron mine. rusty-weathering strata, mined here some years ago, containing scales of specular iron and minute veins of ankerite, quartz and calcspar. They are finely striped or banded, but often too massive to show the dip, include bands of greenish pyritous slate and of pearly slate and grey and bottle-green and whitish, compact, rusty-weathering quartzite. The cliffs immediately below the saw mill contain a considerable quantity of red hematite in blotches and threads. The specular iron seems to indicate the proximity of igneous masses such as come to the surface in the adjoining country. Above the saw-mill the brook comes through marshes and intervale, but on the road are outcrops of purplish rock

Mount Thom. which extend to Mount Thom*.

Earltown. On the Salmon River road near Earltown, succeeding the syenite of Upper Kemptown, are red and green flinty rocks perhaps of this age; but they require further examination to separate them from the Silurian of the vicinity.

Iron ores. Above Jacob Fenton's, the Salmon River shows good outcrops of greenish-grey, flinty, rusty-weathering, ferruginous rocks, with patches of botryoidal limonite, alternating with other red and grey

* Acad. Geol., p. 502.

rocks as far as the foot-bridge at John and David Ross's. Similar rocks, also containing a considerable quantity of limonite, have been worked in Upper Kemptown at several places. Between Kemptown and Upper Kemptown are indications of the red rocks of Union, and some of the large blocks of rusty-weathering Devonian rock which are abundant on the Telegraph road east of the road to Mount Thom contain traces of botryoidal limonite. On the road to the left from the mill, debris of purple and green Devonian slates and of grey flaggy sandstone and shale is seen as far as the clearing of John and David Ross. Upper Kemptown.

Whether or not newer rocks occur on the road between Kemptown and Upper Kemptown is somewhat obscure; the red rocks are perhaps all of the Union series. But there is no doubt of the Devonian age of the rocks of Matheson Brook, the first stream to eastward north of the post office, which flows over red and green slates not far below the road, and, about half a mile below it, dashes down fine little falls composed of grey, compact, flinty, rusty-weathering slates, succeeded down stream by all the rocks of the river below the Telegraph road, including light grey, bluish-grey and greenish-grey quartzites, of considerable variety of texture, more altered than usual. Salmon River, above the mouth of Matheson Brook, exposes rocks like those of the Red Bridge, sometimes massive and crumbly, with several red beds. These extend to the mouth of Ross Brook, where many blocks perhaps indicate the beginning of the syenitic rocks of the mountain, which are in place higher up. In Ross's clearing and on the road to the eastward, as described above, and in the fields as far as Pat McAulay's clearing, Devonian slate abounds. Red and grey Devonian rocks apparently follow the Telegraph road from McAulay's westward to the Riversdale road, and extend southward along the latter nearly to the top of the hill where the dark slaty strata of Riversdale and the vicinity begin. Syenite of Salmon River.

The strata of Salmon River about a quarter of a mile below the mouth of Black River are perhaps near the base of the red rocks of Union. They comprise indian-red and purple, coherent, flaggy rocks, striped with lighter colours and interstratified with beds of softer, crumbly argillite, resembling the rocks of Rocklin, underlying which is a thick bed of rusty-weathering, glistening quartz-veined sandstone or quartzite.

Up Lamby's Brook, two miles west of Riversdale, red quartzite and argillite are interbedded with whitish quartzite. At Allan's logging road in this neighbourhood are blocks of light-coloured sandstone or quartzite, spotted with hematite, and of flinty con- Brooks between Riversdale and Union.

glomerate, like that of Salmon River near the fork of Black River. Narrow Mouth Brook, below the logging tramway, shows good outcrops of light grey, massive sandstone, of somewhat coarse texture and very coherent, among a great mass of red rocks. Reddish and greenish flinty flags and shales and whitish quartzite are also found up along the tramway; and on the track past Moose Lake are light grey and whitish quartz-veined sandstone and quartzite, apparently belonging to the intermediate series, although no iron ores appear yet to be discovered in this vicinity.

About half a mile above the Greenfield Brook a little brook enters Salmon River from the north, showing, for some distance up stream, reddish and rusty, quartz-veined flags and argillites, white-weathering, forming rocky barrens like those of Loch Lomond and Grand River*.

Greenfield Brook.

Greenfield Brook shows fine outcrops of these rocks in as great volume apparently as is exposed on the railway. Immediately above the railway are cliffs of bright red, crumbly, micaceous argillite, with flinty layers and bright green spots covered with broken carbonized plants. They resemble the red rocks of Rocklin and Concord. Higher up they are more sandy, jointed and flinty, include a band of bottle-green, ribbanded, flinty, fine sandstone, and exhibit lines of jointing at right angles with the bedding. A short distance up, at a turn of the brook, is a very compact, reddish and greenish, glistening, micaceous, red-spotted quartzite, like that of Salmon River and the Pembroke road, breaking into blocks which encumber the almost barren surface of the land adjoining the brook. Higher up are greenish rocks veined with quartz, and above the Greenfield settlement similar rocks extend towards Smithfield, and are exposed in all the little brooks of the neighbourhood.

Diorite east of Valley.

East of the cross-roads near Valley, the Telegraph road passes over red flinty rocks in contact with coarse diorite. With the former are interstratified greenish quartz-veined rocks containing minute veins of limonite.

Henry Christie's Millbrook.

In Henry Christie's Millbrook, Triassic rocks are underlaid by light grey flinty quartzite, with minute veins of white quartz, succeeded up stream by indian-red quartzite and argillite, well exposed in rough falls and exhibiting numerous veins of white crystalline quartz, some of which are nine inches thick, contain traces of crystalline pyrolusite and have been worked. For some distance above the mill are good exposures of red argillite, and the occasional outcrops higher up are of red flinty sandstone and argillite.

Manganese ore.

* Geol. Surv. Rep. for 1877-78, p. 20 F.

In Murray's Brook, below the Triassic, are quartz-veined red quartzite and argillite and whitish compact quartzite. Similar rocks, sometimes full of fossil plants, extend south to Harmony and across to Henry Christie's Millbrook, the land being very rocky.

Truro.

The rocks of the lower part of Victoria Park Brook, of Truro, are reddish or purple crumbly shales which might represent the upper beds of Tracadie and Rocky Bay*. Higher up at a fall, they are succeeded by fine grit, sandstone or quartzite, whitish and like that of Grand River, part of the surrounding country being also like the Grand River barrens. The bands of sandstone interstratified with the shales are very coherent and contain markings of plants. The brook is rocky and steep and presents views of extreme beauty.

Fossil plants.

Clifford's Brook.

Passing to the tributaries of the north side of Salmon River, the first rocks from beneath the Triassic in Clifford's Brook are red crumbly argillites, followed by reddish-grey, fine, striped sandstones and coarse grit, with streaks of green, containing a little pyrolusite in the joints which has led to the cutting of many pits and trenches in search of that mineral. Above the road, at one of these openings, pieces of Carboniferous limestone are found in the drift, and not far up stream this rock forms a cliff. In McKenzie Brook, above Philip Archibald's, the red argillites first seen are succeeded by dark grey argillites and rusty-weathering sandstones or quartzites probably of the Riversdale series. A little lower down, red argillites are found in contact with green marls, which may be associated with the gypsum of the quarry. Down stream from the fork to Salmon River are outcrops of grey and reddish, sometimes bright red, mottled, greenish, cream-coloured and reddish sandstones and shales, with a two-foot band of concretionary limestone conglomerate. Plates and veins of manganese ore occur in the planes of bedding and jointing. On the railway between the mouth of this brook and Valley, the quartzites are curiously channelled in the direction of the joints which are at right angles to the dip; they belong, of course, to the higher series of Union.

Manganese ore.

Carboniferous outliers.

Manganese mines.

In the west branch of Halfmoon Hill Brook, which follows the Telegraph road for some distance, are reddish, purplish, greenish and grey, striped and banded flags and shales, with layers of flinty, micaceous sandstone, containing veins and large blotches of pyrolusite, just as the hematite and specular iron ores occur in the Guysboro' quartzites. Many pits have been opened on these deposits which are unconformably covered down stream by Triassic rocks.

* Geol. Surv. Reports for 1879-80, p. 39 F; and An. Rep. Geol. Surv., vol. II., 1886, p. 65 P.

Triassic and Carboniferous rocks.

The purple and red argillites, with greenish and grey spots, of the upper part of Farnham's Millbrook will be described with the Carboniferous limestone at their unconformable contacts.

On the Jollytown road for 472 paces north of the Telegraph road, obscure traces of greenish perhaps Carboniferous sandstone are met with. In the brook a short distance further, pieces of grey, flinty, flaggy sandstone are succeeded down stream by red argillite and quartzite, overlaid at one point by Carboniferous limestone. Further out, the road crosses grey and reddish soft sandstone and shales, comparatively unaltered, very like Carboniferous, but also like certain Devonian rocks of the North and Salmon Rivers, not well exposed, and associated with flinty sandstone and with dark bluish-grey or blackish shales, resembling rocks of the Three Mile Lake near Lochaber and of the bridge on Salmon River near Riversdale.

Rocks between East and West Rivers of Pictou.

These exposures connect the rocks of Salmon River with those of the south branch of North River. But before describing the latter, we may again turn eastward to the great block of Devonian rocks lying north of the railway between the East River of Pictou and the head of the West River, which consists chiefly of the red rocks of Union and of the ferriferous intermediate series. They are affected even more than the other series by faults and flexures, the minute structure being in many cases still obscure.

Devonian of the Pictou coalfield.

The extension of these rocks from the Middle River nearly to the East River of Pictou on the north side of Blackwood's Brook, as shown on the map of the Pictou coalfield by Logan and Hartley, seems to be a mistake, no outcrops being found and the drift pointing rather to the presence of sandstone, like that of Fraser Ogg's quarry and of the New Glasgow conglomerate.

Dyke near Fishpools.

On the other hand, the red, flinty, veined slates of Fishpools and the rocks immediately south of the south fault in the East River are apparently Devonian rather than Millstone grit; and, as was pointed out by Mr. Poole, superintendent of the Acadia Coal Company, they are cut on the left bank by a small dyke of diorite, five yards wide, containing spots of

Veins.

quartz. The adjacent strata, which resemble those of Rocklin on the Middle River, also contain veins of quartz, calcspar and ankerite. The red rocks on the right bank of the river, a short distance above the mouth of the McKay Brook, are, beyond question, Devonian. In the most northerly of the three branches of this brook, the rocks are of the flinty series, with a possible exception of the highest outcrop of flaggy red sandstone which seems to belong to the Millstone grit. The fields indicate Millstone grit between this and the middle branch

and also the outcrops near its head where it turns into the woods. Thence to the head of the third or southerly branch, the debris is of flaggy Millstone grit, down to an outcrop about 150 yards from the road, which seems to belong to the lower series. Good outcrops of rocks, often vertical, extend down stream from the road to the river. In a very small brook on the left bank of the river is an outcrop of greenish and reddish flinty sandstone like that seen at the south fault. It has, however, a vein of quartz one-quarter of an inch in thickness. In the river bank immediately above the mouth of the brook are bright red slaty rocks, like those of Fishpools, passing apparently insensibly into the red rocks of Rocklin and the south fault. Fifty-five yards above the brook is the dyke mentioned above, which may account for the greater alteration of the rocks hereabout. At a short distance higher they are greatly faulted and twisted, but are soon succeeded by the limestone of the Riverton quarry, in the neighbourhood of which a little brook crossing the railway shows red, flinty sandstone and argillite so cleaved as to make it difficult to obtain the dip.

McGregor's Mountain.

The outcrops in the brook near D. J. McDonald's at the west end of McGregor's Mountain are probably of the same series; while below the road they are undoubtedly of Millstone grit. On the hill are knobs of trap, north of which is a conglomerate and on the south-west escarpment is a large quantity of red and green slate, veined, and like that of the East River.

Cameron Brook.

Another tributary of the East River, Cameron (Meadows) Brook, exposes rocks, some of which perhaps belong to the lower group. They comprise red, greenish and bluish-grey argillite, dark bluish-grey shales, sometimes siliceous and quartzose, sometimes brecciated, containing crystals of pyrite, druses of calcspar and markings of graphitized plants, with bands of massive quartzose grit and greenish and yellowish siliceous slate, resembling certain rocks of Alma and Glengarry, and altered by the igneous rocks of the neighbourhood. The red sandstones on the railway, a short distance above the crossing of the main branch of this brook, are probably Millstone grit, the vertical dip of which may indicate a great fault. A short distance further west, in the brook immediately below the meadows, they are succeeded by red rocks apparently of the Union series, with two bands of shaly, calcareous argillite, six feet in thickness, and with layers of grey sandstone or quartzite, like that of Grand River. The shales are coherent and slaty, the sandstones flinty, ringing and rubbly; they are associated with bluish-grey and greenish-grey slates, similar to those found north-east of Glengarry. On the road which crosses the railway west of the marsh, there is

Fault near Hopewell.

no question of the Devonian age of the purple slates; to the north of this road are many blocks of Devonian rock, with others of syenite; and rocks similar to those of Watervale extend to the Marshdale. Marshdale cross-roads. On the road to the left from the cross-roads, slaty, Devonian sandstones and argillites, greenish and grey, purple and reddish, extending to the road along the Middle River, are well exposed in a large brook not far above Concord Mills. On the road up the river to Glengarry the debris is very like that seen on the railway and on other roads north of it.

Lorne. Blocks of purplish argillite and striped diorite on the railway east of Lorne probably indicate the rocks of Glengarry and Big Brook; and a rusty-weathering limestone, resembling that associated with a black shale of Big Brook, is found with whitish sandstone, perhaps that dug with the black shale at Jesse Grant's.

The green shales below McDonald's road near Lorne are probably the equivalent of those of Middle River; the black graphitic rock below is perhaps the black shale, with lenticular limestone masses, of Middle River and Balfour Brook. The flinty, rusty-weathering sandstone and grey and greenish flags, below the limestone and dark shale, belong probably also to the Devonian. The limestones of this formation when not well exposed are apt to be confounded with the Limestone quarry at Glengarry. Carboniferous. Gordon's quarry is on one of them. Near the road to the quarry are greenish and grey, rusty-weathering, flinty, siliceous, slaty argillites, like certain strata found in the neighbourhood of Marshdale cemetery associated with red argillites and sandstone.

Contact with Carboniferous at Lorne and Elgin. From Lorne siding on the road towards Lorne the debris indicates Devonian slates and igneous rocks; but on approaching the post office these give place to the plaster pits of the Carboniferous. On the road to Elgin, reddish and bluish slates occur; and the red rocks in the little brook a quarter of a mile north of the Elgin post office are perhaps Devonian; but the reddish and grey micaceous flags of the larger brook, half a mile further along the road, are undoubtedly Carboniferous, and in the river, below the mouth of this brook, are fine cliffs of red and grey Carboniferous sandstone and shale which continue to Hopewell.

Middle River. No finer exposures are anywhere to be found than those of the various branches of the Middle River, and, judging by the variable dip, there must be many displacements of these strata. In the west branch, above the fork below Glengarry, the bluish-grey sandstone and slate first seen are not more altered than most of the rocks of Riversdale, and the greenish-grey sandstone greatly resembles the rubbly sandstone of the barrens. Immediately below the fork, dirty

greenish-grey, rubbly sandstone and argillite, lying nearly horizontal and, lower down stream, dipping southerly, resemble the rocks of Riversdale; the soil on the banks being rusty like that of West River and Riversdale. The cliffs on the left bank, lower down, are of dirty greenish-grey, crumbly argillite and of soft, flaggy, micaceous, quartz-veined sandstone, very like the rocks of Campbell's siding, the argillite containing small nodules of ironstone. Underlying these, still dipping down stream, are reddish, slaty argillites like those of Campbell's siding, and also remarkably like rocks seen in Salmon River. On the right bank, at Murray's mill-pond at Concord mills, are red rocks like those of Union, with greenish-grey bands, dipping north-westerly at a high angle, extending for some distance below the dam and being succeeded, in nearly vertical bedding, by alternations of light steel-grey, dark greenish and bluish-grey, flinty, micaceous, compact argillite and sandstone, cut by small veins of quartz, with a calcareous band, one foot thick, associated with the prevailing reddish argillite which is slaty or prismatic, breaking into large scaly pieces or into knife-and-needle-shaped fragments. The sandstones are spotted with minute cubes of pyrite and interstratified with darker papery shales, with lenticular masses of pyritous, rusty-weathering limestone. Some of the more arenaceous bands are full of reticulations and blotches of whitish quartz. Similar rocks extend in almost unbroken cliffs and reefs, the whole section being very much like that between Union and Riversdale, and some of the quartzites strikingly like those of the fork of the Black and Salmon Rivers.

Ironstone.

Concord mills.

Quartz veins.

Limestone.

The slates at the head of Rocklin mill-pond are greatly altered, as well as those off the brook coming into the pond, among which a pit has been dug in search of copper. The dip is southerly as far as the mouth of Balfour Brook; and up stream in this brook is a descending sequence of the red rocks of Union, jointed into blocks, the argillites greatly predominating, with a low angle of dip. The blackish shales higher up are, perhaps, those of the fork of the river; they are papery and include lenticular masses of greenish-grey limestone, slaty, polished and graphitic. Above the bridge on the river road are light sea-green nacreous slates, cut by veins of ankerite and quartz, sometimes one inch thick, interstratified with whitish-weathering quartzite with rusty patches; overlying are purplish, rubbly, flinty sandstone or quartzite, and up stream is a mass of greenish-grey, fine, pyritous limestone, succeeded by rusty-weathering, pebbly grit, containing specular iron ore, and by compact quartzites like those of Guysboro'. Higher up the rocks form a gorge. The dip is generally obscure.

Rocklin.

Black shales.

Iron ore

Whitehill. On the road from Hopewell to Whitehill school, the reddish and grey, flaggy, wavy sandstones are probably Millstone grit; but, on the steep road north-westward from the school, flinty, friable Devonian argillites are immediately in place. On the road south from the school, blocks of flaggy Carboniferous sandstone are in one place seen, but for the most part, for two miles, as far as the road on the left, the debris seems to indicate Devonian. On the road to the left are quartzites and trap, succeeded by Carboniferous rocks, which extend to Hopewell. Up stream in the brook, not far west of Whitehill school, are outcrops of grey and red, rubbly, coherent rocks, with veins of ankerite and films of specular iron in the joints. Below the road in this brook, similar coherent rocks, often rusty or cream-coloured, full of ferruginous matter, and very like strata of the Londonderry iron ore series, are fairly well exposed down to the house in a clearing, where a high hill is on the right and low land on the left. At the foot of the clearing, not far from the house, the brook exposes rocks of a totally different character—red, soft sandstones, dipping at a low but variable angle, perhaps Carboniferous, A short distance lower, however, reddish and dark grey, rubbly, veined, ferruginous strata are again in place and are well seen at the bridge below on the river road.

New Larig. On the road north-east from New Larig post office, purple Devonian slates are interstratified with greenish and grey varieties*.

Millbrook. Upper Devonian rocks are well exposed at and below the picturesque thirty-feet fall at Thomas Fraser's mill at Millbrook. They consist of grey, rusty-weathering, greenish, sometimes silvery, and reddish, flinty, splintery sandstone and slate, which are also found in the roads and brooks of the neighbourhood, spotted with specular iron, pyrite and ankerite, like the rocks containing specular iron at Guysboro' and West River. Certain beds contain fossil plants. Succeeding the quartzites and slates of the falls down stream, are reddish argillites with greenish bands and blotches, and hard layers of micaceous, fine sandstone, the argillites crumbling into pieces of a regular shape as large as marbles. Lower down these are associated with graphitic slate, containing papery layers and lenticular patches of wrinkled graphitic limestones, like that of Balfour Brook. Below the bridge, at Kerr's old factory, are ribbanded shales with a high and variable dip, they include grey soft beds of argillaceous shale and sandstone, with many carbonized plants, and some of the associated rocks are veined with ankerite and contain much yellow iron oxide in the joints. The road from this point up the Middle

* Canadian Naturalist, vol. IX., 1880.

River is probably all underlaid by Devonian flinty rocks. From the end of the Millbrook road and down along the river road, the land is flat and cultivated, and shows no rock to the road across Middle River at Union Centre. Argillaceous debris is still found, but perhaps only as drift. In front of Mr. Duncan McDonald's house are several blocks of grey Carboniferous sandstone and in the road beyond, near the next house, are many pieces of red Carboniferous sandstone. On the road from the bridge to the Pleasant Valley cemetery no rocks are seen, but on the back road the debris is Devonian.

Copper ore.

In the little brook which enters Middle River opposite the Millbrook, greenish and grey sandstones lie at a variable angle. Below the bridge they contain traces of copper ore. Higher up are red rocks like those just described. Perhaps at or near this brook is the passage of a great north-and-south fault.

Hugh's Brook.

The first rocks seen in Hugh's Brook above the Middle River roads, are, perhaps, Carboniferous. Those found a little higher resemble the red rocks of Union, which are also indicated by the blocks in this neighbourhood and towards Pleasant Valley. The rocks of Hugh's Brook, from the school at Pleasant Valley down stream, are singularly rubbly, notwithstanding their great lithological resemblance to Carboniferous. The Devonian metamorphic aspect is, perhaps, best seen at a little brook from the left, below a bridge on a farm road, where the dark argillaceous shales with calcareous bands strongly resemble a rock on the railway between Hopewell and Lorne, and also that of Balfour Brook and Millbrook.

Balfour Brook.

In Middle River, below Balfour Brook, is a descending sequence of red flags and argillites, underlaid by light grey and greenish-grey, flaggy sandstone, all of which contain broken plants. The sandstone is about twenty feet thick and is underlaid by five feet of greenish shale, succeeded by red rocks, one fine, flinty bed of which contains spathic iron in the joints. The grey sandstone is on both sides of the river and seems to form an anticlinal to it. It is very flinty and, like the rocks of West River, contains pipes of coal. Lower down are reddish, coherent rocks, almost certainly the same as those above Rocklin and including a band of red quartzite. Then come the nearly vertical, reddish-grey and greenish, rusty, broken, flinty sandstone and argillite beneath the church, veined with ankerite and glistening with quartz. The red beds greatly predominate. The grey and greenish beds include pipes of coal. These rocks are exposed to a little below the bridge, the grey sandstone being perhaps the same all along, the strike

carrying it down the river. They are still seen at a brook from the right opposite Millbrook, where a sparkling, fine sandstone, breaking into pieces of irregular size and shape, shows none of the smooth-bedded, flaggy character of Carboniferous sandstone. Below this brook rocks are concealed for some distance, and red, greenish-grey and grey sandstone and argillite are next seen, while immediately below are grey sandstones of flaggy, coarse variety, full of broken plants, less altered than those above described and perhaps Millstone grit, the Carboniferous limestone being apparently all cut out on the river by a great fault.

Brown's Brook.

At the mill on Brown's Brook, not far east of Pleasant Valley road, are outcrops of greyish, dark-grey, greenish-grey and reddish shales and sandstones, coherent, rubbly, nearly vertical and like the rocks north of Glengarry. Eastward from the mill to the main road the grey soil perhaps indicates Devonian, although at the bridge and in the brook up to the mill the New Glasgow conglomerate is in place. Devonian debris is very abundant on the road to the south from the bridge. On the main road, north as far as the carpenter's shop, the soil is also grey, but outcrops of the Permian conglomerate are in the brook on the right. To the westward, however, on the Truro road, 744 yards before coming to the watering brook east of Salem church, greenish Devonian rock, precisely like that of McCulloch's Brook and the railway, is in place in the road cuttings. Thence the boundary seems to follow the road to the fork of the road to Limerock, the conglomerate of

Greenhill.

Greenhill lying to the north. Up stream the watering brook for half a mile from the road shows only blocks of grey and greenish-grey Devonian rock with films of specular iron. From this point north-westward to the road above the church, similar debris is found in the fields, and pits have been sunk in search of iron ore.

McCulloch's Brook.

The Devonian rocks of McCulloch's (Bear) Brook, Alma and Waters' Hill have been described by Sir J. W. Dawson*, Dr. Honeyman†, and Mr. Hartley, but the latter has included in his description small areas of the New Glasgow conglomerate, which lie unconformably upon them§. In McCulloch's Brook they underlie the Permian and Carboniferous, and comprise greenish-grey and red, mottled, rubbly slate and micaceous sandstone, with patches of conglomerate which contain large pebbles of a quartzite, like that of Guysboro'. With these are associated

Newer rocks.

* Acadian Geol., p. 502, and Supplement, pp. 48-70.

† Trans. N.S. Inst. Sc., vol. III., p. 141.

§ Geological Survey Report for 1866-69, p. 58, l. 4.

greenish soft rocks and light grey micaceous quartzites, full of quartz-veins. The series resembles certain rocks of Silvey Brook and of Elgin. In the lower part of the brook the outcrops are interrupted by overlaps of the New Glasgow conglomerate. From these rocks in 1866 Dawson obtained "stipes of ferns, apparently of two species; a *Pinnularia* and branching stems much resembling those of *Psilophyton*, a characteristic Devonian genus; also fragments of carbonized and pyritized wood, but not sufficiently perfect to show structure." The broken conglomerate and bluish-grey slaty rocks of the railway cuttings west of this brook, and the rocks which underlie the New Glasgow conglomerate above the bridge at Alma are also of this age. They consist of greenish-grey fine breccia or conglomerate and light grey, micaceous, compact, flinty sandstone, resembling in their brecciated and rubbly character Cambro-Silurian rocks; but the argillaceous layers are soft and earthy. Fossil plants.

The crystalline, non-fossiliferous limestone of Waters' Hill is a shaly and thick-bedded, greenish, compact, splintery and ringing variety, full of veins of calcspar. It is underlaid by greenish, rubbly, splintery slate, cut by blotches of ankerite; and obscure deposits of iron ore have been found in the immediate vicinity. Limestone of Waters' Hill. Iron ore.

Exposures of Devonian rock, perhaps equally interesting, are exposed in the West River of Pictou, between the railway and Saltsprings. The debris seen on the road down the west side of the river indicates, as already stated, rocks similar to those of the railway west of the station. The first outcrops in the river, a short distance above Watervale, are grey and greenish-grey rubbly argillites and siliceous sandstones, blotched with quartz and with joints full of films of specular iron, somewhat pearly but not graphitic, with veins of rusty-weathering ankerite and specks of pyrite. These are associated with layers of green and reddish more evenly bedded rocks, with graphitic streaks, all very flinty and compact, and including patches of conglomerate; also with ripple-marked flags, sometimes dark and graphitic, resembling the rocks of Guysboro'. Immediately above the Watervale bridge, are cliffs of bluish and greenish-grey, massive, siliceous and argillaceous slates, dark grey graphitic flags containing a few veins of quartz, and joints glistening with specular iron. Among them are patches of conglomerate or breccia and several purplish layers; the green slates are finely ribbanded; the quartz veins contain also spathic materials. Succeeding these rocks some distance down stream are greenish, soft, pearly slates, like those of Silvey Brook, with specular iron in the joints and reticulating veins. Some of the West River. Iron ore. Watervale.

Fossil plants.

layers show *Cordaites*, *Calamites* and other land plants. Lower down the proportion of red beds is larger, and a fine gorge shows nearly unbroken outcrops of banded and mottled red, green and grey rocks, often veined with quartz, sometimes calcareous, and with limestone nodules. Many impressions of trees occur in the sandstones, and of broken plants in the dark shales. At the high picturesque bridge above Saltsprings, rocks are still exposed, being here bright green, bottle-green and grey, with red layers, and a

Crystalline limestone.

rusty-weathering, wrinkled, slaty, impure, crystalline limestone, ten feet thick. At a fault a short distance down stream, soft Permian rocks succeed these strata, but they reappear in cliffs on the right bank, where they contain patches of conglomerate and of bluish-grey flinty breccia. Still lower down are cliffs of greenish-grey, thick-bedded or massive Devonian quartzite.

Watervale Brook.

In Watervale Brook, for a great distance above the red, purple and greenish slates and quartzites of the mill-dam at the river road,

Carboniferous and Devonian.

the ground is covered with blocks of bright red and grey conglomerate, grit and soft sandstone, probably Carboniferous strata resembling those of the West River of St. Mary's, and of Galant River, Margaree. On the north side of the brook, however, is a hill upon which are exposures of purple, grey and greenish Devonian slates, and high up the brook are good outcrops of Devonian rock. On the road from the Telegraph road to Watervale all the rocks are Devonian as far as the crossing of the first branch of Watervale Brook, where the conglomerates begin. On the road from the head of this brook, at McKay's, back to the railway, Devonian rocks again appear, but the greater part of the track is occupied, as already stated, by Carboniferous sandstone, grit and conglomerate. At the head of Watervale Brook, on the road to McKay's, and elsewhere in the neighbourhood, are good outcrops of light grey, greenish and whitish slates and quartzites.

In the brook from the west below Watervale exposures of broken rocks above the road, perhaps indicate a fault. The rocks on the north-east side of the vertical dip are grey sandstones and dark shale or slate, like those near Riversdale. Higher up, the steep dipping rocks do not again appear, but to the northward is a glen supposed to indicate newer unconformable rocks.

Saltsprings.

In the little brook which enters the West River from the eastward at the forge at the end of the suspension foot-bridge opposite Saltsprings, there are exposed greenish-grey, rusty-weathering, flinty Devonian rocks, with whitish calcareous bands, layers of rusty-weathering sandstone, full of blotches of specular iron and ankerite, associated with lilac and red rocks. In the

large brook to the eastward, the outcrops show a large preponderance of red. They are associated with wrinkled, brecciated, very pyritous limestone, veined and blotched with calcspar, underlaid by a considerable thickness of whitish sandstone like that of the suspension bridge. The limestone passes into, or is intimately associated with, black shale, veined with calcspar and quartz, and full of pyrite. These rocks are overlaid by the soft sandstone and conglomerate of the river. The limestones here and in the river are no doubt those referred to by Sir J. W. Dawson*, as "altered Carboniferous rocks." But they differ from and are unconformably beneath the unaltered Carboniferous limestone of Limerock further down the river. Limestones.

The large blocks of purplish, flinty conglomerate on the road between Lovat and Millbrook are perhaps Devonian. Between Millbrook and Limerock, purple Devonian slates are cut by igneous rocks; they include a greenish breccia, like that of McCulloch's Brook, and are overlaid with soft sandstone, probably Permian. Other brooks of this region present good outcrops, but need not be referred to as they are indicated on the map. Dykes.

South-west of Millsville, among the felsites and breccias of Mount Dalhousie are red and green argillite, probably of Devonian age. Mount Dalhousie.

In this connection the doubtful red rocks of Waugh River and the vicinity may be described as probably of this age. Near the head of Nabiscump Brook they are found, near the margin of the Silurian areas, altered by dykes of felsite and diorite, and comprise flinty red argillite, quartzite, grit and conglomerate. South of this brook are reddish and purplish flinty, micaceous, rubbly sandstones, spotted with white and green, in part calcareous, and massive, with traces of hematite, very like the red rocks of Union, and associated with bluish-grey massive argillite, blotched with quartz. Waugh River. Dykes.

On the road down along Waugh River, below Earltown, are great blocks of very flinty conglomerate, like that of Arichat or Barney's River, in which are found traces of hematite. Where the river crosses the road, outcrops both of sedimentary and dioritic rocks are present, while in several brooks of the neighbourhood there are red flinty rocks, which resemble the Devonian lithologically. In a little brook from the north, which crosses the road below Earltown Falls, reddish, very rubbly argillites, with polished joints, full of calcspar and hematite, are found above the road, associated with layers of reddish, micaceous, nearly compact, somewhat flinty sandstone, showing a few *Psilophyton*-like markings of Fossil plants

* Acadian Geology, p. 315.

plants. They most closely resemble the red rocks of Union, and probably include a very flinty conglomerate of the neighbourhood. In other brooks this is calcareous, blotched with green and veined with quartz and calcspar.

Not far above the bridge, on a road to Baillie's, is an outcrop of dark greenish-grey, soft trappean and dioritic rock, followed by reddish, fine and somewhat flinty argillaceous sandstone, interstratified with red, soft, crumbly argillite, and with pebbly patches.

Limestone nodules.

The shales hold many greenish and grey nodules of limestone, smaller than a hen's egg, also one greenish nodule of argillaceous rock, nine inches thick. Then in cascades are seen alternations of reddish-grey, flinty Arichat conglomerate, composed of pebbles of felsites and quartzites. Similar outcrops occur in other streams of the neighbourhood about Ferguson's Brook.

In a branch of McDonald Brook, a tributary of Waugh River, blocks of diorite or trap are found not far above the mouth, succeeded up stream by outcrops of light grey, flinty, fine sandstone, reddish sandstone, and grey, soft, argillaceous flags, used

Whetstones.

locally for whetstones. But the greater part of this district is underlaid by dark grey, massive, fine diorite.

Cobequid Bay North River.

Devonian rocks are well exposed in all the streams flowing into Cobequid Bay from the north. Of these the first is North River, in all the branches of which they are met with. In the south branch of North River both the upper and lower rocks are present and have in most places been indicated on the map. The contact of the iron ore belt of these rocks with the overlying conglomerate of Carboniferous age is well seen in the little brooks which flow into the North River from McKenzie settlement; the junctions appear nearly all to be faults. On the road from this settlement to the Earltown road, the debris indicates Devonian rocks, and the Carboniferous seem to be cut off in this direction. On the track through the woods eastward to the south branch of North River, the blocks, as far as the crossing of this river in a hay-marsh or meadow, are of reddish-grey, somewhat flinty sandstone, often coarse and flaggy, possibly Carboniferous, but more probably similar to the coarse rocks found greatly altered by the syenite in the branch above John Munro's. On the east side of the meadow a great quantity of rubbly quartzite debris, chiefly red, and containing traces of specular iron, points to the extension of these rocks in this direction; and at the edge of the clearing, near

Iron mine.

the site of an old portable mill, limonite has been dug in considerable quantity from red and cream-coloured slates. Down stream from this mill are outcrops of grey, rusty-weathering and red or

purple, coherent, slaty argillite, full of threads of limonite, and with films of red hematite in the joints, interstratified with bands of fine, micaceous, flinty sandstone or quartzite. Rocks less altered succeed down stream; then none are seen down to the branch from a meadow and large lake, and for nearly half a mile below this fork; then grey and reddish-grey, fine, flinty sandstone is found, the river passing through a barren waste, like that near Landsburg's, on the West River. Few rocks are, however, seen to Mingo's intervale where they appear to be chiefly of the lower group.

Contact of Triassic.

Reddish crumbly shales with bands of flinty sandstone come from beneath the Triassic on the right bank of North River, seventy-seven yards below the iron bridge, the Triassic lying at a very low angle; and in the brook immediately to westward are outcrops of grey slaty argillite and of reddish and grey, somewhat flinty, flaggy sandstone and rusty-weathering shale. On the opposite side of the river the contact is again seen in Smith Brook, the boundary between the Triassic and the reddish, flinty, sandy shales following the edge of the intervale for some distance.

Coaly shale and limestone.

On the south side of, and underlying the conglomerate and grit in the North River near Cranberry Brook, is a great thickness of red rocks of this series in descending order, the dip at the top being about 61°, but generally much lower. If there is no fault here, the rocks exposed must represent a thickness of 4,745 feet, as computed from the dips. They consist of reddish-grey and grey, flinty, micaceous flags and quartzites, the grey beds being full of broken plants, and including a layer of flinty nut-conglomerate, of mottled red and green crumbly argillite. The sandstone is fine, sparkling with grains of quartz; it includes patches of grey and greenish limestone conglomerate, streaks of black carbonaceous shale, and lenticular layers of greenish argillaceous shale, and of light grey, rubbly, wavy sandstone, with *Calamites*. The dip to this point has been up stream. Now it is reversed to 172° < 67° perhaps at a fault, and there is a fine exposure of grey wrinkled shale and thick-bedded limestone, probably fifty feet thick, full of calcspar veins. On the north side this stands nearly vertically against red argillite, succeeded by grey flinty sandstone or quartzite. On the south side the rocks are concealed for some distance. It is like the limestone found altered among the syenite and diorite above McCallum settlement. Below the bridge, on the post-road, the rocks are dark bluish-grey with reddish bands; evenly-bedded shales with limestone layers and nodules, perhaps belonging chiefly to the lower group; and on the road to the westward, perhaps underlying the red

shales, is a coal seam which has been worked in a shaft*. At the limestone the rocks dip down stream at a very high angle, but a short distance from it they again dip up stream, and the grey rocks would thus underlie the red, as at Riversdale and Salmon River. In Canoe Brook, the red rocks are also well exposed, as shown on the map.

Upper North River.

In the river, where it follows the Earltown road, between Upper North River and Nuttby, the flinty rocks succeed the conglomerate and Carboniferous grit about 240 yards above the bridge on the road to the McKenzie settlement. Here they are light grey, flinty, sparkling sandstone or quartzite, with reddish bands, greatly altered, followed by greenish, more argillaceous rocks, flinty and porcellanous, full of reticulations of quartz. Then, at a little cascade, greenish sandstone is seen within four feet of a granular chloritic diorite of many shades of dark green, traversed by veins of epidote, and mixed with bright red syenite. The slaty rocks are half a mile wide; then comes half a mile of coarse syenite and diorite, then sedimentary rocks mixed with igneous, the former consisting of greenish-grey, flinty, nut-and-egg conglomerate, with fine, grey, rusty-weathering sandstone, succeeded by black shales with layers of bluish-grey calcareous rock, sometimes a fair limestone, and in one place eighteen inches thick. The slates show graphitized markings of plants, and perhaps belong to the lower group. Higher up are flinty bands of grey grit and of greenish and dark porcellanite, the prevailing rocks being dark shales and flags of lighter colour, often greatly contorted and in contact with greenish fine diorite, full of grains and threads of quartz. Similar rocks occupy a great breadth on the road towards Earltown. In a brook near the top of the hill they are flaggy and quartz-veined, but in the first brook flowing the other way, trap and diorite prevail, although among them are still found red flinty rocks. On the old Earltown road red syenite is the country rock for a great part of the distance from McKenzie settlement to the junction of the new road at the top of the hill, altered red argillite being, however, found three-quarters of a mile from that road; and from the junction to Nuttby post office apparently including masses of diorite. On the road towards New Annan at Kavanagh's mills, about 200 yards beyond the house, half a mile from the fork of the roads, is a mass of pinkish porphyritic felsite, but almost immediately again come in dark slates, Silurian or Devonian. Slates extend for some distance on this road, as far as the last house at the head of the brook, beyond

Contact with igneous rocks.

Earltown.

New Annan.

*Geol. Surv., Ann. Rep., Vol. I, 1885, Part E, p. 47.

which rusty-weathering porphyritic felsite, dark diorite and black and grey trap extend to Kavanagh's mills.

In the west branch of North River, above the bridge at the Presbyterian church on the Tatamagouche road, blackish shales are succeeded by reddish and greenish sandstone and shale, with a few bands of ironstone, again succeeded by greenish and grey and reddish argillaceous shale, with layers of compact, flinty sandstone or quartzite. At one point a light grey sandstone includes a patch of pea-and-nut conglomerate and of limestone conglomerate, while higher up a dark grey underclay is interstratified with the greenish shales and with coarse grey sandstone, full of small pebbles of white quartz. Among these rocks are many carbonized plants. Then come rusty, coarse sandstones, with a coaly band, fifteen feet thick, consisting for the most part of carbonaceous shale, with thin layers of shaly coal and many irregular layers and nodules of ironstone. An upright tree one foot in diameter is found in connection with the coal seam. Then come coarse and fine sandstones, with pebbly patches, dark shale and greenish-grey shale. Some of these coarse beds may belong to the higher conglomerate series, brought in by faults or unconformity. Above a band of newer conglomerate come grey flinty sandstones and shales like those of Riversdale. Then for some distance below the mill at McCallum Settlement is a coarse reddish conglomerate containing pebbles of the Devonian and igneous rocks. But above the road at this settlement these higher rocks are succeeded by the diorites and reddish-grey, rubbly, flinty quartzite and altered slates, which here include a limestone, the contact of which with the igneous rocks is described elsewhere. The quartzites in thick beds dip 123° < 85° near the contact. After more than a mile of diorite and syenite in the river comes another patch of altered sedimentary rocks, more than half a mile wide, immediately above a saw-mill. These consist of light pea-green, bottle-green and dark bluish-grey nut-and-egg conglomerate, with bands of fine grit and sandstone, patches of shale like that of Baxter Brook, and compact quartzo-felspathic sandstone. The pebbles are of porphyritic felsite, quartz and other rocks, but none of the syenite and diorite with which they are in contact. Then follow dark grey, flinty quartzite and conglomerate, in colour and texture very like that of Cape George, but also reddish, with pebbles of red syenite, but for the most part of altered quartzite. These rocks have blotches of rusty-weathering limestone and one bed four feet thick of whitish-grey crystalline limestone or dolomite, succeeded immediately by red slate and conglomerate with many veins of crystalline quartz, which cut both

Carboniferous rocks.

McCallum Settlement.

Igneous rocks cutting limestone.

pebbles and matrix. Then a greenish, slaty, fine sandstone shows black graphitized markings of plants; and dark grey slaty shales higher up, associated with flinty grit and sandstone, are full of markings of minute plants and of broad *Cordaites*. Some of the shales are fit for whetstones. The grit resembles that seen lower down near the coal, but is of course much more altered. Dark slates and rusty calcareous flags are again cut off by light greenish trappean rocks, granular quartz-felsite, fragmental and porphyritic, mixed with greenish diorite and small blotches of red syenite; but higher up, immediately below the bridge where this stream crosses the Tatamagouche road, dark bluish-grey slates are again present.

Fossil plants near igneous rocks.

The rocks, which begin almost immediately below the little branch from the lake on the west side below McCallum settlement, are probably those of Union. The grey sandstones and grits underlying are probably equivalent to those of the middle branch. Below them is a band of rusty conglomerate, loose in texture, like that of McCallum's mill, composed of felsitic and quartzose rocks; this is Carboniferous and is underlaid at a little brook from the right, by dark shales containing coaly matter, and by more rusty grit and conglomerate, the river falling over rocky cascades. Then follow grits to a brook from the right, below which alternations of grit and black shale dip up stream. Then light grey, flinty, syenitic grit, with layers of black shale, occur on a roll. The outcrops are far apart. Lower down is an extraordinary thickness of grey, fine, flinty sandstone and slaty flags.

Coalmine Brook.

In Coalmine Brook, reddish, very flinty, micaceous sandstone and rusty-grey, rubbly, compact rocks, greatly metamorphosed, come against the coal-bearing rocks by a fault. The red rocks predominate and have green spots, with specular iron in the joints, like the rocks of the manganese mines near Valley. Higher up, are dark slates in contact with light grey and greenish, granular, syenitic rock; and wedges of light greenish-grey trap penetrate the argillite. Above a mass of syenite and diorite, reddish, micaceous, flinty argillite is again in place at the head of the brook near the old Tatamagouche road. On this old road among the igneous rocks are many outcrops of altered sedimentary strata shown on the map.

Dykes.

Belmont.

In Beaver Brook above Belmont, are only a few obscure outcrops of grey shale, flaggy, flinty sandstone and other rocks perhaps of this group. In the west branch of Baird Brook are reddish, greenish and grey, mottled, somewhat crumbly shales, with greatly contorted dip.

A large proportion of the rocks of Chiganois and Folly Rivers and of the streams of East Folly Mountain belong to this group, but they are so intermixed with the others by frequent foldings that it has been found more convenient to describe them with these latter. And the same rule will be followed with regard to such rocks of the lower group as occupy small areas among the red rocks in the country west of Folly River.

Folly Lake. About 330 yards north of the road-crossing below the foot of Folly Lake, a large brook from the westward crosses the Intercolonial railway, and up it a logging sluice has been laid for about one mile and a half to a mill. At this mill are reddish and greenish, flinty, banded, altered rocks, followed down stream by light green and dark bluish-grey, flinty, compact slates in contact with a massive dark magnetic diorite. In falls and rapids further down there are flinty slates, almost gneissic, with included irregular masses of diorite in the bedding, the gneissic rocks carrying veins and blotches of quartz and epidote; and light-coloured and rusty quartzites or greatly altered fine sandstones and schistose argillites, intermixed with epidotic diorite and compact quartz-felsite, extend to the cascade, about thirty-five feet high, immediately above the bridge on the railway, at which diorite, veined with syenite, is well exposed.

Great Village River. In the gorge of the east branch of Great Village River below the mouth of the tributary mentioned on page 40, are cliffs of massive reddish syenite, quartz-felsite and diorite, among which lie greenish more or less schistose rocks, chloritic, dioritic and quartzose, dipping 167° < 80°, with small veins, layers and blotches of quartz; succeeded a few yards down stream by well-layered, flinty quartzites and splintery slates with the same dip, coherent and strongly bound together, interrupted again by greenish calcareous, chloritic diorite, followed among the falls of a wild gorge by reddish and grey, compact, syenitic rock. Below the foot of this gorge, about 750 yards above the dam for the Londonderry company's sluice, the igneous rocks no longer predominate, but are replaced by those of the iron ore series, presenting purplish altered slate or quartzite, of considerable thickness, among greenish and grey and cream-coloured rusty-weathering quartzite. About forty yards below the lowest of a succession of fine falls are dark bluish-grey slaty layers which ought to yield fossil plants.

Contact with Carboniferous. Between the falls and the overlap of the Carboniferous at the pond at the rolling mills, are occasional outcrops of cream-coloured, greenish and red, mottled, micaceous, very fine rocks. The conglomerate is reddish, contains pebbles of all these rocks, and its

contact is well seen in the brook which here enters the river from the eastward, nearly parallel with the Base-line road.

Above the tributary, the river shows only small detached outcrops of greenish, flinty, layered quartzite or gneiss and slate, which occur for only a short distance up, red syenite and epidotic chloritic dark diorite, often with thick and thin banding or jointing, and with masses of whitish nearly pure quartz, extending to the head of the river, sometimes one sometimes the other predominating, the diorite being blotched and veined with syenite in very many instances. In one of the branches is an interesting "pudding-stone" consisting of a paste of reddish and whitish syenite, in which are pebbles? three inches and downward, of dark greenish fine diorite; and in the immediate vicinity is a jointed diorite veined with syenite.

West Branch of Great Village River.

Up stream from the nearly vertical exposures of Carboniferous sandstone, shale and conglomerate of the neighbourhood of the Base-line road, the west branch of Great Village River* exposes grey slate and quartzite, bluish and grey fissile, ferruginous, unctuous slates, with small veins of quartz and ankerite.

Londonderry iron mines.

At the wooden bridge at the falls, the rocks are more or less massive, rubbly, full of ankerite in spots, blotches and minute veins. They dip up stream, are sometimes blue or lilac, but generally cream-coloured, grey or greenish. Where the gorge begins, there is a band of blackish, slaty, veined argillite. Opposite the old charcoal-furnace, excavations have been made and considerable quantity of white ore or carbonate extracted from the hill on the west. At the first dam above are greenish argillites, followed up stream by purple siliceous argillite and grey sandstone to the iron bridge on the Cumberland road, where diorites occur among the bedded rocks. Then for a considerable distance follow alternations of quartz-veined bedded quartzites, micaceous schist and hornblende-schist and diorite, followed by syenite with gneissic foliation and by mixtures of the two rocks which extend towards the head of this branch of the river.

Cook's Brook.

In Cook's Brook, west of Great Village River† immediately above the Base-line road are dark graphitic slates, full of veins of ankerite, specular iron and limonite and too twisted to show fossils; succeeded up stream by grey and greenish and cream-coloured, rusty-weathering rocks, sometimes soft and argillaceous, sometimes flinty and quartzose. Among the grey rocks are blotches of plum-coloured sandstone and shale. About 300

* Acadian Geol., p. 582.

† Geol. Survey Rep. for 1872-73, p. 23.

yards above the Base-line road is a band of blackish, micaceous, sandy slate, marked with narrow impressions of stems of plants. Up stream, greenish and grey soft shales are succeeded by greenish-grey, massive, compact, flinty argillite and sandstone or quartzite, spotted and veined with specular iron, at one time largely mined by two long tunnels driven into the steep banks on opposite sides. In a pit sunk in 1890 in the bed of the brook by Ned Langille and others, specular iron and ankerite were found in a vein, said to be from two to five feet thick, running up stream between the tunnels and perhaps on the line of the old workings higher up, above which a grey and greenish-grey, massive, quartz-veined, flinty sandstone or quartzite occupies the brook, the pasture land at its head and the hillside as far as the river. Fossil plants. Iron mines.

At the head of Martin's Brook, dark fine diorite is in contact with grey and light-coloured, altered, massive quartzite and purplish argillite. A short distance down stream, purple argillites are interstratified with greatly altered, cream-coloured, grey, purple and olive argillite and quartzite, resembling the rocks of Baxter Brook; and near the road is one of the deepest shafts on the iron ore veins of the West Mines. Martin's Brook.

In Cumberland (or Spencer) Brook the iron ore rocks again succeed the Carboniferous above the Base-line road, the first seen being black graphitic slates or shales, succeeded at a fall fifteen feet high, by reddish porcellanous argillite in contact with dark bottle-green, flinty, massive, more or less porcellanous rock, in part resembling volcanic breccia, stained with hematite and chlorite, like a rock seen in Martin's Brook, and with compact flinty porphyritic quartz-felsite. Higher up stream are the light grey quartzites, associated with grey, greenish, yellow and purple quartzite, which have been largely mined; and, at a fork of three branches, with greenish-grey and dark shales and flags which show blackened markings almost certainly of fossil plants. In the east branch are light greenish and grey rusty-weathering shale and flinty sandstone, succeeded by dark greenish dioritic rocks, causing cascades, and by mixtures of altered flaggy sandstone and purplish porcellanous argillite, with dark hornblende-rock and schistose, chloritic diorite, blotched with red syenite, which continue to the head of the brook. Similar mixtures of sedimentary and igneous rocks are found in the middle branch, which follows the Cumberland road. In the west branch a level has been driven in fine, rusty-weathering quartzose rocks, veined with ankerite, from which a considerable quantity of ore seems to have been taken. Cumberland Brook. Igneous rocks.

The rocks of Matheson Brook require no special mention, they resemble those found in other streams of the neighbourhood.

Portapique River.

One of the finest exposures of Devonian rocks is found in the gorge of the Portapique River after passing, on the lower part of the river, red Triassic sandstone and conglomerate and nearly vertical outcrops of grey and red Carboniferous sandstone and shale. The dark shales, flinty sandstones and quartzites appear in cliffs, and among certain coarse grey sandstones, in black and grey, lenticular, mottled beds on the left bank, a large quantity of carbonized vegetable debris was found. These lenticular beds resemble underclays, but are greatly altered. The associated dark shales yielded only obscure fragments of plants, but closer examination might lead to other discoveries. The fossil-bearing beds have veins of ankerite and limonite, and are strikingly like the dark sandstone of the west branch of North River, above the Earltown road. At the mouth of Otter Lake Brook, diorite is in contact with gneiss or greatly altered micaceous sandstone, almost certainly that seen below, and similar alternations extend for a considerable distance up stream. Between Sutherland Lake and the river stratified rocks in abundance are met with.

Plant remains.

Big Bass river.

For some distance above the bridge over Big Bass River on the back road the intervale is low and no rocks are exposed. Then follows an outcrop of light grey, soft, Triassic trap, in part amygdaloidal, with black spots, weathering or separating into more or less globular masses. The next rocks up stream are grey and reddish broken sandstones and shales, in all probability Carboniferous, greatly tilted and broken, among which a bed of grey thick-bedded, unusually fine sandstone has been quarried for building; it shows numerous markings of plants, streaks of mineral charcoal and coal, contains patches of conglomerate and grit and bands of light grey concretionary limestone-conglomerate. These are succeeded in cliffs in a gorge by quartzites of the iron ore series, associated with syenite and diorite. At the junction is a loop of the river round a little island of Devonian rock. Higher up occur alternations which are shown on the map.

Devonian and Carboniferous

Birch Hill boss.

Near the shore east of this river, the prevailing Triassic of the neighbourhood is interrupted by a knob called Birch Hill, in which are good outcrops of the red quartzites of Union, containing quartz veins and traces of specular iron ore in small veins and blotches. These veins have been prospected in little pits, one of which is twenty or twenty-five feet deep, but no promising quantity of the ore seems to have been obtained.

Little Bass River at and below the run which goes to Bass River, shows outcrops of grey and reddish, coarse and fine, rubbly, probably Carboniferous sandstone, with bands of reddish and dark grey crumbly argillite, with very small veins of calcspar and limonite, interstratified with bands of limestone-conglomerate passing into a pure limestone, among the pebbles of which are many of red syenite. The dip is up stream nearly to the contact with the older rocks, the last beds consisting of coarse conglomerate, with layers of reddish and grey, fine, flaggy grit and sandstone, in falls; the pebbles being of syenite, diorite, quartzite, and other rocks of the mountain. There is a concealed gap of only seven yards between this and a dark argillite with lenticular masses of dirty limestone—the first of the Devonian—beyond which is a band of dark grey, coarse, Carboniferous conglomerate which occupies fifteen yards in the brook, above which, however, there is no break in the continuity of the iron ore series, as developed at the Londonderry mines, their identity with which is indisputable. Some of the grey and greenish olivaceous shales contain obscure impressions of plants, and certain grey sandstones look like underclay, while higher are the grey and rusty quartzites of Cook's and Martin's Brooks, full of grains of specular iron. Greenish and grey and purple sedimentary rocks extend thence to the great fall, at which flinty syenite, diorite and other igneous rocks show a sort of rough bedding, like that of Economy Falls and seem to have greatly altered the sedimentary rocks. West of the falls, on the hill in McLellan's clearing, are outcrops of dark diorite, in part gneissoid, followed nearer the house by a narrow belt of dark grey Devonian slate, and that by reddish coarse and fine Carboniferous rocks in which is the small coal seam worked at Robert Young's.

Little Bass River.

Contact of Carboniferous

Carboniferous with coal.

On the back road in the next brook, which crosses west of the school, Triassic conglomerate extends nearly up to the saw-mill, about 60 paces below which, however, in a run from the westward, and again about 200 paces below it, is a mass of light grey vesicular trap, mixed with the conglomerate which seems to contain pebbles or boulders of it. At the mill, grey and greenish rusty sandstone and shale, with red bands, dip nearly vertically down stream; while half way up the mill-pond the dip is very steepy up stream. These rocks resemble the coal-bearing strata at Young's, and are probably Carboniferous.

In the next brook to the westward, grey and reddish Carboniferous flags and sandstones show a nearly vertical dip up stream, are associated with coarse grit and conglomerate, containing pebbles of the iron ore series, and are succeeded, near the head of the brook,

by grey Devonian quartzites. Below the road, Triassic conglomerate and sandstone are exposed to the fork of the brook from the school; but on the road, a short distance to the southward, these are succeeded by grey, flaggy sandstone and argillaceous shales, like those of Economy River, which extend nearly to the shore and are again succeeded by Triassic.

In the second brook to the eastward of this road, at a bend from the eastward, not far from the shore, Triassic sandstone grit and conglomerate, with impure argillaceous limestone, dip eastward 38°, in high sloping cliffs, immediately behind which lie unconformably blackish shales, holding *Naiadites*, *Cythere* and other fossils, strongly resembling the dark shales of Port Hastings, and other points on the Strait of Canso, interstratified with red shales and very coherent, micaceous sandstone or quartzite.

Fossil shells.

The outcrops of blackish shales, holding *Naiadites*, *Cythere* and other fossils, associated with red shales, which include bands of very coherent micaceous sandstone or quartzite, seen below the Triassic in the little brooks on the shore towards Economy River, are probably Devonian.

The rocks of the lower part of Economy River have been described by Dr. Ells*, and a careful survey of the relations of the fossiliferous, quartz-veined slates to the syenites and diorites of the gorge above the falls was made in 1877 by Mr. Scott Barlow, who discovered in the former indistinct vegetable fragments and obscure *Orthis*-like forms of the gold mine at the mouth of Peleg Brook. Immediately above Economy Falls are great cliffs of greenish argillite, passing into gneissic rock with coarse diorite, syenite and compact quartz-felsite, which prevail thence for two miles to the fork of the river, interrupted only by patches of greenish-grey slate. At the fork are cliffs of grey, massive, compact or obscurely granular quartz-felsite. Above it is the following succession measured along the windings of the west branch, which will give some idea of the mode of occurrence, the exposures being nearly continuous:—

Fossil plants.

Section of West Branch Economy River.

Paces above the Fork.	
200	Dark dioritic rocks among the prevailing felsite and quartz-felsite.
700	Felsite and quartz-felsite, including a patch of bluish sedimentary rock or slate.
1000	Reddish, compact, flinty quartz-felsite, at a little brook from the west.
1300	Red, jointed, compact felsite and quartz-felsite, with grains of hornblende; sometimes fine-grained.
1387	A large outcrop of slates begins. Greenish and bluish-grey, highly altered, jointed, broken slates.

* Geol. Surv. Rep. for 1885, p. 49 E.

Paces above the Fork.		
1396	The slates are associated with flinty, porcellanous sandstone or quartzite, containing grains of pyrite.	
1482	Slates with bands of quartzite; small veins of quartz. Certain dark bluish-grey rusty beds, very like the darker portion of the Londonderry iron ore series; rubbly, with the bedding obscured by cleavage. In the planes both of jointing and bedding are films of specular iron ore. Certain bands have a peculiar appearance, as of altered underclay, so often noticed in the iron ore series. One small patch of red syenite, like a vein in the slates.	Syenite dyke.
1494	Light grey, cream-coloured and rusty slates, containing veins of specular iron ¼ of an inch thick.	Specular iron ore.
1620	Rusty slates continuous to this point. Then an exposure of dark bluish-grey slate.	
1700	Greenish grey, schistose quartzo-felspathic rock which may be of igneous origin.	
1790	Reddish and grey, massive, compact, flinty felsite.	
1797	Greenish-grey, flinty, porcellanous, slaty argillite.	
1865	Chiefly slates, to a small logging-dam, 6-feet fall.	
1921	Greenish slates, to another dam and fall.	
2080	Reddish and grey, compact, flinty, porphyritic felsite, with blotches of quartz, exposed in a cliff. Then a rough stretch of the river, showing alternations of igneous rocks with slates and greenish quartzites.	
2380	Greenish slaty porcellanites, at a little brook from the eastward.	
2457	Greenish slates at a dam.	
2620	Greenish slates cut by a greenish-black fine hornblende-rock.	
2650	A cliff on the left bank shows a few obscure markings of plants in greenish-grey, evenly bedded, flinty shales and quartzites.	
2745 to 2760	Blackish, graphitic, slaty shales, in a cliff on the right bank, yield plants among which Dr. Ami has detected *Cyclopteris (Aneimites) obtusa** and obscure impressions of *Orthis?* in abundance.	Fossil plants
2855 & 2916	Blackish quartz-veined slates, well exposed.	
2970	Greenish, flinty, greatly altered slate.	
3026	Light grey and rusty slate and quartzite with quartz veins.	
3210	Greenish coherent slate, dipping steeply down stream at a little brook from the eastward.	
3220	Darker, somewhat papery slates or shales.	
3446	Light and dark shaly and slaty argillites, with very few hard bands, at the mouth of Peleg Brook.	
3490	Very black shales.	
3510	Slates lighter in colour.	
3533 & 3590	Greenish, rusty slate, with bands of quartz, at two little dams.	
3730	Greenish, more flinty and quartzose rocks. Outcrops now become fewer.	
3850	Greenish, flinty quartzite in thick beds. A little brook from the eastward.	

* Dawson's Fossil Plants of the Devonian and Upper Silurian, p. 45.

Paces above the Fork.	
4360	Greenish, flinty slate and sandstone at a little brook from the westward.
4435	Greenish, fine, epidotic trap or diorite begins.
4483	Greenish, reddish and purplish amygdaloid, then amygdaloid and diorite.
4551	A patch of reddish, greatly altered argillite and nut-and-egg conglomerate, containing pebbles of reddish quartzite, mixed with purplish amygdaloid.
4555	Dark green, fine, epidotic, flinty diorite.
4570 & 4600	Outcrops of grey amygdaloid and purple trap.
4670	Bridge on the road to River Philip, at a large driving-dam above the road. Outcrops of grey amygdaloid and diorite, with a small exposure of greenish, soft, slaty rock between the dam and the road.

Similar alternations are found on the road from this dam to the settlement of Ebbtown, while to the north past Simpson Lake the blocks and cliffs seem to indicate principally red syenite.

Economy Falls.

At the foot of Economy Falls* the rock seems to be igneous, but has an appearance of being in steeply inclined thick beds. Down stream, however, reddish or indian-red Carboniferous conglomerate, with layers of grit and sandstone, occupies a considerable breadth in the river, dipping first southerly, then vertical and very highly inclined, below which is a great breadth of dark grey and rusty sandstone and argillaceous shale containing ironstone nodules, with bands of pebbly grit, resembling coal measures or the rocks of Debert, the high variable dip indicating faults. At the turn of the river to westward these rocks are succeeded by cliffs of brick-red, coarse, pebbly grit, probably Triassic, dipping down stream at a low angle, but afterwards steeper and variable, which occupies the river to the bridge on the road to Beaver Meadow, where the Triassic gives place to rubbly rocks, resembling those of Union, which contain a few greenish and bluish-grey bands, dipping at a high variable angle. Lower down the road follows the river which exposes dark and light grey rocks, which may represent the grey and black slates of Peleg Brook, and extend nearly to the iron bridge on the shore road, where Triassic rocks are again in place and the land is low and good.

Rocks probably equivalent to the Devonian of Union are also seen on the road from the post office to Ebbtown as far as the top of the hill, beyond which the debris indicates Carboniferous Triassic.

Slates similar to those just described in the west branch occur in the Chain Lakes Brook and other tributaries of the east branch

* Acadian Geol., p. 557.

of Economy River. In Murphy Brook is a great breadth of dark slates, some beds of which are "full of leaf stalks of ferns, but only remnants of fronds. The stalks are like those of *Aneimites Acadica* of the Lower Carboniferous."* Fossil plants.

Kerr Brook and all the rivers of Five Islands to the westward show fine alternations of Devonian sediments and igneous rocks. The altered shales and quartzites of the North River, containing traces of *Cordaites* and other plants, are described by Dr. Ells as Devonian, as including the Londonderry Mines series†, and as identical with the quartzite series south of Truro. No line of separation between them and the iron ore series seems here possible; on the contrary the greatly altered rocks of the latter are sometimes succeeded by less altered beds yielding fossils, and in most cases the greatly altered rocks are immediately in contact with diorite and syenite, which appear to have been the cause of their alteration. North River of Five Islands.

The various slates and quartzites of the west branch of Economy River are repeated in Harrington River,‡ and also on the road to the pretty little settlement of Lynn. Among the slates of the lower part of the river were found "fragments apparently of crustaceans—one may be an *Estheria*—and a small Cyclopterid leaf, resembling a *Cardiopteris* of the millstone grit, but very imperfect."§ Harrington River. Fossils.

On Harrington River between the mouth of Boyd Brook and the shore road, light grey sandstone or quartzite is interstratified with blackish argillaceous shales, with greenish shales and underclays, the shales containing *Cordaites* and other fossil plants, layers and nodules of ironstone, and dipping steeply down stream. Above Boyd Brook for about 1,000 paces to an old dam, the black shales, besides the usual abundance of *Cordaites* and *Calamites*, show delicate branching ferns and the crustaceans mentioned above, and include a coaly layer. About 75 paces above this dam they are more altered and in contact with greenish granular, coarse and schistose, syenitic or dioritic rock, containing many grains of specular iron. For 250 paces higher the rocks are chiefly cream-coloured quartzites and slates, traversed by thin veins of claystone, with small porphyritic crystals, succeeded by a small dyke of massive crystalline diorite, on both sides of which are reddish compact quartz-felsite and syenite. Alternations of sedimentary and igneous rocks, found higher, contain veins or blotches of quartz and calcspar which have been Coal. Dykes.

* Determined by Sir J. W. Dawson, from a few little pieces sent to him, but large slabs covered with these impressions are in the Museum.

† Geol. Surv., Ann. Rep., vol. I., 1885, pp. 50 and 53 E.

‡ Ibid., p. 50 E; Acadian Geology, p. 264.

§ Determined by Sir J. W. Dawson.

prospected, some of the red and green slates resembling those at the base of the Union series. Near the fork are reddish flinty quartz-felsite and felsite with apparently a north-easterly dip.

Shore of Minas Basin.

From the post office at Lower Five Islands, the road towards Parrsboro' runs across a plain and shows only debris of grey and bluish-grey flinty rocks as far as the bridge over Harrington River. Immediately below this bridge, on the right bank of the river, are outcrops of grey, flinty, jointed sandstone or quartzite, forming a prominent hill, interstratified with grey argillite with impressions of fossil plants. The dip seems to be 62° < 17°, which is also the direction of certain striæ, which may be glacial, on a smooth face of the rock on the river bank. About 150 paces below an old dam, dark shales and grey, flinty flags dip 60° < 67° and a few paces lower are more nearly vertical; they resemble the rocks of Riversdale and are well exposed to within 150 paces from the mouth of the river, where they are succeeded by indian-red, soft, marly, Triassic sandstone and conglomerate, with many concretionary, nodular patches, associated, a few feet further along the shore, with brick-red sandstone which occupies the shore for some distance; the Devonian rocks coming very nearly upon the shore in several of the small brooks. The dip of the Devonian a short distance from the contact is 27° < 67°; that of the Trias is westerly at a low obscure angle. The contact of the Triassic sandstone and Devonian is also seen on the road from Harrington River to Blue Sack, which comes to the shore at the mouth of a little brook, a short distance west of which the high cliffs expose reddish and grey soft sandstone, somewhat altered, mixed with globular masses of trap. Immediately to the westward at the mouth of another little brook, a breccia of grey flinty rock with a paste of red gypsum perhaps indicates a Carboniferous outlier. Here the Devonian rocks also come to tide-water, although at ten paces further, Triassic sandstone is on the shore, mixed, at 125 paces, with trap-conglomerate overlaid by concretionary calcareous marl. The high cliffs of red Triassic rock with bands of greenish-grey coarse sandstone which then fringe the shore for a great distance, produce a fine scenic contrast with the thick layer of dark boulder-clay—composed of debris of the dark shales or slates of the Devonian—which in most places caps the cliffs or falls in great masses to the beach. Then come cliffs of the Riversdale rocks, cut by small veins of quartz and ankerite, contorted and jointed, full of fossil plants, black shales predominating as far as the mouth of Moose Creek, and beyond it interstratified with flinty flags. Past Moose River, which has a narrow rocky mouth, grey, rusty-weathering quartzites, in thick layers and wavy bands, with

Contact of Triassic.

Blue Sack.

Moose Creek and River.

a large quantity of comminuted carbonaceous matter, include only small beds of dark shale. Not only is iron ore present in the joints and in veins, but the dark shales have also many layers and nodules of clay ironstones. The bright green massive rocks immediately west of Moose River are like those of the shore west of Clarke Head, of Port Greville and also like those which overlie the dark strata of Riversdale; and above them seem to come the red rocks of Wasson Brook and Swan Creek, above which lie unconformably the gypsum and limestone series of Clarke Head. At 310 paces from the river, dark bottle-green and red trap—which has been seen below high water for some distance back—mixed with red Triassic sandstone, succeeds Devonian rocks, which are again, however, on the beach at 83 paces further; and similar alternations are found beyond as far as Wasson's Bluff. The traps are here in part blackish hornblende rocks, in part roughly columnar. In some places the Triassic sediments dip into the basin at a very low angle; but the number of points at which the ends of the beds strike against the black shales or appear to dip under them where they are all but in contact seems to indicate great faults which affect even the Triassic and are not apparently dependent on the intrusion of the trap.

Iron ore.

Carboniferous of Clarke Head.

Near Moose Creek the Devonian rocks come to the shore of Minas Basin and to the westward are exposed on the coast, as well as up the rivers and brooks, in contact with Triassic sandstones and traps and with Carboniferous limestone, so that several fine examples of the unconformable superposition of the limestone upon the Devonian can be distinctly seen.

From Moose River mouth westward along the shore-road are outcrops of light grey flinty sandstone or quartzite and dark shales also exposed in two small brooks nearly to the shore. Opposite the Two Islands (the Brothers) dark Triassic trap is in the road, while in a little brook north of it there are ledges of quartzite, and westward along the shore and in the brooks they alternate with red Triassic sandstone, as shown on the map. Up the brooks east of Wasson's, the red rock of Union are exposed. On the post-road, from the bridge on Parrsboro' River for some distance towards Five Islands only drift is seen; then, near the top of the hill, dark and light grey flinty rocks, like those of Moose River, and probably Devonian.

Two Islands.

At the mouth of Phinney's Brook are outcrops of slate like that of the East River of Pictou at Sunnybrae, netted with small veins of quartz, calcspar, ankerite, &c., with beds of compact quartzite. Immediately above these lies a great mass of limestone, rusty, bluish-grey and whitish, the upper part white, brecciated, apparently

Phinney's Brook.

Crystalline limestone.

intimately associated with the slates, which at one point it seems to vein; it is crystalline and full of spots of pyrite, shows a little arch and cave, and is interstratified with greenish brecciated sandstone containing specular iron. In contact with these rocks to the eastward are dark, pearly slates with bands of quartzite; then an interval of drift, succeeded by greenish and cream-coloured rocks, like those of the pinnacle west of Clarke's Head—the olivaceous rocks of Londonderry—soft and hard, rubbly, with brecciated, rusty-weathering veins. At a little brook are black twisted slates; then another mass of brecciated limestone, often crystalline, possibly a vein, but more like a mass irregularly bedded among the black slates. Pearly, soft, graphitic slates then stretch along the shore, weathering so as to look like the outcrop of a great seam of coal, crumpled, wrinkled, polished, cleaved and full of veins; they do not seem to promise fossils.

Natural arches and dykes.

About 300 paces before reaching a little island of rock and natural arch is a small outcrop of greenish, fine diorite, succeeded, 80 paces nearer the arch, by dark, flinty, altered slate or porcellanite. The arch itself is of similar porcellanite with an immense number of quartz veins. Past it is a little brook and beyond this—all the shore being of black slate—another, called Henning's Brook, on the left bank of which the black slate contains lenticular masses of breccia, also a mixed rock containing black slate, quartzite, limestone and lenticular masses of schistose rock. Then follow greenish rocks, slaty but otherwise like the foregoing, in a great thickness of dark slate. Dark diorite and fragmental rock, on the beach below high water, stretch past the first of the Brookville brooks to rise into a cliff at the Big Rock; but in the bank the dark slates, with light grey and greenish-grey layers of soapy rock, extend to the next natural arch. Immediately past De Wolf Brook are fine cliffs of greenish, brecciated, rather massive rocks, apparently largely dioritic, behind a mass of which, in a small cove, are reddish and greenish, mottled, rubbly slates; succeeded by reddish, greenish, cream-coloured and black slates, greatly mixed and like rocks near the pinnacle. The Big Rock projects nearly to low-water mark and consists of red, compact felsite and quartz-felsite, in contact with which are the black slates which stretch along the shore past four little brooks, and contain crystals and aggregations of pyrite. Soft, soapy, graphitic matter is found in a hole at the Big Rock.

Henning's Brook.

Brookville.

Port Greville.

The rocks of De Wolf Brook, below the coal, are described elsewhere. Along the shore from Ward Brook to the mouth of Greville River and up the left bank to the road black slates prevail; but

from this point to the mouth of Fox River only banks of gravel are found; at the mouth of Fox River is a deposit of fine sandstone, whereas, immediately beyond, the Carboniferous rocks are exposed. Carboniferous

In Swan Brook, above the road, are light grey and whitish Devonian sandstone or quartzite and argillite, succeeded up stream by light grey, somewhat soft, flaggy sandstone, forming a rocky country, nearly barren; and by dark and light grey, sandy and argillaceous shales and flinty sandstone, with small veins of quartz, dipping 207° <70°, and resembling the rocks of the North and Harrington Rivers. Below the road the brook comes to tide-water over a cliff of dark Triassic trap, in part crumbly. Swan Brook.

The Devonian rocks of the Parrsboro' River are described with the Carboniferous. Those near the pier are red and green and grey, rippled, crumpled flags, with a large proportion of argillite, underlaid by dark shales and flags, like those of Horton Bluff, containing layers of limestone and of fine calcareous grit, as well as blackish bands full of broken plants. Parrsboro River.

G.—Carboniferous.

Unlike the Devonian, the continuity of which is scarcely broken, the Carboniferous rocks occur in detached areas, as sketched on page 4. These will be described under the following groups, the general characters of which have been given fully in previous reports:

G. 1m.—Carboniferous conglomerate.
G. 1.—Carboniferous limestone.
G. 2.—Millstone grit.
G. 3.—Coal measures.
G. 1.—Carboniferous conglomerate.

G. 1m.—Carboniferous conglomerate.

Following Dr. Ells and including in this formation the coarse sandstones and shales, with small seams of coal, which lie immediately south of the Cobequid Hills, (from which, however, he seems disposed to exclude certain grey rocks of Folly River)* the principal areas may be enumerated as follows:—1. Small doubtful patches on the east side of the East River of Pictou. 2. The detached areas north of the railway west of West River station. 3. A small narrow belt along the Truro road west of Saltsprings. 4. The patches of the Stewiacke Valley, including the conglomerate in which search has been made for gold Areas.

* Geol. Surv., Ann. Rep. for 1885, vol. I., p. 47 E.

at Brookfield. 5. The long strip of irregular width on the south side of the Cobequid Hills, which occupies the railway between the Triassic of Folly River bridge and the Devonian of the foot of Folly Lake.

Pictou coal-field.

1. *Basal Carboniferous rocks east of the East River of Pictou.*—Among the greatly faulted rocks which surround the Pictou coal-field the conglomerate east of Sutherland's River, in McLaurin's Brook, down stream from the iron mines, is perhaps of this age. The pebbles are principally of Devonian quartzite, sometimes three inches in diameter; and among it are a few grey beds. It is seen on a line of fault near the contact with the Silurian. In the vicinity is a greenish and reddish, impure, concretionary limestone, like that found at Park's Mills. Similar conglomerate occupies a considerable breadth in Sutherland's River between the north fault and Park's Mills, and extends up along McLean's Brook, where it is associated with or overlaid by gypsum and by the limestone of McDonald's.* This conglomerate is seen in the cuttings on the new road between the Vale colliery and McPherson's Mills. It is reddish, greenish and grey, and contains beds of red and grey sandstone, as that of Sutherland's River, marked with plants. The reddish, flinty, micaceous sandstone of the mill-dam may possibly be lower. The limestone has been somewhat largely quarried.

McGregor's Mountain.

On McGregor's Mountain a conglomerate, seen in contact with trap and Devonian sedimentary rock south of the south fault, is perhaps also of this age; and large outcrops of conglomerate are also found near Churchville.

2. and 3. *Basal Carboniferous Rocks of West River of Pictou and of the Truro Road.*—Above the railway near the 30th mile-post and on it east of West River station are large blocks of conglomerate, perhaps indicating a patch among the Devonian of the neighbourhood. Possibly a basin of Carboniferous may at one time have extended up the river to this point.

Watervale.

The reddish, grey and whitish soft sandstone, grit and conglomerate, west of Watervale, are well seen on the road up the large brook, as far as the crossing of this brook, and on those about Botany Bay Brook. They are like the rocks of Londonderry station, and like those of the Telegraph road between Mount Thom and Salt-springs, from which they are separated by a ridge of Devonian which extends nearly to the valley of the Telegraph road at Reid's. On this road to the westward is a cliff of grey conglomerate, loose in texture, which seems to lie in patches in the valley, and to be

* Geol. Surv., Rep. of Progress, 1866-69, p. 39.

composed of fragments of the greenish Devonian slates of the vicinity, and of reddish-grey coarse syenite. From the second house west of Reid's, and immediately past the road to Bezanson's, a wood-road running north shows blocks of reddish conglomerate and grit, as far as the crossing of the first branch of the Juniper Meadow Brook; and the outcrops here are no doubt continuous with those of the road south of Bezanson's. North from Pat McAulay's, on the track to Lippincott's old clearing, and also at other points in the vicinity, conglomerate seems to be in place beyond the red syenite.

On John McKay's track, as already stated, the barren shows blocks of reddish-grey grit and conglomerate, with pebbles as large as a hen's egg. Light grey, fine, flaggy sandstone is associated with the coarse rocks as far as the Watervale road; while on the west branch of the track the coarse rocks extend to within a quarter of a mile of McKay's, where they are succeeded by Devonian slates. In the large brook which crosses this track a few outcrops seen below the track seem to be of this age, comprising reddish-grey, fine and coarse, flaggy sandstone, indian-red soft sandstone and marl, lying at a low angle; reddish conglomerate and grit, and near the Black River, indistinct outcrops of reddish and grey fine sandstone and coarse grit. On the barrens are blocks of grey and reddish-grey, fine, flaggy, somewhat soft sandstone. But on the railway are cuttings of the flinty rocks, perhaps along one of the many faults of the district or unconformably beneath the conglomerate. Fault or unconformity.

Possibly some of the outcrops along the Truro road are continuous with those of Steele's (Irving's) Run, but the latter seem rather to be detached. About half a mile above Salmon River, a bank of reddish conglomerate and sandstone seems to follow the brook. The conglomerate contains pebbles of whitish quartzite and of red sandstone; it is overlaid by layers of indian-red, soft, crumbly, fine sandstone and marl. Grey, greenish and drab, fine sandstone, glistening with quartz and covered with impressions of fossil plants, occurs higher up the brook, and about one mile and a half from the river these give place to the iron ore rocks, beyond which, in a little brook from the north above the marshes, Carboniferous rocks again appear with a vertical or very steep dip, being here dirty greenish-grey, soft, rusty-weathering shales, with reddish-grey, flaggy, fine and coarse grit. Steele's River.

On the road along Salmon River, below Jacob Fenton's, are blocks of reddish and grey, flaggy, fine and coarse sandstone.

Unless these are drift, like the numerous blocks of grey syenite and granite, they may indicate a Carboniferous outlier. Red, fine sandstones appear near the Telegraph road. On the road to Earltown, reddish flags prevail, which may belong, however, to the red rocks of Union, as do most of the rocks of the vicinity.

4. *Basal Carboniferous Rocks of the Stewiacke Valley.*—Associated with the limestone and plaster, which so largely prevail in the valley of Stewiacke River, are small areas on both sides of the basin, generally of little extent or importance, which will be described with the associated rocks. The road from Brookfield to the iron mine passes over coarse grit and grey flags. Up to the first brook on the north side of the river, above the road across the river to Johnston's, the rocks first seen are brownish or reddish, flaggy and thick-bedded sandstone and shale, interstratified with grey fine beds and with grey coarse conglomerate, made up chiefly of quartz, but having also pebbles of grey quartzite and fragments of dark slate, perhaps derived from the Riversdale rocks, and of red sandstone or quartzite, perhaps from the rocks of Union. To the head of this brook are many outcrops of grey grit and conglomerate, probably Carboniferous and not unlike rocks seen north of the Gore.

Brookfield.

To the eastward above the mill in Bill Putnam's Brook are dark grey shales which perhaps underlie the Carboniferous limestone. At and below the dam are alternations of very flinty, coarse, quartzose grits, sandstones and shales. Down stream is a patch of coarse conglomerate which seems to contain pebbles of these flinty rocks and is perhaps Carboniferous; it extends to the boundary of the limestone and gypsum.

Goldmine Brook.

About 170 paces above the road in the Goldmine Brook, good outcrops dip $217° < 35°$; they show reddish conglomerate with pebbles, larger than a hen's egg, of red and white quartzite and soft argillite; sandy and argillaceous flags, apparently like the rocks described above. About 50 paces above an old milldam, are other outcrops of reddish flags underlaid by grey, rusty-weathering, plant-marked sandstone and grit, very micaceous and usually somewhat flaggy; associated with reddish flags. About 180 paces higher, grey, coarse quartzose grit of similar texture appears to show a south-easterly dip; and 120 higher, indian-red, micaceous, soft, argillaceous rocks dip $228° < 65°$. Then comes a long intervale or marsh, at the end of which, about 450 above the last outcrops, the barren on the left shows blocks of grey, rusty-weathering, friable, quartzose sandstone. Then at a brook from the left near the gold mine, the dip is $227° < 36°$, as shown in the cliffs of light and dark grey, rusty-weathering, micaceous, sandy flags,

including bands of coarse grit and conglomerate full of pebbles of white quartz as large as a hen's egg, upon which the so-called gold mine is situated*. The pebbles of the conglomerate when not of quartz are with difficulty determinable; they may be of the whin and slate of the gold-bearing series or of the Devonian. The flags are of loose texture and do not resemble rocks older than the Carboniferous; although they may underlie the limestone and gypsum, which may be also the position of the grits and sandstones south of the Stewiacke River. Some distance above the mine, grey flags, a quarter of an inch thick and over, dip 219° < 49°, well exposed in cliffs and underlaid as before by grey, pebbly, quartzose grit and conglomerate. At a little brook from the left, a band of bluish-grey argillaceous shale or flag is included among the coarse grits, and at the next cliff on the right, dark micaceous sandy flags again show layers of dark argillaceous shale, though the coarse grits greatly predominate. Cliffs of grey flags and grits alternate to the uppermost of two dams across the brook, representing a great thickness of rocks of only these two varieties. Above the dams, a long boggy meadow obscures the rock for some distance, above which are outcrops of bluish-grey, fine, jointed, striped, argillaceous sandstone, interstratified with a considerable thickness of bluish-grey argillaceous shale. Only a small exposure is seen here; but higher up stream are grey and blackish flags and grits, precisely like those of the gold mine dipping 224° < 43°, extending as far as the brook shows exposures and northward to the red Devonian rocks of Little River. Supposed gold mine.

5. *Basal Carboniferous Rocks of the Southern Slope of the Cobequid Hills.*—As already stated, there is nothing to fix the precise age of these rocks except their strong resemblance to the Lower Carboniferous of other localities, and as an immense thickness of them is sometimes exposed among the faults of the mountains it is not improbable, that assuming most of them to lie beneath the Carboniferous limestone and gypsum, higher beds may be brought in. And as at Parrsboro' but a small belt of conglomerate intervenes between limestone holding typical shells of the G.1. formation, it is not improbable that the latter as well as Millstone grit may be included. But the limestone is distinct at Valley, on Minas Basin, in the basins of the Stewiacke and Shubenacadie Rivers and also throughout a large portion of Hants county, so that in the absence of other evidence that of lithology will be followed. Fossil plants abound, but such evidence seems too vague and uncertain to settle the question.

* Summary Geol. Surv. Rep., 1890, p. 41.

Upper North River.

These rocks are seen furthest east, in the various branches of Cranberry Brook, in contact with Devonian ferriferous slates. For a short distance above the bridge at Upper North River, and for more than half a mile below it, they are again in contact with the flinty rocks, from which they are separated on the north side by a fault, the course of which seems to be about east and west magnetic. They consist of reddish, somewhat crumbly egg-and-nut conglomerate, containing fragments of the rocks cut by the syenites and diorites, of reddish-grey coarse grit, and reddish, soft, crumbly argillaceous shale, not unlike the Permian rocks of the west branch of River John. They are also met with in all the little brooks of the immediate neighbourhood. In the middle branch, conglomerate is present, as already stated, for a short distance above the road, but on the hill between this settlement and McCallum's, there is apparently evidence of the want of conformity of this with the slate series, the latter appearing generally on the hill, while the conglomerate is present in both valleys. The conglomerate of the west branch of North River, near McCallum's mill, includes pebbles six inches in diameter, and is interstratified with patches of light greenish-grey, soft, coarse and fine sandstone. The cliffs above the mill-pond, however, show grey and reddish massive sandstone or quartzite, as hard and brecciated as those of Guysboro' and St. Mary's, belonging to the Devonian. The conglomerate first seen here lies at a low angle; and on the road it is exposed for at least 150 yards north of the mill.

Coalmine Brook.

Coalmine Brook, a tributary of this west branch, shows near its mouth, grey, greenish, rusty and reddish contorted shales and flags, the shales containing *Stigmaria* and nodules of ironstone. Up stream, a grey, coarse grit contains fragments of blackish, shiny, argillaceous

Coal.

shale, and masses of coaly rock, lenticular, and sometimes nine inches thick, from which layers of good bituminous coal, one inch thick, may be broken; coaly matter is again found in a flinty, grey grit and pea-conglomerate, in which *Stigmaria* is very abundant; and a lenticular layer of an inch and a half of bright clean coal, in grey shales full of large nodules of ironstone and interstratified with greenish and reddish, mottled, crumbly shales. The dip is variable, generally very steep. Greenish shales are found at the road to Delaney settlement. Above it, these rocks occupy a breadth of more than half a mile, with a dip increasing from an angle of 30° at the road to vertical where they come against the Devonian slates, the direction being southerly—they are grey sandstone, greenish shale and pea-

Coal mine.

and-nut conglomerate. About ten chains from the road are openings made on eighteen inches of stony coal; and about a quarter of a mile higher, flaggy, argillaceous shales include three feet at least of carbon-

aceous shale, from which in places a foot of shaly coal may be obtained. Small bands of coal occur higher up in lenticular layers in the shales and in streaks in the bedding of the grey and greenish conglomerates and grits which come against the Devonian rocks 140 yards above the fork of a little branch from a lake, the two formations for a short distance keeping on opposite sides of the brook.

Carboniferous and Devonian conglomerates

Some of the bands of nut-and-egg conglomerate interstratified with the grit and finer rocks of this Coalmine Brook not far above its confluence with the North River, give the key to the difficulty connected with the conglomerate and dark sandstones above Upper North River bridge in the middle branch, showing clearly that these latter belong to an older series, although at first sight it would be hard to distinguish them, the pebbles not being always distinctly identifiable, and those of the dark grey sandstone being readily confounded with those of a bottle-green, chloritic, weathered diorite so largely found everywhere with the syenite. The conglomerate of Coalmine Brook is largely made up of pebbles of dark grit and blackish coarse sandstone. If we assume therefore, that the shales and flags of this brook are G. 1m, as supposed by Dr. Ells, no further proof of the Pre-Carboniferous age of the pebbles would be necessary, and the underlying series must be Devonian. If however, the upper series be millstone grit, as supposed by Mr. Barlow, the rubbly rocks might be G. 1m, for they are equally unconformable to the Carboniferous limestone. Between the Devonian and G. 1m, there are still perhaps doubtful areas.

North River.

The outcrop in North River below the Coalmine Brook yields large pebbles of greenish sandstone and conglomerate, with others of red sandstone; it weathers red and has indian-red streaks and patches. Perhaps all the grey and greenish flags and shales in the river below, as far as the next conglomerate, which contain a three feet layer of dark carbonaceous shale with a quarter of an inch of good coal at top, may belong to this group. The conglomerate extends thence for fifty yards below a little brook from a lake on the west side of the river; and the rocks immediately down stream are more like those of Union.

Coal.

Chiganois River.

The conglomerate of Chiganois River, in the cliffs above Higgins' mill, contains pebbles of red, flinty sandstone and of the rusty rocks of the iron ore series, as well as of the syenite, diorite and felsite of the falls. It appears to be more altered than that lower down the river; but this appearance may be due to the smooth wearing by the river or to faulting; for a few paces higher are the rocks of which it seems to be composed and the boundary in this river and in the three brooks to the westward seems to be a straight fault.

Fault.

Coal. In Higgins' Brook immediately to the eastward, the conglomerate is well exposed and holds traces of coal; and on the old Tatamagouche road it is seen nearly to the fork of the Coalmine Brook, On the Higgins' road west of the mill, grey, rusty-weathering sandstones are seen, and also in the brooks to the boundary of the Devonian a short distance above the road. In the first of these, a branch of Old Sam's Brook, the first rocks seen are igneous and altered; but in that which crosses the road a mile to the westward are grey and greenish-grey, fine and coarse sandstone, grit and nut-and-egg conglomerate, with pebbles of the iron ore series, the rocks resembling those west of Debert River and at Londonderry. Down stream in Old Sam's Brook, are outcrops of reddish-grey, broken, flaggy, somewhat coherent sandstone, in part calcareous, with rusty, grey, fine sandstone, often flaggy, but with few argillaceous beds; some of the flags are covered with impressions of fucoids and rain-marks. Grey, brown and reddish-grey, earthy, flaggy sandstone, with carbonized plants, extends to a little stream from the left near Chiganois River, where conglomerate and more argillaceous rocks succeed. At the river here, coarse grit and conglomerate are found, whereas lower down are red argillaceous shale and sandstone, spotted with green; and similar rocks extend up the river to Higgins' mill.

Succeeding the Triassic in Staples Brook, are dark grey sandstones, with reddish-grey belts, which extend to Higgins' road, but are not well exposed and may be in part Devonian.

Debert River The rocks of Debert River, at the mouth of Totten's Brook, have been already described. Higher up are bluish-grey and greenish

Coal. shales containing a layer of clean coal of indefinite thickness and crowded with nodules of ironstone; they are associated with coarse, grey sandstone. Above the bridge at Cottam settlement is a repetition of the seam probably, which is eighteen inches thick. Immediately above this coal are outcrops of red conglomerate and coarse grit, as in North River (containing pebbles, sometimes one foot in length, of red syenite, green diorite, reddish and greenish, soft, slaty argillite, compact quartzite and quartzose grit), which

Fault. seem to come against the graphitic slates above by a fault.

Totten's Brook. The red sandstone and conglomerate seen near the river in Totten's Brook, are associated up stream with reddish and grey and rusty flags and shales, marked with *Cordaites*, *Calamites* and other plants, ripple-marks and rain drops; among them are layers

Coal. of matted carbonized plants, passing into seams of coal sometimes an inch thick. Above the road to East Mines are frequent outcrops of grey, rusty-weathering, fine and coarse sandstone, with layers

of whitish pea-and-nut conglomerate, and a patch of reddish coarse conglomerate, containing pebbles of syenite and of Devonian rocks, associated with dark grey, soft shales and flags, covered with impressions of ferns, *Calamites* and other plants, including a seam of coal more than two inches in thickness, and succeeded at a fall by the Devonian.

Coalmine Brook.

In the Coalmine Brook, another tributary of Debert River, the red rocks nearest the river are succeeded up stream by dark grey or bottle-green, somewhat massive, coherent, pebbly grit, overlaid by reddish-grey fine grit and conglomerate. Small seams of coal have been mined on this brook in several pits, but their dimensions could not be ascertained. The associated greenish, rusty-weathering, soft shales are crowded with ironstone nodules, precisely like those of the Coalmine Brook of North River. Above the road are outcrops of light grey or whitish, fine, soft sandstone, and of greenish-grey, rusty-weathering conglomerate, which extend to a house on a hill at the head of the brook, beyond which dark Devonian slates appear.

Pine Brook.

Pine Brook flows in a marsh or intervale from the Base-line road to a little brook from the west, at which reddish-grey Carboniferous sandstone and shale dip about 133° < 50° and are thence well exposed without great variety, forming an ascending section to a brook from the left, immediately below which red sandstone and marl lie at a much lower angle; again become higher and undulating, and at a fall dip 351° < 45°. Immediately down stream the angle is lower, then nearly vertical for a great breadth to a high cliff at a turn, where a greenish concretionary layer, embedded in the red sandstone and shale, shows a large quantity of broken carbonized plants. The dip is up stream, and one of the last rocks of the series is a grey and reddish pebbly sandstone. Not far down stream is a cliff of more altered, rubbly rock, fine, micaceous, generally red, but with siliceous flinty layers full of broken plants; it might easily be mistaken for a rock of the Union series, but is perhaps Carboniferous, its rubbly condition, the presence of limonite in the joints, and other appearances of alteration being probably due to faulting or to the proximity of the Triassic sandstone, which, 200 yards down stream, lies apparently horizontal. A similar appearance of alteration near a contact was seen in Saltspring Brook, near its confluence with Great Village River, and another where the north fault of the Pictou coalfield crosses McCulloch's Brook. In a small branch of Pine Brook from the eastward, more than half a mile above the road in the Totten settle-

Altered rocks.

ment, is a small outcrop of conglomerate among and apparently unconformably upon the altered rocks of this brook.

At the East Mines conglomerate is nearly everywhere seen south of the openings on the iron ore.

Folly River

Where the Carboniferous conglomerate comes in contact with the Devonian rocks at a fall in Folly River, it holds pebbles of all the latter, those of dark diorite and syenite being very numerous and up to one foot in diameter. Below this point outcrops are continuous for a great distance, and the conglomerate is seen first to inclose bands and patches of reddish and grey and greenish-grey soft sandstone and grit, with large carbonized markings of plants, and afterwards to be succeeded by these rocks, which show prostrate trunks of trees and minute veins of coaly matter, overlaid by greenish and dark grey argillaceous shales, which contain *Stigmaria* and streaks of coal, one of which is an inch thick, in the bedding. Grey and brownish sandstones then extend to the bridge on the Base-line road, at which outcrops of conglomerate are again found, interstratified down stream with reddish sandstone and shale. A large proportion of the rock, for some distance below the bridge, is of conglomerate; but in one place a quarry of red sandstone shows included layers of concretionary limestone-conglomerate, grey, greenish or rusty in colour, with carbonized plants. Below the quarry are cliffs and ledges of indian-red and grey sandstone and shale, with strong, calcareous, concretionary bands. At their contact with the Triassic these rocks strike 243°, with a dip both ways at angles varying from 73° to 87°; and the Triassic rocks also, although not seen on the river section, seem to be faulted; but at the railway bridge they dip at a low angle.

Coal.

McElman Brook.

In McElman Brook, about half a mile above the fork, the doubtful flinty rocks are succeeded by grey and bottle-green sandstone and shale containing rootlets, *Calamites* and broken plants, interstratified with grey, coarse, pebbly grit, red soft marl and reddish and greenish sandstone, often calcareous and including a band of one foot of pure concretionary limestone-conglomerate, precisely like some of the Permian strata of Pictou and Tatamagouche. The sandstones are crowded with plants, one trunk, three inches in diameter, being converted into black spathic iron ore. The coarse rocks contain pebbles of black argillite. At and near the railway, the brook exposes cliffs of grey and greenish sandstone and conglomerate, darker beds, crowded with plants, and reddish shale, succeeded above by greenish egg and courser conglomerate, with a low dip down stream, seen only a few yards above the railway, and followed by the iron ore rocks.

In the west branch of McElman Brook, the rocks which succeed the Triassic resemble those just described, and above the railway, outcrops of conglomerate are succeeded by flinty Devonian slates. On the railway, at the entrance of the snowshed near the 82nd mile-post, Devonian rocks are succeeded by nut-and-egg conglomerate holding large boulders of the former, interstratified with finer beds which, nearer Londonderry station, predominate to the junction with the Triassic conglomerate, the grey and greenish layers inclosing stumps, prostrate trees and *Cordaites*.

Saltspring Brook.

Below the mines-railway at Londonderry, Saltspring Brook cuts reddish, soft, flaggy sandstone and shale, dipping about 42° < 41° and containing grey beds fit for quarrying, small patches of conglomerate and greenish concretionary sandstone, as far as the Telephone line road. Below the road, similar rocks, jointed or rubbly, somewhat coherent, dip first 34° < 18°, and 120 yards below an old dam, 36° < 51°. Still lower, rocks precisely like those of the railway bridge dip about 16° < 72° and continue to Great Village River, about 150 yards above which is a light grey, greenish and rusty sandstone, in places a compact ganister, with *Stigmaria*, and three bands of blackish shale, one of which is coaly, interstratified with red rocks and nearly vertical. The hard bands are very flinty and rubbly.

Coal.

Above the mines-railway on Saltspring Brook similar beds dip about 52° < 33°, and a grey, flaggy layer has been quarried for rough building stone. About a quarter of a mile up stream, a black, coaly shale, overlying grey sandstone, has been worked in a shaft and several pits, and a quantity of coal from a layer at least one inch thick, and perhaps much thicker, lies on the bank. Grey sandstone has been quarried near the shaft and prevails for some distance up stream, becoming mixed with greenish coarse conglomerate and grit; and at the bridge on the Base-line road the coarse rocks predominate, striking about east and west with a vertical dip. From Great Village River to this point the section is, according to the dip, continually ascending, and many of the upper flags resemble Millstone grit and Coal measures in texture.

Great Village River.

A similar sequence is well exposed in Great Village River. At the dam, about 267 yards above the Base-line road on the east branch, is a coarse, Carboniferous conglomerate, which contains patches of grit and fine sandstone, and is succeeded down stream by light green, pebbly sandstone, with patches of conglomerate, and by grey sandstone, with layers of greenish shale and streaks of coal an eighth of an inch in thickness. At the dam the dip is doubtfully horizontal, while seventy yards below it red shales dip confusedly

147° < 80° and are succeeded by blackish shales, including layers of whitish flinty sandstone. In the black shales are siliceous concretions and concretionary, rusty-weathering layers. They are

Coal. again followed by red sandstone and shale, with one carbonaceous layer. At 325 yards below the bridge red shales and sandstone dip 12° < 15°, while at the bridge close by, on the road down the river, near the fork of the rivers, grey and greenish, rusty-weathering,

Fault. coarse and fine sandstones dip 157° < 47°. At forty-five yards below the fork, red, soft rocks are nearly horizontal, showing a dislocation between them and the sandstone of the fork. But immediately below is a pebbly band which may be the conglomerate of the fork, dipping 17° < 18°, while a few yards down stream are dips of 87° < 25° and 57° < 27°. Thence to the fork of Cumberland Brook the dip is about 43° < 37°, on red rocks, including ledges of grey sandstone and coarse grit. Immediately below this brook is a

Quarry. quarry of rough, grey sandstone. Down stream are reddish sandstone and shale; grey sandstone, fine and coarse, some beds rippled, rusty-weathering, holding carbonized plants, with bark converted into coal, dipping 5° < 42° to a point nearly a mile below Cumberland Brook, where the dip is 12° < 80° and the rocks differ from those seen above in being finer in texture, flaggy or evenly-bedded, rubbly and perhaps more coherent. They are all reddish, rusty and greenish in colour, full of broken, carbonized plants, and include a layer of blackish, papery shale, with lenticular bands of ironstone, precisely like the adjoining rocks of Saltspring Brook, about 250 yards below which they are overlaid by coarse

Triassic. conglomerate, with patches of nearly horizontal Triassic sandstone.

Cumberland Brook. Up Cumberland Brook to the mouth of Cook's Brook, reddish sandstone and shale, with patches of grey and red conglomerate, full of broken, carbonized plants, dip about 12° < 41°. They are exposed up the latter with a somewhat lower dip for some distance, after which they dip 55° < 21° to the Base-line road, above which the dip is 172° < 67° and higher, to the contact of the slates. Between Cook's and Martin's Brooks, reddish, brownish and grey sandstones and shales are exposed in cliffs, dipping about 345° < 31°, but disturbed near the mouth of a little brook from the south, as shown by two dips of 355° < 80° and 247° < 19°. Not far below the Base-line road the dip is 352° < 27°, above which no rocks are seen to the Devonian slates.

Black shales. Immediately below the main road in Cook's Brook, the reddish conglomerate and grit contain bands of black graphitic shale with

hard nodules. Good outcrops are seen everywhere in the neighbourhood of the iron mines.

These rocks as they occur in Portapique River and other streams to the westward have been described with the Devonian.

In Crowe Brook, above the Base-line road, greenish-grey breccia and olivaceous shale of the iron ore series are in contact with coarse, flaggy, Carboniferous sandstone and conglomerate, dipping about 157° <80°. Below the road and near a mill-pond, reddish-grey sandstone and marl and greenish and grey flags and sandstone dip about 6° < 43°-90°, and are succeeded above the settlement of Montrose by Triassic conglomerate and sandstone. Triassic.

G. 1.—Carboniferous Limestone.

This formation is characterized by the occurrence of gypsum, limestone, sandstones, marls and other soft and friable rocks, apparently everywhere unconformable upon all the underlying formations.* It appears at the following localities, from most of which fossils have been described by Sir J. W. Dawson†, Sir Chas. Lyell‡, and others: 1. In a basin along the East River of Pictou, and in isolated areas at the south-eastern corner of the Pictou coal field. 2. In small areas on the Middle and West Rivers of Pictou. 3. In broken areas of small extent north-east of Valley and Truro stations, in Farnham's Millbrook and on Penny's Mountain. 4. A large and important basin along the Stewiacke and Shubenacadie Rivers. 5. In outliers on the north side of Minas Basin.

1. *Basin of the East River of Pictou.*—Reference has been made already to the narrow basin of these rocks which the East River follows from above Sunnybrae to Bridgeville, and which then expands between the Pre-Carboniferous rocks of McLellan's Mountain and those of Middle River.§ The small patch shown on the map as of this formation at Fall Brook displays limestone blocks only, and the valley, although very like a Carboniferous glen, may, perhaps, indicate only the contact of the Silurian and Cambro-Silurian. Fall Brook.

In McLellan's Brook, where the limestone overlies the Cambro-Silurian, it strikes vertically 20°, and is streaked with marl and patches of grey conglomerate; it has been quarried and is over- McLellan's Brook.

* Geol. Surv. An. Rep., Vol. II., 1886, Part P, p. 69; Proceedings of the Geol. Soc. of London, vol. III., p. 712; Lyell's Travels in North America, vol. II., pp. 148, 177-183; Summary Report of Geol. Survey for 1891, p. 35.

† Acadian Geol., pp. 285-316.

‡ Geol. Soc. of London, vol. IV., p. 185.

§ Geol. Surv. An. Rep., Vol. II., 1886, Part P, pp. 86 and 109; Trans. Roy. Soc. Can., vol. IV., pp. 159-163; Acadian Geology, Supplement, 1878, p. 76; Trans. N.S. Inst. Sc., vol. III., p. 63; vol. IV., pp. 143, 144, 161, 163, 465; vol. V., pp. 31, 65, 66, 213.

laid by reddish shales with green blotches. Where quarried, near the Mountain road, it is coherent, veined with calcspar and associated with grey and reddish sandstone.

On McGregor's Mountain, limestone of this age is in place as shown on the map. It is grey and blackish, oolitic, full of shells, and overlies conglomerate, while not far off is a hill of diorite and flinty conglomerate, and on the opposite side of the road a knoll of Silurian. That at Finlay McDonald's, near the Vale, is a grey variety which makes good lime: it has been already referred to.

St. Mary's road.

In McLean's Brook, below the St. Mary's road, near the Vale colliery, gypsum is found in a small exposure near the conglomerate, and again on the hill slope west of the brook. It is associated with a grey compact limestone containing shells. The lime-

Park's mills.

stone of Park's mills, on Sutherland's River, is grey, veined with calcite and full of characteristic fossils. It is in place, 100 yards north of Park's house, and is undoubtedly identical with that of McLean's Brook, and, perhaps, also of McLaurin's Brook, near the iron mine, as a conglomerate below the falls is the equivalent of the conglomerate of McLean's Brook. This conglomerate indicates an unconformity rather than a fault, the south fault crossing, apparently, further down the river.

East River.

The best known crops of gypsum and limestone of the East River of Pictou are defined on the map. Perhaps in places they are mixed in the river with rocks of the lower group. Above the bridge at St. Paul's, reddish and grey and rusty, micaceous, soft shale and calcareous, argillaceous sandstone show large impressions of plants. Up stream are grey, ferruginous, flinty, massive, jointed sandstones, succeeded by light bluish-grey limestone, massive or in thick beds, associated with limestone-breccia and shale, veined and blotched with calcite and baryte and succeeded by grey grit and conglomerate. Immediately above the confluence of John McDonald's (Ogg) Brook, are outcrops of whitish and grey marly grit and calc-veined Carboniferous limestone. Below the mouth of this brook, grey limestone with white blotches and veins follows on the strike down the river. A short distance down stream is a

Crystalline limestone.

greenish and grey crystalline limestone or marble, full of rusty blotches, which may be Carboniferous, altered by some of the adjoining traps, or Devonian. In the bed of the river, near the mouth of the brook from William Grant's Lake, a crumbly, argillaceous limestone, containing shells, is associated with grey, greenish-grey and reddish, coherent, fine, flaggy, calcareous, argillaceous sandstone, often finely ripple-marked, and

with dark nodular and flaggy limestone, passing into a limestone, full of shells, some of which has been quarried. At the old mill is a band of twenty feet of limestone in horizontal bedding. Nearer the Springville bridge, there are cliffs of red marl, greenish-grey shales and bluish-grey shales and flags, blotched with ferruginous veins and with gash veins of calcspar. Below the mouth of the brook, nearly continuous cliffs of Carboniferous rocks extend to and below the fork of the west branch at Ferrona, the dip being very changeable and the reddish soft sandstones and shales, with greenish and grey bands, resembling those of the lower part of French and Sutherland's Rivers. With them is a band of eight feet of limestone, full of fossils, blackish or grey, somewhat shaly, in part nodular, overlaid by grey calcareous shale and sandstone; and other bands four in number, found lower down, range from one to three feet.

Gypsum of Bridgeville.

Cliffs and mounds of gypsum are found south of Bridgeville. Near the post office is a quarry from which a good mortar limestone has been taken, and other outcrops occur on the lands to the southward. The reddish-grey sandstone and shale on the road to Hopewell, in Centredale, and on the left bank of the East River, between Springville and Bridgeville are perhaps also of this age; but the rocks of Archibald's Brook may belong in part to the conglomerate. Above the road to Archibald's mill, beyond a considerable exposure of red flinty rocks, greenish slate and trap, probably Devonian, is a calcareous conglomerate, with patches of light grey, good Carboniferous limestone, the conglomerate holding pebbles of the flinty rocks; and still higher are immense blocks of grey limestone, which perhaps indicate an outlier among the slates.

Springville.

The limestone of Springville is apparently in several detached patches in the neighbourhood of the Sluice; about Lime Brook, it has been largely quarried and in Campbell Brook is seen to overlie the Silurian above the road. In the little brook from Calder Lake it is associated with bluish-grey sandstone and flags, dipping 224° and containing small impressions of a lamellibranch. In Holmes Brook, the Silurian rocks are in contact with conglomerate and limestone, presenting the following section:—

Contact of Silurian.

	Feet.	
1. Grey limestone, beneath which the water of the brook disappears. Of unknown thickness. [Trans. N.S. Inst. Sc., vol. IV., p. 465, vol., V., p. 202.]		
2. Rusty-weathering, somewhat crystalline, ferruginous, whitish limestone, with specks of copper pyrites	15	Copper ore.
3. Grey limestone, composed of a mass of shells	2	
4. Soft soapy conglomerate	12	
5. Silurian rocks	..	

Near Lime Brook*, outcrops of gypsum and limestone abound. Lists of the fossils of the limestone are given by Sir J. W. Dawson† and Dr. Honeyman‡. It is interstratified with reddish crumbly sandstone, shale and marl, with green blotches; and similar rocks are found in the river above and below the iron bridge; while a short distance down stream, greenish massive sandstone is associated with a conglomerate or breccia composed of Silurian pebbles; down stream from which is a grey, flaggy, massive limestone, with spots of baryte and ferruginous veins, described above.

At the foot of David's Lake are great blocks of Carboniferous conglomerate which probably indicate an outlier in this direction. The contact of the Carboniferous and Silurian follows closely the road from Springville to Churchville, and the various outcrops towards Forbes Lake§ require no special mention. At Churchville the limestone appears to be closely associated with reddish coarse conglomerate. In Robinson Brook, limestone appears near the contact, associated with red sandstone, shale and marl and greenish grey flags, underlaid by the Cambro-Silurian. Below the outlet to Forbes Lake, this brook exposes reddish sandstone; and on the road from the brook to the East River, a limestone, probably fifteen feet thick, usually in thick beds, veined with calcspar and stained with copper ore, is interstratified with reddish sandstone, and has been quarried to some extent.

Copper ore.

West Branch East River.

Above the fork, the west branch of East River shows a few exposures of red sandstone as far as Eureka mills. Here on the shore of the mill-pond a thick band of limestone has been quarried. Above the pond are cliffs of red sandstones and shales, with variable dip, including some grey beds. Above the bridge at Hopewell, for more than two miles the river cuts few rocks, but the banks seem to indicate chiefly red micaceous sandstones and flags, of this age, or Millstone grit, which are exposed as far as Elgin, and also on Fox Brook. Similar rocks are found at Elgin as far as the outcrop of Carboniferous limestone in the west branch. This latter is dark bluish-grey, shaly and thick-bedded, veined with calcspar and at least ten feet thick. Overlying it are reddish and grey soft sandstone and shale. The limestone has also been largely quarried up the Big Brook, where it seems to lie

* Quarterly Journal Geol. Soc., vol. IV., p. 276; Gilpin's Mines of Nova Scotia, pp. 105, 107.

† Acadian Geol., p. 315.

‡ Trans. N.S. Inst. Sc., vol. V., p. 213.

§ Acadian Geol., p. 317; Trans. N.S. Inst. Sc., vol. III., p. 67.

unconformably upon grey sandstones and ferruginous shales, the dip to the south being apparently caused by a fault which seems to separate it from the older rocks. Near the brook, on the road from Lorne to the railway platform, is a shaly and thick-bedded limestone of the usual character; and near the school-house the land is broken by gypsum, as already stated, interstratified with grey and greenish, soft, crumbly shales. Fault.

The limestone of Lorne seems to form a tongue in the valley of Big Brook, runs thence across to William Dunbar's quarry, and appears again on the farms of Murray, Halliday and Grant. In the other direction it has been traced to the west branch, to William Ross's, to Macdonald's on the Crockett road, to the Bridgeville post office, thence up the East River. Whitish-grey, rusty-weathering, rough, somewhat soft, brecciated and oolitic limestone is found on the brook which crosses the railway north of Lorne siding. A short distance further west, flinty, whitish, siliceous grit, probably Upper Devonian, is in place. Lorne.

The rocks of Cameron (Meadows) Brook, for some distance above the river, perhaps belong to this formation, whilst the reddish-grey, fine, coherent sandstone and argillite and impure limestone of the neighbourhood, altered by diorite, and having the joints full of grains of specular iron, are probably Devonian.

On the East River, at Stellarton, the outcrops begin near a tunnel from which a blackish underclay, probably of Millstone grit age, was extracted for brick-making. This underclay and an accompanying dark band are succeeded up stream by grey false-bedded sandstones with a dip of about 30°; these by reddish-grey, crumbly, argillaceous shale and sandstone, which prevail for some distance, and are succeeded by bluish-grey or blackish shales with bands of rusty, nodular ironstone, associated with greenish and grey sandy shales, apparently both overlaid and underlaid by red rocks, including bands of greenish and grey sandstone, on one of which quarries are situated on opposite sides of the river; and, towards the base, with thick layers of nut-and-egg conglomerate. At the bottom of this conglomerate, on the west side of the river, Logan puts the south fault. But a line drawn from this point to the base of a similar conglomerate on the east bank, instead of giving the direction of Logan's fault, runs 137°. These and other questions connected with the Pictou coalfield are now being studied by Mr. Poole. Immediately up stream are rocks which resemble those of Rocklin—reddish, flinty, slaty or prismatic sandstones and argillites, with bright green patches and veins of quartz and ankerite, three inches thick and downward, cut by a dyke of diorite, already Stellarton. South fault. Devonian rocks.

described as Devonian, and succeeded up stream, probably unconformably, by bluish-grey Carboniferous limestone, upon which a quarry has been opened in the bank north of Riverton station.

Waters Brook. Immediately south of Power's clearing and north of Waters Brook, is an apparently nearly vertical dip of reddish sandstone. Down the brook, reddish, grey and greenish-grey sandstone, pebbly grit and fine conglomerate dip 310° < 40°, and forty paces lower, 342° < 32°. They are succeeded immediately by light grey and rusty, fine, flinty sandstone or quartzite, greenish and reddish amygdaloid, probably Devonian; but lower down, grey, fine, quartzose sandstone, and greenish-grey and reddish, spotted, coarse, pebbly grit, containing carbonized plants, are interstratified in thick beds with reddish fine sandstone, dipping 85° < 30° at Power's quarry. At the Drummond railway these rocks are again seen nearly in contact with the Devonian, from which they are separated by a fault. In a well ten yards north-west of James McDonald's house, a bed of green and grey soft marl, full of fibrous gypsum, was cut; and gypsum is said also to be found on Robert Waters's land in the vicinity. Perhaps the rocks seen north of the north fault on the Drummond railway and at the mouth of Waters's Brook are Lower Carboniferous. North-west of McDonald's is an exposure of spathose rock, apparently ankerite, mixed with a rock probably Devonian.

Fault.

2. *Lime-rock Outlier on the West River of Pictou.*—The limestone quarried at this locality Sir J. W. Dawson compares with the lower limestone of Hants and Colchester*, "containing *Crinoids*, *Terebratulæ*, *Fenestella*, *Corals* and other fossils," particularly in the upper, yellowish, shaly part, which is spotted with crystals of pyrite. It is light and dark bluish-grey, strongly bituminous, veined with calcspar, in both shaly and massive beds. It is evidently an outlier in contact with Devonian and Permian rocks and would seem to indicate not immense incredible changes of conditions of deposition, but rather the faulting which has given rise to the assemblage of so many distinct geological formations in this small district.

A similar outlier of gypsum, marl and limestone is found in the first brook South of Millbrook, about three-quarters of a mile above the Middle River road.

Carboniferous and Devonian. 3. *Outliers in Farnham's Brook, Penny's Mountain and the vicinity.*—Red Devonian argillite is found both up and down stream from an outcrop of greenish marly rock, probably Carboniferous, in the bed of McKenzie Brook, near Philip Archibald's. On the bank, also near

* Acadian Geol., p. 315.

the flinty rocks, gypsum has been quarried. The funnel-holes at the quarry do not seem to reach below the level of the brook*.

Carboniferous limestone has been quarried on the left bank of Clifford Brook, the next stream to the westward, below Mr. Hoar's house and not far from a cliff in which the unconformity between this formation and the Devonian is not less well-marked than that between the Devonian and the Triassic. At the point of contact on the right bank, a runlet from the westward has cut its way through the cliff about fifteen feet high into the main stream. Beneath the limestone, which is more or less massive and concretionary, is an irregular bed of egg-conglomerate, composed of pebbles of the red rocks of Union, upon which it immediately rests. On the left bank also is a knoll of red spotted limestone and conglomerate, and immediately east of it, outcrops of grey and reddish, whitish-weathering quartzites, which occupy a considerable breadth of the brook higher up. The dip of the limestone is $107° < 10°$, that of the quartzites obscure but probably $172° < 55°$, and of those up stream nearly vertical. Cavities in the limestone contain crystalline or botryoidal concretions of calcite and limonite, and in places both it and the underlying slates are stained with hematite. A little higher, doubtful indications of Carboniferous marls are met with, while at the fork of the branch from James Clifford's house, marl and limestone are in the brook, apparently continuous with the gypsum and shelly limestone at the house. Up the west branch, blackish shaly limestone and greenish-white marl are succeeded, immediately above the fork, by slates like those of the iron ore series, cut by veins of ankerite which contain fine specimens of specular iron ore. Higher up, greenish, Carboniferous shale is again present; and near the Telegraph road, dark grey massive limestone with white veins of calcspar, has been largely quarried; but it is not known to cross the road or to crop on Johnston's farm adjoining.

Clifford Brook

Unconformity

Iron ore.

Limestone quarry.

Succeeding greenish and reddish quartz-veined Devonian slates on the east branch of Farnham's Millbrook, is a cliff of grey brecciated Carboniferous limestone, stained chocolate-brown and indian-red with hematite; and at the contact a large quantity of crystalline pyrolusite has been taken from a shaft. Devonian rocks are seen lower down, succeeded again by red, grey and greenish micaceous shales and gypsum in cliffs; while still lower, dark bluish-grey, flaggy limestone is well exposed in the bed of the brook, separated from the Triassic by a belt of greenish and reddish, shaly argillites, apparently Devonian. In the adjoining branch, a few yards above the fork, light grey, fine, soft

Farnham's Brook.

Manganese ore.

* Gesner's Geol. of Nova Scotia, p. 132.

sandstone is interstratified with dark bluish-grey limestone, or calcareous flags, containing shells; and good exposures of blackish limestone are found nearly to the back road, the outcrops being, perhaps, continuous with those which extend from Penny's Mountain along the road.

Penny's Mountain.

On the top of Penny's Mountain, south of the turn in the road, a large outcrop of Carboniferous limestone forms a hill. It is of various light colours, somewhat dirty, weathers on the surface rusty and indian-red, and is probably the equivalent of that seen in Farnham's Brook. In a branch of this brook, from about the middle of the mountain, are reddish and light greenish-grey shales and marly sandstones. At the eastern end of the mountain a brook on the north side shows black, calcareous, shaly limestone, earthy, and full of brachiopods; but not far distant are the flinty Devonian rocks. From the top of the mountain the limestone does not seem to extend far in any direction, most of the neighbouring brooks exposing the older rocks, upon which both Carboniferous limestone and Triassic are spread in very irregular unconformity.

4. *Basin of Stewiacke and Shubenacadie Rivers.*—Carboniferous limestone occupies the Stewiacke River from its mouth to the top of the settlement at Eastville, where a narrow basin lies between Devonian on the north side and light grey, fine, micaceous, schistose, quartz-veined slates of the gold bearing series of Berry Hill Brook and other brooks of the neighbourhood, a large quantity of drift sand, gravel and boulders often obscuring the contact.

Iron ore of Newton Mills.

The red hematite of Newton Mills is in a contact conglomerate, containing pebbles of whin and other rocks. Cox Brook, in the main branch above the road, shows the gold-bearing rocks in contact with Carboniferous limestone. In the branch which follows the road where it climbs the hill is a conglomerate full of hematite, containing pebbles of the red rocks of Union. At Upper

Caves.

Stewiacke are caves, springs and natural bridges among the great deposits of gypsum and limestone which occur on the north side

Lead mines.

of the river and towards Pembroke. At Pembroke and Smithfield the limestone contains galena, which has been prospected to some extent at the junction with the older rocks. At Smithfield the limestone is interstratified with reddish, soft marl, including bands of greenish and grey, flaggy, calcareous sandstone, grit and conglomerate.

Unconformity

The boundary between the rocks of Union and this series in Smithfield Brook shows patches of the latter after the first exposures of Devonian, as if to mark a great unconformity. On Otter Brook for a great distance from the river the country is

low and occupied by sandstones, shales, gypsum and other rocks of this formation. After crossing the road to Pembroke, one branch displays red Devonian argillites, with associated whitish quartzites, which extend thence to the Pembroke River near the bridge at Sam Deyarmond's, immediately below which a little brook from the westward exposes Carboniferous limestone, apparently at the contact. East of this river, the boundary seems to follow the brook along the road, past the lead mine, to Eastville, and is well shown in several of the little brooks, the conglomerate of the Carboniferous being easily distinguishable from the quartzose grit or conglomerate of the underlying formation. In the little brook which comes into Sam Deyarmond's clearing from the north-east, red and grey, flinty Devonian rocks contain layers of quartzose, pea-and-nut conglomerate, about 300 yards from the house. North of the house for a short distance is a flat piece of land, perhaps indicating Carboniferous rock; and in the brook from the westward, immediately below the bridge on the Riversdale road, are, as already stated, good outcrops of limestone, rubbly pieces of the red rocks being on the left bank, as if the brook here followed the contact. Red Devonian rocks are met with thence along the road as far as Glenbervie mill-dam, where they are well exposed, dipping nearly vertically down stream. Not far from the pond is an outcrop of flinty conglomerate, which has been mined for gold. It is included between layers of the red rocks of Union, which are succeeded by the grey, greenish-grey and bluish-grey sandstone and shale, rusty-weathering, coherent and rubbly, so well exposed in the large brooks near the school to the northward, and which occupy most of the road to the top of the settlement, some of the dark strata being like those of the road south of Lansdowne. After passing the track to Island Lake, there is a quantity of red argillite and sandstone, belonging probably to the lower part of the Union series.

Supposed auriferous conglomerate.

In the immediate neighbourhood of Stewiacke River, rock exposures are so scarce that it is doubtful whether the grey sandstone and shale of the East Brook are of this age. Immediately south of the road, a seam of coal, said to be eighteen inches of mixed coal and coaly shale, is overlaid by eight feet of dark shale, dipping about 277° < 14° at the openings and also at the outcrops some distance up the brook; while higher still the dip changes to 202° < 19,° the rocks being for the most part red; and, not far up stream, to 127° < 17°. A bed of fine ironstone or impure limestone, a few inches in thickness, then lies nearly horizontal among grey and rusty shales, succeeded further south by alternations of grey and red sandstones

Coal of East Brook.

and shales. A quarter of a mile below the road, grey sandstones dip 281° < 14°; and at the rocky falls in the river, 167° < 15°; but both these outcrops are small and somewhat obscure. In Johnston Brook to the eastward, as I am informed by Mr. James Pitblado, a shaft was sunk forty feet and a borehole continued forty feet below the bottom of the shaft. No coal was found but only traces of dirty gypsum. Similar rocks are found between the main river and the south branch, although most of the brooks are sluggish and dirty.

Brookfield quarries.

A large quantity of fossiliferous limestone from the Brookfield quarries is used at Londonderry in the reduction of the iron ores, and from a fine specimen presented to the Provincial Museum in 1887 Dr. Honeyman has described the large species *Nautilus Brookfieldi*.*

Out the road from Brookfield station towards Pleasant Valley, about a mile from the railway-crossing and a short distance past a cutting in red shale, the plain and marsh give place to higher land, broken on the left by pits which probably denote Carboniferous limestone. Past the road on the left to Short Lake, the limestone which has kept parallel with the road, crosses to the right and shows outcrops of shaly and of rough massive limestone, which has been quarried and burnt. On the road to the left towards Green Oak, across the outlet of Short Lake, and again on the road to the left beyond, are exposures of red marl. At Francis Short's farm, immediately past the school-house at Upper Pleasant Valley, gypsum has been quarried and is perhaps continuous with that at Kennedy's a mile and a half nearer Irwin Lake. Grey, reddish, greenish and rusty soft marls and sandstones are interstratified with limestone and gypsum at various points which require no special mention. The principal outcrops are indicated on the map as well as the contact with the Devonian wherever it has been ascertained.

Short Lake.

Broken gypsum-land.

Much of the land north of Pleasant Valley is wooded and boggy, and the Cunard Swamp affords a good example of the broken land produced by the outcrops of gypsum which abound at the head of and for some distance down Soley Brook, where they are succeeded by the rocks of Union, which extend to the contact of the Triassic near Cobequid Bay.

Irwin Lake.

On the road to Irwin Lake from the fork of Pleasant Valley road, gypsum is indicated by pits, and quarries and limekilns indicate the presence of limestone as far as the house near the head of the lake, where outcrops of dark grey rusty-weathering slates begin, and nearer the head of the lake have been cut by trenches

* Trans. N.S. Inst. Sc., vol. VIII., p. 13.

and small shafts in search of gold. To the northward the debris indicates the red rocks of Union. A brook comes into the head of Irwin Lake from a small lake about a mile out, on the side of which gypsum has been quarried. From the house at the head of the lake a track runs through woods to Beaver Brook settlement at the fork of a road north of Yuill's house, but shows no rocks. In the brook, however, below the bridge immediately past Yuill's house, greenish-grey, flinty, micaceous sandstone or quartzite, with dark grey, slaty argillite, containing threads of quartz a quarter of an inch thick, is associated with whitish, massive, coarse, quartzose grit or fine conglomerate, dipping about 160° < 80°, resembling the rocks which underlie the red rocks of Union, and overlaid by red, soft, hematitic, marly, Carboniferous limestone. Search for gold.

Northward from the fork of this road, along the main road through Beaver Brook settlement, the land is flat; and at 595 yards a small brook exposes five feet of bluish-grey bituminous limestone, dipping 237° < 17° in a quarry, a few yards above which the Devonian rocks begin. Further north, other points of contact are found; and the boundary has been traced round to the brooks of Clifton, in which the red rocks of Union are well exposed beneath the Triassic. At the saw-mill in Irwin Brook, they dip 299° < 40°, their contact with the Triassic being immediately opposite a fork of the road lower down. Devonian and Triassic rocks.

About 500 yards below the fork of Beaver Brook road, and the post road, on the left bank of a little brook from 270°, are two shafts, twenty-three yards apart, which have cut the red Devonian rocks and from which a considerable quantity of limonite has been taken. It occurs in small veins or concretions. One of the shafts is said to be seventy feet deep and to have cut a white sandstone in the bottom. Clifton iron mine.

Along the post road, west of the Beaver Brook road, a red hematite has been dug for paint, and beyond it are outcrops of the rocks of Union. It is doubtful whether the limestone and gypsum formation appears again between this point and Blackrock, where large exposures of dark, shaly Carboniferous limestone, containing spots of pyrolusite and hematite and white veins of calcspar, dip south-westerly into the Shubenacadie River, and are succeeded up the river by cliffs of red marl and sandstone, gypsum, limestone and other strata of this formation, described by Mr. Gilpin*, and Sir J. W. Dawson.† At Anthony's Nose, a limestone about forty feet Blackrock. Shubenacadie River.

* Trans. Roy. Soc. Can., p. 159.

† Acadian Geol., p. 266.

thick, which is a mass of corals and shells, "stands quite on edge, projecting like a huge wall into the river. Soft marls rest against each side and include a bed of gypsum, and, at a little distance, a thick bed of this mineral appears with an arched stratification. On the opposite side of the river there are other limestones and gypsums, also very much disturbed; and, immediately adjoining them on the south, there is a cliff of nearly horizontal reddish sandstone, like that of Eagle's Nest."* The banks of the river are rocky by turns, and rocks of this formation are seen on most of the roads of the vicinity as well as on those towards Pleasant Valley and Brookfield. At Green Creek, red and green and grey soft marl, with limestone and gypsum, are found lying at a low angle.

Down the west side of the river, between Shubenacadie railway station and Maitland, none of the land is high, although occasionally hilly, and some of it is wet and barren. Outcrops of gypsum and limestone are met with along the streams, but are still better exposed in the banks of the river. West of Maitland, Triassic rocks skirt the shore for some distance; but on the western edge of a large piece of dyke land past Selmah Creek, and not far below the shore-road, irregular, and nearly vertical beds of reddish, greenish and grey, coarse, flinty grit, probably Devonian, have been quarried for rough building stone. Above the road, in Sterling Creek, however, is a large quantity of grey and red marl, probably associated with the gypsum exported at one time from this locality.

South shore of Minas Basin.

From Sterling Creek the coast is low, with a few headlands of Triassic rock, to Mungo Creek, where, between the bridge and the shore, the Triassic includes several beds of very coarse conglomerate. It follows in high cliffs to the westward and up King Creek to a mill. No Carboniferous limestone rocks appear on the shore to the westward, except in small patches, as at Walton, Cheverie, and Summerville, either the Triassic or Devonian strata occupying the coast; but a short distance inland and over a great part of the country between the shore and Kennetcook River, the gypsum, limestone and associated strata occur; and at their contact with the older rocks are found ores of manganese and iron.

Outliers among Devonian and Trias.

The road from Noel to Kennetcook runs south up the east side of a large brook which shows, at a fall and shingle mill, about half a mile from the corner, fine outcrops of grey, micaceous, flinty flags and sandstones, with rusty spots, and plants probably Devonian

Noel to Kennetcook.

*Op. cit., p. 268.

These dip up stream at a low angle and are associated with wavy, micaceous, somewhat massive sandstone and light grey flinty grit, many of the strata resembling those of the Tenecape manganese mine. But a short distance north of the outlet of a long lake, the soil is rusty and sandy, perhaps denoting Carboniferous limestone and gypsum, which occur on the east side of the lake. Immediately south of the fork of the roads at this point, about fifty yards south of the house of Mr. John Hennigar, and 100 yards west of the road, a pit dug in search of manganese ore cut a reddish and grey rock, full of calcspar veins with threads and specks of pyrolusite, and a red soft sandstone, probably Carboniferous; and in the immediate vicinity are outcrops of limestone and gypsum. South from Hennigar's, blocks of grey, soft, flaggy sandstone and of dark marly rocks indicate this formation as far as Captain Scott's, about four miles from Kennetcook River, where limestone is exposed; and probably also as far as the river. Out the road to the Gore the land is bouldery with blocks of grey granite or syenite, covered with spruce, tamarack and birch second-growth or small clearings, for some distance. Then coarse, rusty sand and pieces of soft, flaggy, coarse and fine sandstone and pebbly grit, composed almost wholly of quartz, no doubt indicate the country-rocks, which are seen on the hill, succeeded by black, papery, micaceous, rusty-weathering, coaly shales and argillaceous shales with rootlets; succeeded in turn by the greenish and light grey, chloritic and micaceous, pearly and soapy, striped slates of the gold-bearing series, upon which also is situated the Gore antimony mine.

Manganese ore.

Gore.

Contact of Cambrian.

Several miles higher up Kennetcook River, in a large brook from the southward immediately below Mrs. O'Brien's, grey fine sandstone near the bridge dips 337° < 30°, and a little higher < 10°; while not far below an old saw-mill, above which gypsum has been quarried, grey soft sandstone, shale and limestone dip 0° < 30°; and in this vicinity search was made for coal.* Near the mouth of this brook, an opening was made from the road in black carbonaceous shale, containing small traces of coal, and on the opposite side of the road are several pits in one of which streaks of bright clean coal, one inch thick and downward, are exposed, and also, it is said, a seam one foot thick. Gypsum and limestone underlie it at no great distance. On the north side of Kennetcook River, immediately below the shop and house of Mr. Nelson Weir, the best of these small coal seams was opened in several shallow pits on opposite sides of the

Coal seams.

*Acadian Geol., pp. 268 and 276.

river; but it appears to have been only a few inches in thickness and an extension of the coal seen both up and down the river. The strike is easterly, the dip doubtful. In a brook from the northward, not far above Mrs. O'Brien's, grey, fine, soft, shaly, flaggy and thick bedded sandstones dip 192° < 18°, so that the width of this basin is apparently not great; but whether limestone and gypsum overlie as well as underlie, was not determined.

Elmsdale. On the road west from Shubenecadie station to Indian road and Bar settlement, rocks of this formation are everywhere in place nearly to the Gore; and on the road down Nine-Mile River to Elmsdale, their contact with the auriferous series is frequently seen.

5. *Outliers of the north side of Minas Basin.*—The limestone and gypsum, red soft sandstones and shales which come from beneath
Debert River. the Triassic of Debert River, not far from its mouth, are described by Dr. Ells* and Sir J. W. Dawson.† For a great distance to the westward, no rocks clearly of this age appear between the shore
Clarke's Head and the Devonian of the mountain, but at Clarke's Head‡ "beds of common gypsum and a beautiful purple variety of anhydrite" occur faulted with strata of the underlying formation; and similar patches are found between this point and Port Greville, the unconformable superposition of the basal beds upon the underlying slates being well marked at several places.

Shore east of Spencer's Island. Between the mouth of the brook east of Spencer's Island post office and Mahoney Brook only drift is seen on the shore. Then red marl and sandstone, shattered, rubbly and slickensided in part, are interstratified with bands of greenish-grey conglomerate, grit and sandstone, dipping inland at a high angle and extending to Fowler Brook, where they have an easterly dip, at first very high but decreasing to the eastward and covered again by drift. In the landwash at the brook next west of Phinney Brook is a patch of very soft bright red sandstone, greenish conglomerate and greenish
Trias and Devonian. soft marl, perhaps Triassic, with a low variable dip seaward and westward, and a band of grey limestone at the base, which breaks into large nodular blocks. At Phinney Brook, Devonian rocks begin and the outcrops of Carboniferous are interrupted as far as Fox River, from which, however, they extend east in cliffs and reefs nearly to Parrsboro' pier. Near the mouth of Fox River they consist of red shales or marls, with green spots and layers, interstratified with grey, fine-grained flaggy sandstone, wavy and false-bedded, containing

*An. Rep. Geol. Surv., 1885, vol. I., Part E, p. 42.
†Acadian Geol., p. 100.
‡Acadian Geol., pp. 105 and 265.

rusty patches full of broken carbonized plants. They greatly resemble millstone grit and the dip would appear to place them, if there is no dislocation, above the rocks of Bull's Bluff and the dark shales and red and whitish, more flinty and broken strata east of Cape Sharp. Between Ramshead and Diligence Rivers, grey sandstones and red marls are finely exposed and probably occupy also the flat land between the shore and the foot of the mountain above the post-road, which extends also towards Parrsboro' with a ridge on the south side. Diligence River.

Up the left or east bank of Diligence River for some distance, rusty and coarse sandstones and rough flags, one of which has a surface of ten feet by six feet and is a foot thick, are interstratified with red and grey shales, like those of Cape Sharp; then tidal marshes prevail. South of the river, the shore exposes a great thickness of reddish and grey, fine, flaggy, wavy, somewhat coherent sandstones and shales, the former very full of carbonized plants. Near Bull's Bluff are two bands of black bituminous shale, one six inches, the other two feet thick, and a coal seam an inch thick. From Bull's Bluff, these rocks, dipping inland, strike along the shore as far as the Triassic trap and sandstone of Cape Sharp, immediately beyond which, however, they are again well exposed to within half a mile of the Triassic of Partridge Island. A close and accurate survey of these shores was made by Mr. Barlow. Immediately east of Cape Sharp a few blocks of limestone were found on the beach. The marls here dip easterly at a very high angle, are chiefly red but include bands of hard grey sandstone, with two inches of coaly matter and a band of coaly bituminous shale, two feet thick, full of *Naiadites* and other fossils. Then for some distance, sandstones and marls chiefly dark-greenish or grey but also red, containing a few small veins of calcite and ankerite, dip inland and undulate, showing good examples of contorted and faulted strata, some of which have been broken without displacing the beds above and below. About fifty chains north-west of the north end of the gravel beach at Partridge Island, these rocks are underlaid by grey and red conglomerate, associated with grey sandstone and with limestone; and, about a quarter of a mile from the beach, resting directly upon Devonian slates which dip 153° <76°, whereas the dip of the conglomerate and associated red sandstone is 284° <18°. The conglomerate is exposed for only twenty-five paces west of the contact; then comes an interval in which a road goes up from the beach, then a little brook shows red crumbly marl, which continues along the coast to an outcrop of black bituminous limestone, full of shells, succeeded by massive limestone; that by red conglomerate overlaid by grey conglomerate and sandstone, Coal and black shale. Cape Sharp. Contorted strata. Unconformity near Partridge Island with Devonian. Fossiliferous limestone.

flaggy and full of broken plants; overlaid by red conglomerate and marl and by grey, thick-bedded, jointed sandstone, with rusty streaks, large carbonized plants and patches of dark shale. From the first band of grey sandstone to the second is about 200 paces. About 130 further, at a little brook, the dip is easterly; about 250 further at a larger brook, red conglomerate is again exposed, with a westerly dip and overlaid by the rocks described above.

Unconformity at Parrsboro' River.

At a point on the east side of Parrsboro' River, lying 121° from the lighthouse, another contact of these two series is to be seen in the cliffs, the conglomerate dipping 282° < 22°, the Devonian, a few feet from the contact, 165° < 83°. The conglomerate is red; its pebbles plainly derived from the underlying flinty rocks, every variety of which is represented, range in size from that of a nut to more than a foot in diameter; it contains lenticular layers of greenish-grey flaggy sandstone, full of comminuted carbonized plants, and is overlaid by reddish shale and flaggy sandstone, with green blotches and spots, which are exposed northward to the mouth of a large tidal brook. On the road at this brook, reddish, soft, marly shales, with greenish bands, dip 18° < 51°. Three-quarters of a mile to the eastward are indications of indian-red Carboniferous marl, and about a quarter of a mile further, of greenish gypseous marl, in the road at a house; whereas immediately above the road, and also below it to the eastward in a brook, the flinty rocks of the iron ore series are exposed and on the shore road eastward to Swan Creek,

Swan Creek outlier.

dark shales and flags. In Swan Creek, a conglomerate outlier, similar to the above, lies among the Devonian near the road. It is indian-red and contains many large pebbles of the whitish quartzite, with which it is undoubtedly unconformable. On the shore between Parrsboro' River and Swan Creek are several outcrops of Carboniferous rocks upon the Devonian.

Wasson's Bluff.

With the exception of one small patch of Triassic conglomerate, of which an area of only ten feet square is exposed, the little brook east of Wasson's is occupied, from the road to the shore, by

Triassic trap.

the red rocks of Union. Immediately to the westward, however, cliffs of trap-conglomerate or globular trap begin, and, in alternations with red Triassic sandstone, occupy all the shore round Swan

Clarke's Head

Cove to the gypsum and limestone of Clarke's (Fraser's) Head, large blocks of the trap being apparently completely surrounded by Triassic sandstone. In contact with the trap on the south side, seven paces north of a fish-house, are soft green and red and blackish gypseous marls, with veins and masses of rose-coloured and white gypsum, succeeded by flaggy layers of calcareous rock or limestone, dipping 9° < 70°, succeeded by a light greenish and rusty

sandstone and dark and light soft marl, dipping 352° < 80°, faulted, and succeeded by gypseous marl, containing masses of gypsum, and by limestone veined with calcspar. At 133 paces from the first outcrop the strike is 170°. At fifty further a mass of gypsum carries specks and aggregations of pyrite; it strikes 173° for 241 paces further, then turns at right angles to the westward, a high cliff of purple and greenish slates towering above it along a fault. Devonian slates and flinty sandstones, with veins of ankerite sometimes two inches thick, here dip 22° < 42°; but thirty paces further, 119° < 50°. The shore turning due west from the Head shows little patches of soft marl and gypsum at 130, 430 and 540 paces, the unconformity of the last being plain; at 900, the granular felsite Dyke.
or diorite of a pinnacle rock has close to it gypseous marls and sandstone, quite unaltered; while through them stick little bosses of the purple and rusty and dark slates, marked with plants, greenish flinty sandstone or quartzite, veined with ankerite, precisely like the country-rock at Londonderry mines, and dipping Iron ore.
200° < 45°. One of the veins of ankerite is six inches thick. At 1380, soft marl lies upon the slates; and at 1,750 rusty Carboniferous sandstone and conglomerate, containing much calcspar are succeeded by whitish and dark limestone and gypseous marl; followed at 1,830 by Triassic trap and sandstone, which extend to the brooks in the cove mentioned above as showing the Devonian near the contact of the Carboniferous. Between this brook and the conglomerate are outcrops of dark gypseous marl, with layers of brecciated black crystalline limestone, of purple, red and green Devonian rocks, with a large proportion of dark beds.

On the west side of the harbour between Parrsboro' and the coal- Parrsboro'.
loading ground at Whitehall Creek are flinty sandstones or quartzites of somewhat doubtful age. Across this creek and that south of it dark shales are well exposed. Then the lighthouse point and a large salt marsh intervene. On Crane Point red and green, flinty, Devonian slates, jointed into rectangular and triangular blocks, and veined with ankerite, underlie a considerable thickness of dark grey and green and grey sandstone and shale. Then towards the pier the red rocks come on the coast, as shown on Mr. Barlow's map, as well as the red and grey rippled flags, underlaid by dark shales and flags, like those of Horton Bluff, containing layers of limestone, of fine calcareous grit and of blackish rock, full of broken plants, upon which rests the conglomerate west of the pier.

Up the large brook quarter of a mile south-west of Parrsboro' railway station, immediately above the road, are dark shales which

have been dug, and grey sandstone in thick and flaggy beds, probably Carboniferous, dipping 341° < 70°. Above these outcrops none occur as far as the large alder-marsh, but on the south side of the brook is a ridge or terrace of low hummocky land, its top showing gravel, its base blocks of grey compact sandstone. Above the marsh, light grey fine sandstone and dirty greenish-grey, crumbly, argillaceous shale, dip 300° <40°; and higher up 335° <30°, in barren land not far north of the Blackrock road.

Northumberland Strait.

The outcrops of this formation on the shore of Northumberland Strait, between Wallace Harbour and Saddle Island, are apparently the lowest beds of a sharp anticlinal or a great fault which passes between Saddle Island and the mainland. They appear first immediately west of the marshy sand-flats at a lobster factory west of Treen Bluff, and consist of blackish-grey somewhat brecciated limestone, whitish gypsum and dark marl, striking 234° with a nearly vertical dip; interstratified with grey and greenish rusty-weathering sandstone, full of carbonized plants mineralized with black crystalline spar, and containing small veins and blotches of albertite, black spathic iron and calcite. Apparently overlying these unconformably* at a small brook, are reddish pebbly grit and conglomerate, probably Permian, like the cliffs of Cape Malagash and the shores of Tatamagouche Bay. Fine exposures of plaster occur on the inner shore of Wallace Harbour, as stated by Dr. Ells.

G. 2.—Millstone Grit.

Rocks of this formation, as they occur at Merigomish, have been already described†; and it has also been stated that certain areas included among the lower formations may belong to this, the great faults and unconformities of the district, and the uncertain value of the evidence of fossil plants having left obscure the relation of the various groups, even in the immediate neighbourhood of the coal measures. At the base, at Merigomish, Sutherland's River, the Vale colliery and McLeod's Brook, is a conglomerate not unlike that described as occurring to the eastward and perhaps its equivalent.

Merigomish.

In the little brooks near the railway station of West Merigomish, reddish and grey soft sandstone, with conglomeratic and concretionary patches, is interstratified with marls like those on the banks of Sutherland's River. The grey flaggy beds are blackened by carbonized plants, and certain layers have been quarried. The age of the outcrops of conglomerate and greatly broken, red, micaceous

*An. Rep. Geol. Surv., 1885, vol. I., Part E, p. 41.

†An. Rep. Geol. Surv., 1886, vol. I., Part P, p. 86.

sandstone along the fault near the iron mine at McLaurin's is, as already stated, doubtful.

Some of the grey sandstones, containing impressions of ferns, *Calamites* and other plants, traces of impure coal and black shale, found in thick beds and in flags along the contact of the Pre-Carboniferous rocks on the St. Mary's road and other roads in the vicinity, such as McLellan's Mountain road, are perhaps of this age or higher. The red sandstones and shales of the railway west of French River contain large nodules of grey fossiliferous sandstone and are similar to reddish sandstones, with bands of grey, found in the neighbourhood of Glenfalloch.

East River Pictou.

The rocks of the East River at Stellarton have already been described. In the rocky land between the head of the McKay Brook and McNaughton's mill on McCulloch's Brook, thence out the old road to the Westville road, are blocks and a few outcrops of a reddish sandstone similar to that of Stellarton and probably of the same age, a large area of rock north of the south fault being referrible to this rather than to the coal measures. The reddish somewhat coherent and greenish-grey and grey beds on the road north towards the Drummond colliery, and also south to the Foxbrook school, exposed in several brooks of the neighbourhood, are perhaps Lower Carboniferous.

Foxbrook.

Near the Foxbrook school, at Finlay's, a band of calcareous concretionary or conglomeratic rock was supposed to be a limestone and an attempt was made to burn it. Some of the reddish and grey, flaggy, fine sandstones in the immediate neighbourhood of the school are flinty and rubbly as if influenced by a fault. They extend through to the Middle River road and on the road turning to the left about a mile past the school. At the Whitehill road here, a brook shows reddish micaceous sandstone, but a short distance down stream, where it turns away from the road, reddish, very rubbly rocks, include bands of sparkling, quartzose sandstone or quartzite, resembling the Devonian of Rocklin. Lower down are others, lying at a moderate angle yet as rubbly as any of the rocks of Riversdale or Loch Lomond, generally red, but including layers of grey flinty sandstone; these extend to the head of the mill-pond. At the bridge are small veins of pyritous calcspar. But almost immediately below the mouth of this brook the Middle River shows grey sandstones, which have been quarried near the bridge at Union Centre, and include layers of concretionary limestone-conglomerate, a few feet above and below the bridge and supposed by Mr. H. S. Poole to be Lower Carboniferous. And from this point, red soft rocks, with bands of greenish limestone-conglomerate

Doubtful Devonian rocks.

and of red and grey, mottled, argillaceous sandstone, like that seen on the road from the Black Diamond colliery to McLeod's Brook, are well seen in the river and on the roads of the neighbourhood, including, about 350 yards above the mouth of McLeod's Brook, a small seam of dirty coal. The rocks seen where the railway leaves the road west of Hopewell, are red, soft, flaggy Carboniferous strata, probably millstone grit. Those in Cameron (Meadows) Brook where it approaches the railway, are similar, as well as those seen in the main branch above the railway and in a cutting west of it. But about 250 yards from the brook is a large block of the dioritic rock so characteristic of this region, which, if in place, indicates the Devonian, a supposition which is strengthened by the next outcrops. And the steep dip of the red rocks seems to indicate a great fault.

Hopewell.

Middle River. At the west end of the Foxbrook road the rocks resemble those of the Black Teeth of East River, being chiefly argillaceous, with hard bands and a layer of green concretionary limestone-conglomerate. Near the river road the dip is 80° < 80°. On the Crockett road near the limestone are reddish-grey Carboniferous sandstones like those of Hopewell and Foxbrook, associated with bands of concretionary, calcareous conglomerate. No limestone is seen between the outcrop at Crockett's and the quarry at John McDonald's. The rocky ridge of reddish sandstone perhaps cuts off this limestone by a fault or overlaps it both here and between Finlay's and Grant's. The adjoining rocks are almost certainly Devonian. The green shale is very characteristic, and the black shale of Jessie Grant's is perhaps that of the Cross Brook and Archibald's Brook, of West River and of Riversdale.

McLeod's Brook. Returning to the Middle River, the rocks of McLeod's Brook* are like those of the East River above the west branch, and seem to dip uniformly down stream. They are reddish shales and sandstones, associated up stream with bands of greenish and grey, rusty-weathering sandstone, with pebbly patches. Below the dam at the road a quarry has been opened on a thick bedded, reddish-grey and grey, fine sandstone. At the dam a thick band of nut-and-egg conglomerate is seen, and similar rocks extend to and beyond Oliver's mill.

McCulloch's Brook. In McCulloch's Brook, a patch of reddish and greenish, micaceous Carboniferous sandstone, which occurs among the Devonian and Permian strata near the Drummond railway, and includes a band of dark grey limestone, is perhaps, like the gypsum of Waters' Hill,

*Geol. Surv., Prog. Rep. for 1866-69, p. 60.

Fraser Brook and the neighbourhood, to be included rather with the underlying formation than with the millstone grit. It is not shown on Logan's map, although the Carboniferous area, a short distance higher, is indicated.

Coal measures

The grey sandstones in Middle River at the mouth of McCulloch's Brook, seem to be coal measures rather than millstone grit. They are for the most part of fine grain, with greenish layers and bands of red and green argillite, ripple-marked and flaggy; and continue in cliffs to the mouth of French's tunnel, from which a large quantity of coal was extracted from a seam supposed to represent one of the workable coals further east. It is underlaid by a rusty, pyritous underclay, and in the river there are reddish argillaceous rocks, with a dark bituminous layer three feet thick, underlaid by calcareous concretionary underclay, perhaps representing the coaly rocks of the tunnel. Grey strata and bands of nut-and-egg conglomerate, and of concretionary grit, occur higher up; but most of the rocks consist of red sandstone and shale, which are well exposed in cliffs. They are succeeded near Union Centre by broken faulted rocks which have been described as Devonian.

Devonian.

Union Centre.

The red sandstones and marls west of Burnside and Union Centre are perhaps of this age, the high angles of the dip no doubt indicating faults. Their contact with the flinty series is still somewhat uncertain in places.

Debert.

As already stated, it is possible that the strata of Debert* and Chiganois Rivers, described as Lower Carboniferous, may be in part at least of this age.

G. 3.—Coal Measures.

Limits of coal measures.

The true or productive coal measures are confined to the area determined by Sir William Logan and Mr. Hartley, in their report of 1869 on the Pictou coalfield. The limits as defined by them remain practically unchanged, but "recent mining operations, borings made by Mr. R. P. Fraser, of Pictou, with the diamond drill for certain mining companies, and geological explorations made by the late Mr. Jesse Hoyt and Mr. H. S. Poole for the Acadia Coal Mining Company, have added many facts necessary for understanding the complicated structure of this field," and some alterations and additions are now consequently required in their map. Some of these are indicated by Mr. Gilpin,† and all of them have been

Changes in map of 1869.

*Trans. N. S. Inst. Sc., vol. VI., p. 93.

†Trans. N. S. Inst. Sc., vol. VI., p. 90; Trans. Roy. Soc. Canada, vol. I., Sec. IV., p. 137; vol. V., Sec. IV., pp. 25-30.

McCulloch's Brook fault.

worked out in detail by Mr. Poole.* As already stated, a narrow belt included with the coal measures on both sides of the East River, along the southern edge of the field, and east of McCulloch's Brook fault, is now regarded as millstone grit, whereas the rocks of French's tunnel appear to be coal measures. This fault is of much more importance‡ than is assigned to it, and the Acadia mine so-called basin, instead of being only 800 feet deep, is more than 1,600 feet, and the fault 2,600 feet.

McLeod fault.

The evidence seems to be insufficient upon which the McLeod fault and other minor faults of the district have been drawn. Mr. Poole believes that the former is of trifling importance, and that the continued deterioration of the seams at the east end of the basin—so marked at Grant's slope on the East River and at the Pictou Company's shaft—has produced such a change of thickness and quality that the McLeod seam of less than eight feet represents the Albion main seam of nearly forty feet in thickness, as would seem to be proved by the large quantity of black shale overlying both. A bore-hole was sunk sixty feet at the bottom of the McLeod pit, but no coal found. There is no evidence of this fault on the railway, where it is shown by Hartley. In the railway cuttings, on the contrary, the northerly dip of the Albion mines measures is retained nearly to the McCulloch's Brook fault, where it changes to west, a dip also seen among the red sandstones at the great turn of the Drummond railway, and probably due to this fault. All the faults of the workings on the main seam are north and south faults with, west of English church downthrows to the west, and to the east on the east side of the church; and it seems not improbable that the McLeod fault is one of these. To the westward of the McLeod pit, red rocks are said to have been cut which perhaps indicate the millstone grit or termination of the coal measures, which is also found in a boring at the Nova Scotia or Black Diamond Company's slope. Mr. McBean found the coal south of the pit. North of the pit it seems to have been lost at a north-and-south fault. A number of little faults and consequent derangements of the dip, the paucity of exposures and their small extent, render the precise description of the structure still obscure.

Another east-and-west fault shown on the map appears to be a combination of the Stair-pit and Dalhousie faults inaccurately represented.

---

*Trans. Amer. Inst. of Mining Eng., vol. XIV., p. 403.

‡Trans. N. S. Inst. Sc., vol. VII., p. 391.

Instead of the west fault there appear to be, according to Mr. Poole, small faults on the flank of a hill of Devonian rock at Highfield farm near Westville. The main seam at the Acadia mine is eighteen feet thick, while at the Black Diamond it is eight feet, the bottom benches having turned into stone. And it is supposed by many that, by a further deterioration, the main seam becomes the dirty seam of French's tunnel. West fault.

The Mill-road fault also, from close investigations made along the supposed course by pits, appears to be of little importance. Sir William Logan states that it cannot be traced north of Black's mill-site, and at the mill-site the displacement by a number of little faults seems to be of little moment. Above the mill-site at a great turn in McLellan's Brook, is a slight fold of the sandstone which gives rise to two small basins and a slight squeeze or dislocation in a distance of 150 yards east and west, the dip going round in one place from 114° to 157°. Lower down, about twenty yards above the old mill-site, is a curious disturbance, which appears to be only local, as if a small piece in the bed of the river has been thrust on edge, whereas on the left bank the measures are undisturbed. Mill-road fault.

Changes as great as those described above take place in the character of the coal and of the strata associated with the coal at the Vale. Conglomerate in one place replaces a fireclay and in another the shale above the seam becomes a massive rock. The coal seams deteriorate in going south towards the mountain, and where dipping east or south they are said to be seldom, except in the case of the Captain seam, of such good quality as where dipping away from the east and south faults. The St. Lawrence pit is supposed to be on the eight foot seam of the Vale. The supposition on page 41 of Logan's Report that the Widow McLean seams underlie the McBean seam has since been proved to be erroneous. The eight foot or McBean seam represents the eight foot nine inches or Widow McLean seam, somewhat disturbed by faults; and the McBean and other seams have been traced by Messrs. Barton, Mitchell and McBean to the east fault. The contact of the different series near Donald McLean's south of the Vale—of the coal measures, gypsiferous series and Cambro-Silurian—is shown on the map. Changes in the coal and strata. McBean seam.

From the George McKay slope a considerable quantity of coal has lately been taken by Mr. Muir from a seam about four feet three inches thick. It is said to be an excellent house coal, easy to work, and is largely sold in Truro. Recent explorations render it doubtful whether Sir William Logan was right in identifying the McKay seam as the six feet seam and in separating the latter from the Mountain seam. The four feet seam, of page 35, line 10 of his George McKay seam.

report, is said by McBean to be only two feet, and he supposes it to represent the ten inches of coal lying above the oil shale.

Potter's Brook fault.

From the Foord pit, levels have been extended a considerable distance east of the East River, and in the opposite direction round the end of a basin, across the supposed position of the Potter's Brook fault and to the high angle of the north rise. Instead of this fault there are here a great number of trifling north and south faults. On this north side of the basin, at Dan Tupper's on the Truro road, a coal seam has been worked, which is supposed by many to be the main seam but is perhaps rather a seam overlying that at some distance. The age of the rocks north of the Truro road at this point is a disputed question. They strongly resemble the Permian grey sandstone of the East River, north of the New Glasgow conglomerate; and their dip at Fraser's quarry is north at a very low angle.

North fault.

The north fault has been shown as crossing McCulloch's Brook a quarter of a mile north of its actual crossing, and, as already stated, the size of the Devonian area of this corner of the map is greatly exaggerated, the rocks in and south of Waters' Brook between Waters' quarry and the railway being millstone grit or Lower Carboniferous, and several large patches in McCulloch's Brook and Middle River, shown as Devonian, being New Glasgow conglomerate.

The rocks of the little branch of McLeod's Brook, between it and the Nova Scotia colliery, along which the road now follows, consist of grey, coarse, rusty-weathering sandstone, associated with one seam of dirty coal. Below the bridge are reddish-grey, fine, soft, marly sandstone and spotted concretionary, reddish-grey sandstone, probably the upper beds of the millstone grit, unless a fault intervenes, of which there seems to be no evidence.

G. 4.—Permian.

Subdivisions.

Rocks of this age as displayed between Merigomish and Pictou and along the north side of the Pictou coalfield, have been already described.* They may be subdivided as follows:—

1. New Glasgow conglomerate.
2. Middle grey sandstone and shale group, with small coal seams.
3. Upper red sandstone and shale group, with thin bands of limestone.

*An. Rep. Geol. Surv., 1886, vol. II., Part P, p. 93.

These groups lie in parallel belts along the shore of Northumberland Strait between Merigomish and Wallace,* dipping seaward, generally at a low angle, but broken by faults sometimes of considerable magnitude. Between the second and third groups there is no distinct line of demarcation and the subdivision is only one of convenience. Distribution.

1.—New Glasgow Conglomerate.

Although rocks of the lowest of these subdivisions occupy a belt from five to two miles wide between Fitzpatrick Mountain and Waugh River, they are entirely absent at Bailey's Bridge, one mile and a half west of Waugh River, owing either to a fault or to unconformity, the grey and brown sandstones coming upon the Pre-Carboniferous rocks of Tatamagouche Mountain. The other groups are everywhere present, exhibiting more or less persistence in their composition and appearance until traced into connection with the large areas in Cumberland county.

The outcrops of the conglomerate between Merigomish and the Middle River of Pictou, between Alma and Granton, have been fully described. At the Middle River, they are broken apparently by a great north-and-south fault, and on the west side of Greenhill by another, beyond which they reappear in Fitzpatrick Mountain and are continuous to Waugh River. Considering that the conglomerate at New Glasgow and elsewhere contains pebbles and blocks of grey sandstone which are as likely to have been derived from the coal measures as from the millstone grit (which here contains far more red beds than grey); that the millstone grit has not been proved unconformable to the coal measures, but seems rather to pass upwards into them, the presumption is strong that the New Glasgow conglomerate is newer than the coal measures, as assumed in last report, the absence of fragments of coal from such coarse conglomerates counting for nothing,† as a larger proportion of pebbles of syenite and diorite and of Devonian and Silurian slates is present in all the conglomerates. A hole 734 feet deep, bored on the south side of Sutherland Point, below New Glasgow, in search of coal, on the assumption that the coal measures were there concealed by an unconformable overlap of the Permian, seems rather to add weight to the supposition that the conglomerate is a basal portion of the Permian, a conclusion at which, I am informed by Mr. McBean, Sir William Logan arrived

Evidence of age.

New Glasgow Borehole.

*Acadian Geol., p. 129.

†Trans. N. S. Inst. Sc., vol. VII., p. 202.

upon a re-examination of part of the coalfield subsequent to the publication of his report. The borehole seems to have cut only strata similar to those naturally exposed on Smelt Brook and on the river.

Fault.

At New Glasgow on the old Merigomish road, and south of it, about a-quarter of a mile from the bridge on the river, the conglomerate strikes 64°, vertically or with a steep dip to the south. Perhaps this is the fault mentioned by Mr. Poole.* The last outcrop is near the fork about 200 yards east of Church's livery stable. A steep dip is also seen on the left bank of East River, above the bridge. Perhaps both are due to the proximity of the north fault, which must be in that case subsequent to the deposition of the conglomerate, as are others in the neighbourhood of the Middle River.

Unconformity

Along Blackwood's millbrook, however, which, as described by Mr. Hartley, is the unconformable boundary between the conglomerate and millstone grit for some distance to the westward, the dip of the former is not so steep. The dip of the millstone grit in the first little tributary from the south, about 250 yards from the river road, is 29° < 62°, while the general dip of the conglomerate is much more northerly. Nearer the old quarry road, the millstone grit dips 44° < 66°, and still nearer, reddish harsh shales of the same age dip 51° < 66°. On the south side of the road at the bridge on this tributary, underclay and coal indicate the measures of the south side of the great north fault. The direct superposition of these rocks is seen in this brook at the dam forty yards above the bridge on the East River and twenty yards north of the old quarry road, showing very clearly the unconformity between the two groups. Grey sandstone, with greenish and reddish tints, dipping 42° < 51°, is overlaid by thick beds of very coarse conglomerate which fills depressions in the lower beds. These are not perhaps, however, necessarily higher than the Carboniferous limestone, patches of which are found on Waters's Hill, although included with the millstone grit by Mr. Hartley.

Coal and limestone

The limestone associated with the seam of coal which overlies the conglomerate at James Small's and William Fraser's (Moose) is said by Mr. Fraser to have been struck in a boring on Middle River, near Sylvester station, and to be there twenty feet thick. In Small's Brook the rocks of this horizon are well exposed, consisting of underclay, coaly shale and botryoidal limestone, but no pure coal seems to have been obtained. The dark layers are perhaps equivalent to those of the Smelt Brook described by Mr. H. Poole. According to Mr. Fraser, the coal and limestone come to the East

*Trans. N.S. Inst. Sc., vol. I., p. 37.

River a little below the cemetery. To the westward they do not seem to have been satisfactorily traced, although the dark layers of Rear Brook are no doubt those of the small brook. At Deacon's Cove, at the mouth of Rear Brook, according to Mr. Poole, a pit twenty-three feet deep struck six inches and a-half of oil coal, passing through light blue clay stone, full of fossil plants; and dark shales are found higher up this brook at the quarry.

Middle River.

About 100 yards above the bridge at Alma, Middle River displays red coarse conglomerate, dipping 155° < 50°, containing patches of grey soft sandstone and of red marl; some of the large pebbles are certainly derived from the millstone grit or coal measures, but most of them are Devonian. Down stream these rocks are succeeded by the Devonian, but again reappear and run up Brown's Brook, in which the conglomerate, in nearly horizontal bedding, includes red and greenish, calcareous, micaceous shale, sometimes coherent and like Lower Carboniferous. Among these beds is a six-inch layer of dark fine sandstone, full of carbonized plants of large size; overlaid by nut-and-egg conglomerate and grey, shaly sandstone, stained green with copper ore. At the mouth of McCulloch's Brook come coal measures, dipping steeply down stream, south of the north fault. Good outcrops of the conglomerate are seen along the Pictou Branch railway, immediately east of Middle River; it contains large pebbles of the reddish, greenish and grey sandstone of the millstone grit, but perhaps none of the coal measures; the dip is northward along the railway at a very low angle. North of the railway bridge, in the small brook shown by Mr. Hartley, as the northern limit of the conglomerate, no rocks are seen up to the bridge on the Nova Scotia Company's old railway, although large blocks of reddish sandstone are found, which may, however, be similar to the thick beds of red sandstone interstratified with the conglomerate in the railway cuttings at Middle River. But far to the northward on the shore are outcrops of conglomerate among layers of red soft marl and sandstone—alternations precisely similar to those on the west side of Middle River some distance back from the river, the western shore of which is skirted by red marl and sandstone, which appear to overlie the conglomerate and thus indicate a north-and-south fault, with a downthrow on the west side. North of the brickyard, conglomerate, sandstone and marl, with a low easterly dip, extend to Little Gut, on the north side of which a greenish and grey marly rock, exposed at the base of the cliffs, includes coaly streaks, overlaid by red marly shale and succeeded to the northward by a fine outcrop of reddish, nut-and-egg conglomerate, which, near the Granton wharves, dips steeply east.

North of this point the shore is low as far as Begg's Gut, where grey sandstone begins.

About 300 yards below the fork of McCulloch's Brook and Middle River, and half way between the river and the Truro road, in a little brook, are large blocks of fine sandstone and conglomerate.

Devonian and Carboniferous ocks.

Lower down and about 450 yards above the dam, also on the right bank of the river, sandstone, marl and conglomerate are in contact with Devonian rocks, which apparently do not extend to the road. The conglomerate first seen in contact with the Devonian below the dam, and below Brown's Brook, dips steeply towards these rocks, from which it appears that the junction is a fault; in the brook it is not seen in direct contact with the Carboniferous rocks. The latter do not resemble the grey rocks of French's tunnel so much as strata somewhat lower in the series; they include, however, a band of dark grey underclay.

McCulloch's Brook.

The road from Alma bridge westward to the cross-road appears to be all in conglomerate, and in the other direction this rock extends apparently to the bridge on McCulloch's Brook, where the grey coal measures begin. The outcrops of New Glasgow conglomerate, first seen in McCulloch's Brook above the Truro road and in the neighbourhood of the high railway bridge, are succeeded by Devonian; but two patches lie nearly horizontally, higher up the bed of the brook, separated by Devonian strata. The hills and left bank of the river near the railway bridge seem to be an extension of those of the east side and to be composed of conglomerate. There is apparently, however, a fault down along the river hereabout.

The little brook 365 yards south of Alma cross-roads shows no rocks above or below the road, but only blocks of grey sandstone.

Greenhill.

On the road south-east from Brown's carpenter shop, at the Truro road, good exposures of very crumbly nut-and-egg conglomerate are seen all the way to Brown's Brook. The watering brook above the Truro road shows only Devonian debris; but the Greenhill, along the south foot of which the road follows, shows coarse conglomerate everywhere on its steep sides, along the tops of the ridges and on its western terraced slopes. The soil of this hill is wonderfully good, having maintained its fertility for many years under constant cultivation. Near the foot of the hill is a very steep dip 167°, but in most parts the dip is nearly horizontal. Some of the blocks of greenish-grey sandstone in the conglomerate are two feet in diameter.

On the road from Durham up along Roddick Brook, are many blocks of reddish, soft sandstone. Above the crossing of the brook the latter shows outcrops of similar sandstone succeeded by conglomerate, with pebbles as large as cocoanuts, chiefly Pre-Carboniferous, but also of rusty fine sandstone, concretionary limestone and other Carboniferous rocks, which continue to the top of the hill, thence south to Salem Presbyterian church. Durham.

The brooks north of Alma show good outcrops of the conglomerate, with a low dip, overlaid by reddish, softer rocks, containing scattered grains of bright red hematite. In Crockett Brook near the school, conglomerate dips at a very low angle. South of Sylvester station, in the brook between John Roy's and Elbridge Archibald's, reddish-grey, soft, flaggy sandstone, including patches of concretionary conglomeratic rock, dips northerly and easterly, probably at the apex of a basin. Further north the dip is more southerly. Sylvester.

The conglomerate of Greenhill is apparently interrupted near the West River by a fault; and higher rocks, still dipping eastward, occupy the country for some miles west of the river. It reappears, however, in Fitzpatrick Mountain, is exposed in Sawmill, Stewart and other brooks, and follows the high land to the westward. Towards Millsville, the sequence of these and the overlying formations can easily be made out in the brooks and rivers; and ledges of reddish coarse conglomerate on the roads show pebbles of reddish and green Upper Devonian flinty rocks and also of softer sandstone, probably Carboniferous. West River fault.

Elmfield Brook, above the post-road, shows red sandstone and marl, succeeded by conglomerate affected by a fault. In the upper branches of Plainfield Brook, grey, greenish-grey and reddish-grey sandstone and marl include bands of coarse, calcareous conglomerate, and the conglomerate which underlies these beds is then continuous to the head of the brook. In the left branch, below fine outcrops of conglomerate, are reddish sandstone and marl, with green layers, calcareous nodules and small veins, succeeded by a coarse conglomerate in contact with very flinty, igneous rocks. These and other fine outcrops of Mount Dalhousie require no special mention. With the conglomerate is always interstratified sandstone of great variety of texture and often marly; sometimes its pebbles are six inches in diameter; sometimes on approaching the older rocks it is too coarse and massive to show the dip. Numerous east-and-west faults affect these rocks, and their dip towards the mountain is no doubt due to one of these and perhaps also the disappearance of the conglomerate west of Waugh River; for it seems hardly probable that in so short Elmfield and Plainfield. Igneous rock Waugh River fault.

a distance it should have lost its conglomerate character and have been replaced by finer sediments, as at Quarry Island.*

West Branch of River John.

The west branch of River John above the iron bridge at the village, flows between cliffs of coarse conglomerate, underlaid by red marl, succeeded up stream by dark grey fine grit, reddish, harsh, sandy shales and purplish and green mottled shales, with calcspar blotches mixed with albertite. At the mill-dam the rocks are vertical. Above the pond, coarse conglomerate and reddish crumbly marl, with green blotches, are overlaid by dark reddish-grey fine grit. These rocks are apparently not changed, either in dip or texture, by the trap with which they are in contact; they are followed up stream by marls with concretionary patches, sandstone spotted with baryte and films of albertite, which is in places the cementing material of the pebbles. Similar rocks extend to Loganville; then coarse conglomerate to the old rocks. The strata below the village are affected by one or more important faults which bring higher rocks in contact with a conglomerate, probably equivalent to that just described. Their relations to the beds lower down the river will be understood from the following approximate section which begins at Cape John and is measured in the river. The limestone (No. 15) is, perhaps, equivalent to that found above the conglomerate in the neighbourhood of New Glasgow. It is said to be hard to burn, but to yield a white, excellent lime greatly prized by plasterers and masons. Overlying it a seam of coal, several inches in thickness, is said to have been found among rocks resembling those of Quarry Island and Big Island and including beds of fine and coarse conglomerate.

Trap.

Albertite.

SECTION OF PERMIAN ROCKS IN RIVER JOHN IN DESCENDING ORDER.

	Ft.	In.
1. Grey and greenish-grey, crumbly, coarse sandstone, rusty-weathering, full of carbonized plants, underlaid by reddish sandstone and overlaid by grey fine sandstone, in shaly or thick beds, with spherical and cylindrical masses of fine rock sometimes 4 feet long	32	0

The thickness may be greater. For the next mile and a half the shore is occupied by red sandstone and marl with grey and greenish bands apparently underlying nearly to the lobster factory at Cape John†, where a coarse, grey sandstone, perhaps the same as above stands vertically in every direction, greatly broken to the "bill" of the Cape. The faults here are hard to understand.

Faults.

*Geol. Surv. of Can., An. Rept., 1886, vol. II., p. 94 P.

†Trans. Geol. Soc., London, vol. IV., p. 507.

	Ft.	In.	
From the "bill" eastward along the outer shore for three miles, the section is ascending to the bottom of a syncline, at a small brook which falls over the cliffs and in which occur small concretions of bog manganese. Perhaps the grey sandstone or conglomerate of the headland is the same as that already referred to, and is separated from all the rocks in the bottom of the basin by a fault. The syncline mentioned above may be only a turning of the strata towards a fault with upthrow on the north-west (magnetic) side which is followed by others near the "bill."			
2. Red sandstone and marl with greenish and grey layers and a band of concretionary rock. Some layers fit for quarrying. Dip turns to 232° < 4°, and the thickness is consequently uncertain.....	217	0	
3. Grey somewhat impure limestone, quarried to a small extent....	2	0	
4. Reddish wavy sandstone, with green blotches, interstratified with red argillaceous shale. Dip 325° < 5°	66	0	
5. Measures concealed by the low shore north and south of Murphy's Creek. On the opposite shore are exposed several bands of grey and reddish, fine and coarse sandstone and shale, in one of which are the nodules of copper glance found on the shore at River John. Dip < 5°. At the base of the long sand beach rocks are again well exposed.....	545	0	Copper ore.
6. Reddish soft sandstone and shale or marl, showing in places broad markings of *Cordaites*. Includes the bands upon which Hines's, Rogers's, and other quarries of the neighbourhood are situated, from which the celebrated brown stone of River John, used in the erection of the New Glasgow post office and other buildings, was obtained. Includes also the strata exposed in "The Brook," one of which contains many plants stained with copper. To the bridge at River John village. Dip 318° < 8°. The exposures are by no means continuous, but wherever seen, the rocks dip at a low angle.....	973	0	Brown stone quarries.
7. Red, crumbly, micaceous sandstone and marl with concretionary, nodular, calcareous layers; grey, fine, banded sandstone, with a tinge of red, quarried in large blocks. To the south end of the railway bridge.....	416	0	
8. Reddish sandstone and shale, with layers of greenish, grey and reddish, nodular, concretionary, calcareous sandstone and grit, rusty in part, and holding plates of coal, perhaps albertite and carbonized plants. To the Telegraph road at Welsford...	164	0	Coal.
9. Brick-red massive sandstone, seen in high cliffs at Man-of-War rock.....	30	0	Man-of-War rock.
10. Red sandstone and shale; grey flaggy and thick-bedded sandstone, some of fine grain but chiefly of coarse grit, of which one band, at least 25 feet thick, has been quarried; band of grey, calcareous, concretionary rock; several bands of coarse, green and red, spotted, concretionary rock, one of which passes into an impure limestone 18 inches thick. Like certain strata of Cape John shore, and not unlike the Trias of Truro.....	970	0	

		Ft.	In.
	11. Red sandstone and marl; fine, thick-bedded, grey, wavy sandstone with concretionary patches and layers of grey coarse grit. Exposed as far as Weir's mill. Dip 337° < 12°. These enormous thicknesses may possibly be due to original deposition on a slope, or the steeper dips may indicate faults which cross in the concealed spaces.....	1,053	0
Grindstones.	12. Grey, coarse, pebbly sandstone, overlaid by reddish sandstone and shale, and by grey, fine, flaggy sandstone which has been quarried and includes bands of red sandstone and shale, and of calcareous, flaggy, concretionary limestone-conglomerate. These latter often occur among the grey sandstones. Grey and greenish fine sandstone then extend for a great distance. The grey sandstone largely predominates, and many beds have been quarried for grindstones. Well exposed to the mouth of the little brook south of the McNab road. Dip <25°. This high angle of dip prevails for nearly the whole distance, and does not seem due to false bedding or faulting.		
Copper ore.	Copper ore has been found at this brook.....	3,124	0
	13. Reddish conglomerate and coarse grit <9°.....	340	0
	14. Red and grey, mottled, concretionary, fine and coarse sandstone.	10	0
Limestone.	15. Grey botryoidal limestone quarried below William Matheson's, on the left bank of the river, and also on the right bank. It is wrinkled, compact, somewhat impure, mixed with clay and sand.....	5	0
Fault.	16. Reddish sandstone and shale, reddish crumbly conglomerate and whitish fine sandstone. The conglomerate greatly predominates; it is generally pea-and-nut conglomerate, but holds pebbles 18 inches in diameter. Among others of syenite, felsite, &c., are pebbles of reddish, soft, Carboniferous sandstone and grit. Dip 0° < 10°. To a fault about 1,000 feet below the fork of the east branch. From the fault the continuity of the section is perhaps unbroken to the mouth of the river.....	160	0
	17. Brownish-grey, fine, sandy flags; reddish-grey sandstone with layers of reddish argillaceous rock, spotted with green; crumbly shale with whitish and greenish patches; concretionary beds full of nodules of impure limestone as large as eggs; patches of whitish-green grit. Some of the rocks show rain marks and blotches of calcspar. These rocks occupy a space of about 1 mile along the bends of the river, and are perhaps unconformably below the foregoing. They are broken by two faults, and a third occurs at their base.....	..	..
Albertite.	18. Greenish-grey, reddish and brownish argillaceous shale and somewhat soft sandstone in irregular flags, more or less calcareous and concretionary, with films of calcite and albertite in the joints. The red strata predominate, the grey sandstone is of good grindstone grit. Exposed only at intervals, dipping 341° < 32°, to an east-and-west fault, at the base of 17, which crosses the west branch about 1 mile below the bridge.....	..	..
	19. Measures concealed.....	..	..

	Ft.	In.
20. Dark grey coherent conglomerate with a few veins of calcspar, overlaid by reddish fine sandstone. Dip 292° < 10°. Seen below the bridge at West Branch, but exposed for only a short distance. Perhaps the same as 16.....	..	..
Total thickness of Permian rocks.....	8,107	0

The conglomerate of North Earltown overlies Silurian, igneous and, probably, Devonian rocks; that of the Biorachin rests upon Silurian, whereas that of Mount Dalhousie is in contact with felsitic rocks: it is composed chiefly of Devonian debris. Many blocks of grey sandstone occur on the Earltown road near the county line, but in the brooks to the southward there are outcrops of conglomerate, like that of Loganville, which extends north apparently to the fork of the Denmark road, and is abundant about McBean's Corner. Outcrops are seen almost everywhere within the limits marked on the map, which are generally well defined; and it would be useless to attempt to enumerate all the localities. In Matheson Brook, not far above its confluence with Waugh River, is a cliff of grey rusty-weathering sandstone, underlaid by grey concretionary limestone-conglomerate, with plates of baryte in the joints, near which a little coal is said to have been found. Further up stream the brook comes through a small spring, bog or barren, on which nothing grows, and from which have been taken pieces of wood impregnated with copper ore; above which reddish-grey fine sandstone, in thick beds, is underlaid by reddish conglomerate, with which the brook is floored all the way up to and beyond the mouth of Moore's Brook. Boulders of Silurian rock found in this conglomerate exceed three feet in length, and perhaps give rise to the large number of field-stones, full of Silurian fossils, which overspread the country between Balmoral mills and the falls of Waugh River. The conglomerate of Waugh River occurs at the base of a succession of Permian rocks between Tatamagouche Harbour and the mountains, of which the following is the approximate thickness and section. French River section begins from the same point but is four miles and a half distant at the base.

North Earltown.

Waugh River.

Coal.

SECTION OF PERMIAN ROCKS IN WAUGH RIVER FROM WHARF AT TATAMAGOUCHE VILLAGE IN DESCENDING ORDER.

	Ft.	In.
1. Red marl and sandstone, including a bed which has been quarried. To bridge on the Telegraph road. Dip 44° < 8°.....	64	0
2. Reddish-grey, coarse, pebbly sandstone, underlaid by red marl and sandstone. To bridge on the back road.....	173	0

		Ft.	In.
	3. Red marl and sandstone, with a band of dark shale towards the bottom	375	0
Quarries.	4. Reddish-grey, coarse, pebbly, massive sandstone, with partings of red and green shale. Quarried	20	0
	5. Red marl and sandstone. Dip 1° < 13°. To mouth of the Black Brook	282	0
	6. Red marl with bands of shaly and flaggy sandstone and including layers of greenish-grey sandstone and of coarse limestone-conglomerate. The latter passes into a grit full of calcspar veins and nodules of reddish impure limestone. The sandstone is sometimes fit for quarrying. In one of the lowest concretionary beds near the bridge copper has been mined. To the red bridge at the mills of Waugh River post office	682	
	7. Rocks for the most part concealed or where seen consisting of reddish and grey soft sandstone and shale. To the mouth of Yellow Brook	653	0
	8. Grey and greenish-grey coarse and fine sandstone, in rough, flaggy beds, with lenticular layers of greenish-grey concretionary limestone-conglomerate. Some beds of light-grey colour and good grindstone grit, in smooth, even layers of 2 feet and 1 foot in thickness, have been quarried. Underlaid by reddish-grey, somewhat coarse, pebbly, soft, micaceous sandstone, often striped and spotted with black, and by brown or indian-red fine sandstone, with green spots, false-bedded. In the quarry-sandstone are occasional hard spots and soft patches. Some beds are prettily striped greenish-grey and brown. Well seen in the Yellow Brook. Markings of plants. Red, soft, marly layers. To near the mouth of Four Mile Brook. Dip 346° < 13°	490	0
Copper ore.	9. Between the mouths of Four Mile and Matheson Brooks. Rocks also well seen in Four Mile and Sutherland Streams and in Yellow Brook near Frederick Haymond's. Brownish and grey sandstone and banded and spotted, arenaceous shale, with layers of dark reddish-grey sandstone. Also greenish-grey, fine and coarse, flaggy sandstone, full of broken plants, with concretionary, coarser patches, containing traces of copper ore dug in the Yellow Brook about half a mile below John McKay's; fucoids in grey and reddish soft shales. Some beds of fine sandstone which have been quarried. Brownish, and grey and blackish, fine, micaceous flags, like rocks in the east branch of River John, not far above the fork of the west branch. The brown stone is sometimes in bands 20 feet thick and somewhat massive or in even flags, some of it fine in colour and texture. Layers of limestone-conglomerate. Blotches and bands of hematite, seen in Four Mile Brook. "Bulls" of harder sandstone; comminuted plants. A streak of albertite, a quarter of an inch thick in bedding of grey, fine sandstone. Films of baryte in the joints. A very large preponderance of sandstone usually more or less grey. Dip 346° < 11°	580	
Albertite.			

	Ft, In.
10. Sandstone similar to No. 9, to the boundary of the conglomerate. A thickness of about half of this or 195 feet brings us to the base to the felsitic rocks at East New Annan; and at Bailey's bridge this is the base there being no conglomerate. The dip at both these localities is low, so that perhaps there is an overlapping and not a fault, in which case the grey sandstone would appear to be unconformable to the conglomerate.....	390 0
11. Conglomerate, seen well in a picturesque, rocky valley above and below the falls. Reddish-grey, nut-and-egg; pebbles chiefly of fossiliferous Silurian rock and of reddish flinty sandstone, like that of Earltown supposed to be Devonian. Some boulders several feet in diameter. Reddish-grey, soft sandstone layers. Lines of bedding sometimes dip at a very high angle but obscure. Thickness consequently doubtful: it occupies a breadth of about 5940 feet, $< 13°$.....	1,336 0
12. *Pre-Carboniferous.* Light grey and greenish-grey, fragmental, flinty agglomerate or breccia of dioritic or felsitic aspect; contains much chlorite, a few blotches of quartz and syenite. Has occasionally a minute jointing or lamination.....	.... .
Total thickness.....	5,045 0

In the Millbrook, a tributary of French River, at 500 and again at 800 yards above the Florida road, and also in the fields east of that brook, a conglomerate is in place which resembles that of New Glasgow; it has been included by Dr. Ells with the Lower Carboniferous. About 800 yards below the road, reddish-grey and brownish, soft shale and flaggy sandstone dip $9° < 35°$ and extend for some distance down stream, including bands of good grindstone grit, and, about one mile and a half below the road, traces of coal. Grey sandstone occurs along the Florida road to the westward, and has been quarried in Higgins Brook; it has the tinge of pink characteristic of the rocks which overlie the conglomerate to the eastward, and is hardly distinguishable from the rocks of Wallace River, at the bridge on the road to Westchester station, coloured Permian on Dr. Ells's map. The road to Swallow settlement shows indications of sandstone, like that of French River, and of a coarse, reddish conglomerate. Florida road.

The road to Westchester station from the bridge mentioned above, runs south along the west side of Wallace River for about a mile, then turns to the westward; it shows no definite exposures as far as the road which turns to the right across the west branch of Wallace River. About a quarter of a mile north on this latter road, however, are probable outcrops of reddish-grey, crumbly, fine sandstone, and at the bridge over the west branch are cliffs and reefs of fine, reddish, Permian sandstone, in thick beds. Up stream the river

exposes reddish, brownish, grey, and greenish, thick-bedded sandstone, fine smooth flags and marly shales, dipping north-easterly at a low angle, with coarse, calcareous, concretionary layers; underlaid by reddish soft, nut-and-egg conglomerate, dipping 350° < 10°, and interstratified with greenish-grey fine and coarse sandstone, coarse quartzose flags and dark reddish and grey sandstone and argillite, among which was seen an upright *Sigillaria*, two feet in diameter. The conglomerate is very like the Lower Carboniferous conglomerate of McElman Brook and the railway west of Londonderry. Up the branch from Westchester station are rough beds of reddish-grey somewhat crumbly, nut-and-egg conglomerate, with layers of dark reddish sandstone, precisely like the rocks of the west branch of River John below Loganville. The proportion of finer sandy beds is very small; some of the pebbles are more than a foot in diameter,

Greenville

and fine exposures occur in cliffs both above and below Greenville station and as far as the bridge on the railway, above which, at Purdy's mill near Westchester station, grey sandstone is said to have yielded threads of coal.

In the other branch of the river, west of Greenville station, outcrops of reddish, coarse conglomerate, grit and sandstone are also found above the railway, along which westward towards Thomson station, and also on the road from the station south to Williamsdale, and on River Philip above the railway, similar rocks dip northerly at a low angle. But as already remarked, the Permian resembles the Lower Carboniferous and millstone grit in lithological character and there are evidently faults along the north side of the Cobequid Hills as well as on the south; so that it would be rash to attach too much importance to these indications without a closer investigation of this district.

2.—Permian Middle Group.

In the two sections presented above, the grey, brownish and reddish sandstones which overlie the conglomerate have been described; and many particulars concerning those which occur on the Big Island of Merigomish and on the coast between King Head and Pictou

Coal.

Harbour were given in last report.* The coal of the Big Island of Merigomish is said to be again found near the lighthouse on King Head, from which coal is said to have been taken a few years ago. Coal is also said by Sir J. W. Dawson to occur at Little Harbour, at Abercrombie and at the mouth of Middle River;† by Mr. Poole,

*Geol. Surv. of Can., An. Rept., 1886, vol. II., p. 95 P.

†Acadian Geol., pp. 326 and 343.

to be found between Abercrombie Point and New Glasgow, and again near the gas-works at Pictou. Several quarries have been opened on the grey sandstone north of New Glasgow, the dip being at a low angle, somewhat hard to distinguish precisely, even with large exposures. Quarries.

A section of the strata between Smelt Brook and Shipyard Point is given by Mr. Poole,* together with many particulars about the rocks of the west side of the East River. Smelt Brook.

Rear Brook above the bridge on the shore-road exposes grey and greenish-grey, nearly horizontal sandstone, full of carbonized plants, interstratified with greenish, rusty, grey and red argillaceous shales and a thin band of underclay. Below Captain Fraser's quarry, a spring deposits yellow ochre; at the quarry is a little band of coaly shale less than a foot in thickness, containing *Cordaites*, fish-scales, teeth and coprolites; above it are grey and greenish flags with a bed of black calcareo-bituminous shale showing markings of plants. On the road towards New Glasgow the point of junction of the conglomerate and grey sandstone is not seen, although many pieces of the latter are found near the first brook south of Rear Brook, and up stream to a farm road, above which are fragments of reddish sandstone, perhaps millstone grit. Rear Brook.

At Abercrombie Point, from the ferry wharf south towards the loading ground, broken, grey sandstone is in the road-cuttings; and further south coaly debris, 120 paces north of a little brook at which is a fine spring, said to come from a bore-hole. Another boring was made at the mouth of this brook, and search for coal lately renewed by Mr. Hugh Fraser and others. At 405 paces further south is a little brook upon which is a spring and bore-hole, on Matheson's farm, mentioned by Mr. Poole.† Abercrombie.

East of McKeen's quarry at Pictou a piece of very rough land shows blocks of coarse sandstone, like that of the shore west of Widow Point. At Mr. Smith's (ice dealer), north of the town-line and west of the road to the Millbrook, the dip is said to be due east at a moderate angle. At Brown's Point is an exposure of red soft shale. Thence along the railway towards Scotch Hill, the debris of similar rocks abounds, the country being low and the streams showing no outcrops. About a quarter of a mile east of Scotch Hill station are blocks of grey fine sandstone, a hill lying on the right. In Lyons Brook, immediately below the dam, are alterna- Pictou.

*Trans. N. S. Inst. Sc., vol. I., pp. 36 and 39; Acadian Geol., Supplement, 1878, p. 35.

†Trans. N. S. Inst. Sc., vol. I., p. 36.

tions of grey and reddish sandstone and shale, with a very high southerly dip down to a bridge on a farm road below which the dip is low. At the railway on a branch of Lyons Brook, the dip is 167° < 35° and immediately to the westward is a nearly vertical northerly dip which probably indicates that the fault is just at the railway track, passes through the Big Marsh and meets a fault shown by the dip in Black River. At the crossing at the main road to the westward, a steep hill is on the right, composed apparently of grey sandstone, resembling that of Battery Point and the marine slip. The high easterly dip north of the southerly dip of Haliburton Creek may point to a master fault coming from the south, which continues to the northward, but against which the Lyons Brook fault ends.

Pictou Harbour.

From Pictou to Brown's Point the railway closely follows the shore which shows no rocks but only a loose, coarse sand formed from grey sandstone like that found near the marine slip at Pictou, near Pictou Landing and the lighthouse. On the shore towards Haliburton Creek are indefinite outcrops of brownish, crumbly sandstone, with a very low easterly dip; and beyond two little brooks where the road comes close to the shore near Gavin Island, is a small outcrop of coarse conglomerate, interstratified with grey, shaly sandstone. No rocks are then seen as far as Sawmill Brook, above the bridge over which, however, grey sandstone has been largely quarried. Further up the harbour is a small exposure of red sandstone and marl; but all the shore is low in the neighbourhood of the bridge over West River, and also down the

Loch Broom.

right bank towards Loch Broom Point for a great distance. At and near the point, conglomerate and reddish concretionary sandstone are interstratified with harder, globular, concretionary masses, almost horizontal. From Loch Broom Point up the Middle River the shore is fringed with marshes infested with mosquitoes, and the cuttings on the railway are in clay and gravel as far as the bridge, above which reddish, coarse, bouldery conglomerate is met with.

North of the marine slip at Pictou, the rocks exposed are for the most part grey crumbly sandstone, lying at a low angle, the dip at the south end of the hospital grounds being 87° < 12.°

Mr. Fraser's section of bore-holes at Pictou.

In the town of Pictou several deep borings have been made in search of water; and from the records of these a section of the Permian strata between the most easterly at the marine slip and the conglomerate of Haliburton Creek, has been made by Mr. R. P. Fraser. The dip is assumed to be easterly < 1 in 7·5. Good sections of two of these bore-holes at Campbell's tannery and Fraser's, give the greater part of the thickness. The principal bore-holes are :—

1. Campbell's tannery, bore-hole 677 feet deep, 60 feet above tide, gives strata to Haliburton Creek, 5,000 feet.
2. McKimmie's, 300 feet deep, 80 feet above tide, 863 feet east of or to deep of No. 1 (=115 feet vertical and 20 feet higher) gives 135 feet of strata overlying No. 1.
3. Howard Primrose's, 140 feet deep, 30 feet above tide, 425 feet to deep of No. 2, all grey freestone. Only 7 feet above top of No. 2.
4. Fraser's, 380 feet deep, 130 feet above tide, 1,100 feet to deep of No. 3, gives 247 higher than 3. Cores at the Pictou Academy.
5. Clarence Primrose's house, 288 feet deep, 70 feet above tide, 1,300 feet to deep of No. 4, gives 113 feet higher than it.
6. Clarence Primrose's mills, 600 feet deep, 20 feet above tide, a little to the rise of No. 5. Cuts the same strata.
7. McConnell's, 121 feet deep, 20 feet above tide, 838 feet east of No. 5, gives 112 feet above No. 5.
8. Ross's borehole, 147 feet deep, 30 feet above tide, 635 feet east of No. 5, gives 43 feet above No. 5.

The section is as follows :—

SECTION OF PERMIAN ROCKS AT PICTOU.

	Ft.	In.
1. Red clay	15	0
2. Dark, mixed, hard rock	5	0
3. Red soft clay	15	0
4. Red sandstone	20	0
5. Dark sandstone mixed with gravel (water)	11	0
6. Grey, soft, pebbly freestone	10	0
7. White hard freestone	3	0
8. Bluish hard freestone	32	0
9. Fire clay (1 to 9 in McConnell's borehole)	10	0
10. Measures concealed	25	0
11. Grey and bluish freestone	32	0
12. Soft, bluish clay-stone	13	0
13. Grey freestone	30	0
14. Red clay-shale	1	6
15. Bluish freestone	25	0
16. Red clay (9 to 16 from bore-hole at Clarence Primrose's house)	18	0
17. Red shale (17 to 34 cut in Fraser's)	8	0
18. Light shale	6	0
19. Light freestone	22	0
20. White coarse sandstone	29	0
21. Red shale	1	0
22. Grey sandstone	38	4
23. Red shale	20	0
24. Light shale	7	0
25. Red shale	23	3
26. Red sandstone	20	9
27. Light shale	1	3
28. Grey sandstone	22	9

	Ft.	In.
29. Sandstone, fine, grey ; 8 feet coarse and 6 feet brown	51	0
30. Red shale with partings of red sandstone—great run of water	13	0
31. Grey sandstone, cut in McKimmie's boring 28 feet from surface and in Howard Primrose's, 54 from surface	24	0
32. Red shale	9	6
33. Red shale with bands of red sandstone ; calcareous	44	6
34. Grey freestone—cut in Campbell's tannery bore-hole and perhaps No. 31 repeated	58	0
35. Red clay rock	3	0
36. Red clay rock with light partings	19	0
37. Red clay rock	73	0
38. Red rocks of lighter colour	10	0
39. Grey freestone	18	0
40. Fine grey sandstone with coal partings	3	0
41. Limestone, oolitic or concretionary	1	0
42. Bluish fire clay	2	0
43. Red marl	27	0
44. Red marl with sandstone partings	29	0
45. Red marl	36	0
46. Grey sandstone	1	0
47. Light marl	5	0
48. Red marl	43	0
49. Red marl mottled	25	0
50. Red marl	30	0
51. Red sandstone	1	0
52. Red marl	21	0
53. Red marl and sandstone	13	0
54. Red sandstone	16	0
55. Sandstone-conglomerate	2	0
56. Red marl	11	0
57. Red sandstone	79	0
58. Sandstone-conglomerate	1	0
59. Red sandstone	21	0
60. Red sandstone with beds of marl	10	0
61. Red sandstone	17	0
62. Red sandstone with beds of marl	15	0
63. Red sandstone	23	0
64. Red marl	21	0
65. A millstone-conglomerate to be seen at Haliburton Creek, where the brook enters the pond above the cemetery	41	0
66. Grey sandstone	0	8
67. Red sandstone	0	4
68. Red marl, bottom of Campbell's tannery bore-hole	10	0
Total thickness	1,146	10

Haliburton Creek.

On the railway between Brown's Point and Haliburton Creek, cuttings have exposed greenish shale, flaggy sandstone, and red marl and sandstone. Above the railway, on the west side of the

creek, similar rocks include a layer of nut conglomerate, and near a tributary dip 147° < 55° a reddish mottled sandstone containing impressions of fucoids. Near the head of this tributary, immediately below a bridge on the road, the dip 177° < 65° probably indicates a fault, the general dip being easterly. In the brook above the road, red rocks contain plants in greenish and grey layers and concretionary, calcareous beds. Above the cemetery bands of coarse sandstone and conglomerate are interstratified with marls, concretionary limestone and patches of rusty-weathering sandstone, spotted with coaly matter. Fault.

Along the Pictou and Oxford railway, from Brown's Point to Scotch Hill station, no other rocks are seen; but the ditch-cuttings seem to indicate red shales and sandstones overlying the grey sandstones of Sawmill Brook. Lyons Brook shows good exposures of the red strata, and at the railway is a nearly vertical dip which seems to indicate an extension of the fault referred to above. Hardwood Hill is composed chiefly of grey sandstone. Before reaching Scotsburn the hill of conglomerate is close on the left, and the rocks immediately overlying the conglomerate are probably those which contain the copper ore of Scotsburn Brook. These comprise greenish-grey fine sandstone and shale, marked with plants impregnated with coaly matter and copper ores, together with reddish and greenish shales and marls dipping 127° < 33°. Large banks of gravel reach nearly up to the mine, and a plain extends to the road behind McIntosh's. Up stream no rocks are met with for some distance, but on the steep hill to the southward conglomerate is apparently in place, separated, perhaps, from the grey and reddish sandstones in the brook at the foot of the escarpment by a fault. In the little brook north of Scotsburn station, immediately above the main road, greenish-grey shaly sandstone, like that of the copper mine, dips 89° < 24° in smooth beds, associated with layers of coarser texture; and a little higher is underlaid with coarse Permian conglomerate. Scotsburn. Copper ore.

In the West River, above Saltsprings, the soft rocks which come against the Devonian are probably of this age, for they resemble more closely the Permian of Big Island than Carboniferous rocks. Those first seen on the left bank are indian-red, soft, micaceous shales and sandstones. At the wire footbridge, light greenish-grey, fine, crumbly, calcareous sandstone and conglomerate, dipping 133° < 70°, are followed by concretionary red rocks and by grey fine sandstone, crowded with broken carbonized plants, passing into streaks of coal, including patches of conglomerate and balls of Saltsprings.

Eight Mile Brook.

harder sandstone. Near the confluence of the Eight Mile Brook a grey, fine, red-spotted sandstone, jointed and broken, also abounds in carbonized plants, and contains patches of reddish soft marl and of calcareous, concretionary rock, sometimes four feet thick. Below the next bridge, grey, fine, soft sandstone is underlaid by reddish, argillaceous sandstone and light grey, rusty spotted, massive sandstone, often exhibiting a very steep dip, and apparently separated from the Devonian by a fault. Lower down the rocks are nearly horizontal, and although generally too shaly they contain many beds fit for quarrying. They include at one point a ten feet layer of reddish nut-and-egg conglomerate, the larger pebbles of which seem to be principally of Carboniferous sandstone, with a few of

Hematite.

Devonian rocks. Many of the smaller fragments are of red hematite, while the paste is a calcareous, coarser grit, with many particles of hematite. Overlying this conglomerate are reddish soft flags which produce a bright red soil. Some of the shaly, marly sandstone and conglomerate lower down are soft enough to be ground up by the fingers, resembling in this respect the Triassic. Similar rocks, with a large proportion of red, extend to tide-water

Durham.

at Durham, but are seen only at intervals. On the left bank, below

Copper ore.

the head of the tide, certain grey beds have been mined for copper ore.

Cuttings in the road along the west side of the river north of Durham expose light grey fine sandstone, containing hard spherical masses and patches of calcareous conglomerate, marked as usual by carbonized plants. In Quarry Brook there is exposed a great thickness of grey rocks, overlaid by reddish-grey sandstone and shale: they resemble the rocks of Roaring Bull and Quarry Island, and above the bridge they include thick beds of coarse grit and calcareous concretionary limestone-conglomerate, and pass downward into red rocks; while in the brook to the westward, and also towards Millsville, are fine outcrops of coarse conglomerate.

Four Mile Brook.

In the rocks which immediately overlie the conglomerate in Four Mile Brook, explorations have been made for coal; they are grey and reddish and brownish fine sandstones, marked with plants, marls and limestone-conglomerates, passing into a fair limestone. The south-easterly dip of the grey rocks of Four Mile Brook beneath the conglomerate of Greenhill, the dip of the grey rocks against the Devonian at Six Mile Brook and Saltsprings, the contact of the conglomerate of Watervale with the Devonian, and of the rocks of West

Faults.

River station with flinty Middle Devonian slates, seem to indicate the existence of an immense dislocation along the river, with an upthrow on the east side.

Rocks similar to those of Four Mile Brook are found in Six Mile Brook, the bands of concretionary limestone-conglomerate being here seldom more than two feet thick and very variable; but the conglomerate does not everywhere intervene between the felsitic rocks of the mountain and the brownish and grey sandstones, which again may indicate a fault. There is a considerable belt of country in which no rocks are seen. At the head of the main branch of this brook are felsitic rocks, unconformably overlaid by coarse conglomerate, succeeded at the head of the settlement by grey, soft, glistening sandstone, upon which are situated the quarries worked by Messrs. Elliott and McPherson. On the flanks of the hills are large blocks of limestone-conglomerate; and the low land underlaid by these Permian rocks in Brookland settlement is fertile and productive. Six Mile Brook. Tombstone quarries.

Between Saltsprings and Ten Mile House, grey sandstone is abundant; and grey sandstone and conglomerate north of Saltsprings and towards Dalhousie Mountain; the conglomerate is sometimes very calcareous and appears in cliffs in the clearings on the mountain and towards Loganville, some of the pebbles being of reddish fine grit, apparently Carboniferous. In the brook near the manse at the Saltsprings, are good outcrops of grey, rusty-weathering, fine, jointed sandstone, full of fragments of carbonized plants and of trunks of trees converted into coal. Below the bridge and as far as the river, grey shales, full of comminuted plants and pebbly patches are associated with red rocks. Saltsprings.

In Limerock Brook, red soft marls dip up stream at a low angle to a bridge on a farm road not far above West River. Above it, coarse conglomerate, largely composed of pebbles of soft sandstone, derived from the millstone grit or Lower Carboniferous, comes against grey and greenish-grey, shattered, rubbly sandstones, nearly vertical and probably belonging to the same series as the limestone at the quarry. Limerock.

On the Truro road past Saltsprings, are outcrops of grey and bluish-grey sandstone and argillaceous shale, associated, further west, with reddish soft sandstone, grit and conglomerate, and perhaps Permian. They have however in the meantime been included with the Carboniferous. Truro road.

The rocks of Caribou, Toney and other rivers of the vicinity, are probably of this age, the brooks running east and west for long stretches nearly on the strike. They consist of rocks similar to those described above: they are perhaps best exposed in the Black River; but outcrops are also seen on the roads throughout the Toney River.

district. At Sundridge, Rogers Hill and other places, are great masses of concretionary limestone. Much of the country underlaid by the grey rocks is more or less barren or covered with second-growth, with large marshes and meadows along the rivers.

Hardwood Hill. At Hardwood Hill, a boring in search of coal was made with the diamond drill through 700 feet of grey fine sandstone.

East Branch River John. In the Black River, or east branch of River John, for a mile and three-quarters above the fork of the west branch, grey and brownish rocks are exposed, with an inclination which seldom exceeds 30°. Then similar rocks show signs of a fault; they are grey and reddish, evenly bedded, flaggy sandstones, brownish fine sandstones, always soft, with a few layers of reddish, crumbly, argillaceous shale. Above the bridge, greenish and grey sandstone, coarse and pebbly, blackened by carbonized plants, is underlaid by eight feet of conglomerate: some of the bands have been quarried. Higher up, a grey, argillaceous, impure limestone, about two inches thick, is found among dirty greenish argillaceous shales and flags, cut by a lenticular vein of calcspar, one inch thick, holding

Albertite a small quantity of albertite. At the second bridge above, similar coarse rocks are found, one of the bands of conglomerate being 20 feet thick and containing a few pebbles of hematite; and, half a mile higher, dip at a high angle; above which no rocks appear in the main river. The ridge of grey sandstone which follows the north side of Black River, resembles that of Hardwood Hill.

Plainfield Brook, above its confluence with Black River, shows reddish, soft, marly sandstone, with a vein of calcspar half an inch thick, interstratified with dark grey and greenish flaggy sandstone and pea-and-nut conglomerate, to the Earltown road; above which grey and reddish flaggy and thick bedded sandstone and red marl

Fault. are exposed at a fault, and succeeded by alternations of marl, sandstone and coarse conglomerate. Coarse and fine rocks in confused bedding extend up to a fork, at which a band, apparently ten feet thick, crowded with plants and rootlets, is in place, blackened with

Copper mines. coaly matter, contains nodules of copper glance, and has been worked. Up stream, grey, greenish-grey and reddish-grey sandstone and marl include layers of coarse calcareous conglomerate, which soon replaces the finer rocks.

Waugh River. Sections of these rocks in the west branch of River John and in Waugh River have been already given, and the tributaries of course expose only the same strata. About 450 yards below Bailey's bridge, at which the last of the igneous rocks of the mountain are exposed, Sutherland Stream displays a bank of reddish and brown fine Permian sandstone, with a low northerly

dip, the thick conglomerate of Waugh River being entirely absent. Red sandstone and marl, with cream-coloured blotches one foot in diameter, and other fine rocks, showing comminuted plants, spotted sandstones and sandstones which have been quarried, extend to the Four Mile Brook.

In Biz (Sam Waugh's) Brook, the red sandstone and shale of the upper part of Waugh River section are well exposed, often on the strike. Above the mill-pond is a band of reddish-grey coarse grit which resembles that quarried on Waugh River at the Telegraph road.

French River.

In French River there is presented a good section of rocks which apparently belong chiefly to the middle group. It begins, like that of Waugh River, at Tatamagouche Harbour, and extends to Tatamagouche Mountain. In these beds Sir J. W. Dawson discovered *Endogenites*, *Calamites*, *Stigmaria*, branching fucoids, *Spirorbis*, scales of ganoid fishes, reptilian foot-marks, and other indications of terrestrial and littoral life.* The strata are as follows :—

Fossils.

SECTION OF PERMIAN ROCKS IN FRENCH RIVER IN DESCENDING ORDER.

	Ft.	In.	
1. Reddish and reddish-grey sandstone and marl with greenish streaks. Includes one bed of fine brown sandstone that has been quarried. The same as No. 1 of Waugh River section. Extends to the bridge on the shore road. Dip 51° < 6°	68	0	Quarries.
2. Reddish-grey fine sandstone in thick beds; interstratified with reddish and brownish shale with greenish layers and streaks. Bands both at the top and bottom have been quarried	234	0	
3. Measures for the most part concealed, but consisting chiefly apparently of red rocks as above. Dip 32° < 9°	733	0	
4. Red marl and sandstone to the mouth of the Millbrook, well exposed in cliffs above the iron bridge near the mouth of the Lake Stream	609	0	
5. Red sandstone and marl, the former largely preponderating; in thick beds, generally fine, but with a coarse layer towards the top. Green blotches. The sandstone has been quarried near the top	267	0	
6. Greenish, marly, concretionary rock, for the most part argillaceous and crumbly or shaly, but including harder bands of concretionary rock and of sandstone. In the soft places are many nodules of clay and calcareous sandstone and of pyrite, copper ore and albertite mixed; these are seldom as large as a hen's egg. The coal adheres to the nodule of pyrite, and is sometimes half an inch thick. Towards the top the shales become more bluish-grey. They yield no fossils except comminuted plants	12	0	Copper ore and coal.

*Acadian Geol., p. 217; Geol. Jour., London, vol. I., p. 326.

	Ft.	In.
7. Reddish and brownish, thick-bedded, fine sandstone, alternating with red marl, with patches of concretionary limestone-conglomerate. Dip. 0° < 9°	310	0
8. Red sandstone and marl, with bands of concretionary limestone-conglomerate from a foot downward. Much of the sandstone is coarse and pebbly, but some thick bands are fine, of a good colour, and fit for quarrying	258	0
9. Red sandstone and marl, with a band of reddish concretionary limestone-conglomerate, and another of reddish-grey, pebbly grit or fine conglomerate	437	0
10. Grey and greenish, shaly, fine sandstone, weathering white	5	0
11. Greenish concretionary limestone-conglomerate, full of prostrate trees, the trunks of which are carbonized and coated with copper ore	2	0
12. Red sandstone with greenish layers and one band of coarse grit, alternating with red marl. To iron bridge on a good road	134	0
13. Red sandstone and marl, with bands of reddish and grey, spotted; some argillaceous and concretionary, greenish, thin layers. A band of sandstone near the top has been quarried. The upper part is fine, but somewhat light in colour, the lower part is of coarse grit. Dip 0° < 12°	970	0
14. Brownish thick-bedded sandstone mixed with grey rusty-weathering sandstone, containing patches of coarse grit, marked with trunks of trees, the bark of which has become coal, mineral charcoal, pyrite and copper ore. The streaks of coal, &c., seldom exceed one-eighth of an inch in thickness. In one nodule, however, two inches thick, the pyrite occupies nearly the whole of that thickness, and is separated from an outside layer of coal by one-twentieth of an inch of grey copper, the coal being little thicker. All the ore, perhaps, comes from one of the concretionary bands so common in these rocks, in which small nodules and grains of limestone are mixed with particles of sand and gravel, the rock being, in places, nearly a pure limestone, in others a grit or sandstone. The coaly matter in certain grey sandstones appears to be in true veins. A tunnel [Gilpin's Mines of N. S.; Poole, Report of Commissioner of Mines for 1877, p. 48] has been driven thirty feet or more to cut the ore at this mine. Included in the preceding: apparently two feet of ore-bearing rock	...	.
Coal and copper ore		
15. Reddish and brownish, fine, shaly sandstone, with red marl and a patch of concretionary limestone-conglomerate. Also reddish and grey, soft, argillaceous sandstone, with whitish yellow blotches and dark stripes. Dip 356° < 12°	540	0
16. Greenish and reddish, coarse, pebbly grit, with layers of nut-and-egg conglomerate, underlaid by alternations of grey, fine, flaggy sandstone, of greenish and reddish, concretionary, nodular marl and of reddish sandstone and marl. One bed of brown sandstone shows a patch spotted with copper ore in spherical spots about the size of a pea. Underlaid by light grey sandstone,		

	Ft.	In.
fine and marked with carbonized plants, below which are alternations of grey and reddish-grey, soft, calcareous, fine sandstone, crumbly, coarse grit and bands of reddish, greenish or grey nut-and-egg conglomerate, largely composed of the waste of the silvery slates which underlie. Like the conglomerate of River John near the confluence of the west branch.....	346	0
17. *Pre-Carboniferous.* Grey and greenish, compact and slaty felsitic rocks seen immediately below the bridge at New Annan.....	...	.
Total thickness of Permian rocks.....	4,925	0

This thickness is greater than that given by Dr. Ells,* the observed dips being much higher than his assumed angle of 7°.

The similarity of many of the coarse beds to the Lower Carboniferous will be at once noticed; and it is not improbable that in districts in which the two come together they may be confounded. In the brooks below Wentworth station, the rocks are perhaps of this age, particularly if those of the Millbrook belong to the conglomerate. They are grey, whitish-grey, reddish and brownish sandstones, like those which overlie the conglomerate, towards Tatamagouche and Pictou, containing masses of reddish calcareous limestone-conglomerate. They show plates and radiating concretions of baryte in the joints, and many carbonized plants. Some of the beds are of considerable thickness and have been quarried. In other parts, the fine, evenly-bedded flags are not more than one-eighth of an inch thick. About ninety yards below the confluence of two little branches of Whetstone Brook the dip is $0° < 81°$, indicating a fault. Wentworth.

3.—Upper Permian Group.

The rocks of this group are well exposed on the coast at several points between Pictou and Wallace Harbours. One of the sections already given includes these beds in the neighbourhood of Cape John, where they seem to occupy a broad syncline with a westerly inclination, on both sides of which limestone appears; and a section from Cape John eastward to Toney River may be given for comparison with it as follows:—

SECTION OF PERMIAN ROCKS ON THE SEA SHORE BETWEEN CAPE JOHN AND TONEY RIVER IN DESCENDING ORDER.

1. Indian-red sandstone and marl, with thin lenticular layers of greenish, fine, calcareous, concretionary sandstone. One band of good brown sandstone, three ft. thick, and another of reddish

*Geo. Surv. of Can., An. Rep., 1885, vol. I., p. 13 E.

		Ft.	In.
	pebbly sandstone, which forms a point. Dip nearly horizontal	50	0
2.	Grey concretionary limestone. Seen again in a brook about a mile from the shore. No. 3 of River John section	1	0
3.	Green marl	0	6
4.	Red marl and sandstone, with two lenticular layers, two inches thick, of greenish, fine, calcareous sandstone. Dip 306° < 4°	74	0
5.	Green marl, with nodules of limestone	1	6
6.	Red marl and sandstone	28	0
7.	Measures concealed at a long pond	32	0
8.	Red marl and sandstone. A reddish or brown sandstone—a good building stone, but spotted in places with carbonized plants. Dip 306° < 5°	103	0
9.	Greenish and grey fine sandstone, with large, brown blotches, showing markings of plants converted into a grey or red copper ore which, on decomposing, stains the rock bright green. Underlaid by a considerable thickness of brownish, fine, thick-bedded sandstone, with large blotches of greenish and reddish-white, concretionary, coarse sandstone, full of threads of calcspar; false-bedding. Towards the bottom, the reddish sandstone is coarse and contains light grey and greenish patches. The estimate of thickness is somewhat vague, the dip being variable. Forms a prominent cape	70	0
10.	Reddish shaly sandstone and marl, not continuously exposed	149	0
11.	Red sandstone and marl, with greenish and grey spots and layers	103	0
12.	Red sandstone and marl, not well seen, with one or more layers of grey, coarse sandstone. The beds are undulating, and the thickness given is perhaps too great	57	0
13.	Measures concealed at a little pond	75	0
14.	Grey, fine and coarse, pebbly sandstone, with spots coloured yellowish, blackish and green by fossil plants, near which occurs a large quantity of coaly matter and of copper ore	4	0
15.	Red shaly sandstone and marl, including fifteen feet fit for quarrying, and occasional thin, green layers	212	0
16.	Indian-red, chocolate brown and grey sandstone, with some beds of marl, but for the most part brown sandstone, much of it fit for quarrying, and like the brown stone of River John; in part coarse and pebbly, passing into conglomerate. The grey beds are spotted and concretionary. To the lobster factory	190	0
17.	Red marl and sandstone, the latter in flaggy or thick beds, some of which are fit for quarrying. One band of fine, brownish sandstone, fifteen feet thick. To a large brook north of Cape John post office. Not continuously exposed. Here the dip, after undulating somewhat, changes to 3° < 6°	172	0

Coal and copper ore.

	Ft.	In.	
18. Red sandstone and marl more nearly on the strike. Some of the beds of fine grain; greenish layers; two bands of grey and reddish pebbly sandstone, the uppermost underlaid by a considerable thickness of dark bluish-grey argillaceous shale. These are on opposite sides of a large brook, one mile and a-quarter south of the last and half a mile from the end of the measurement. Dip 3° < 7°. On the lowest beds two openings have been made to quarry stone in three benches aggregating ten feet; some of this stone is very good	305	0	Quarry.
19. Red marl with bands of fine sandstone, shaly and in thick beds; and masses of reddish and greenish limestone-conglomerate; greenish layers and blotches, often pebbly, sometimes concretionary. To a quarry on a small headland more than a mile from the last	160	0	
20. Red sandstone and marl with a large proportion of sandstone. Some beds rough and occasionally greenish or grey with fossil plants. Too coarse, spotted and concretionary for quarrying. To a little brook. Dip 0° < 10°	126	0	Fossil plants.
21. Grey and greenish-grey, fine and coarse, pebbly sandstone, with carbonized plants; yellowish-weathering; bands of concretionary limestone-conglomerate; layers of reddish coarse conglomerate and sandstone and fifteen feet of fine and coarse brown sandstone	69	0	
22. Reddish and brown, fine, shaly sandstone underlaid by greenish fine sandstone with concretionary layers; rusty-weathering, passing in patches into conglomerate; underlaid again by red shales. To the mouth of Toney River	320	0	Toney River.
23. Rocks seen at intervals on the coast as far as the lobster factory one mile and three-quarters from Toney River. Reddish and greenish mottled sandstone, brownish, shaly, fine sandstone; grey, greenish and brownish coarse sandstone, with many carbonized plants in the bedding; bands of reddish and greenish limestone conglomerate and, at the base, red marls. The estimate is, of course, vague	320	0	
24. The rocks of Toney River, consisting largely of grey sandstones appear to underlie these directly and at a distance of about 2,000 feet, (< 14°) is the coal which has been worked. Immediately beyond it there seems to be a fault	2,000	0	Coal.
25. Coal of Toney River—a small seam cut in several shafts	..	..	
Total thickness	4,622	0	

The importance of a carefully compiled general section of the Permian rocks for comparison with the strata cut in the many deep borings made in search of coal in the region is very great. The shore between Cape John and Pictou Harbour, probably gives the most continuous section, to which might be added data from some of the rivers. Search for coal.

Sea shore west of Pictou Harbour.

The east and west anticline, complicated apparently with a fault, the axis of which seems to strike the shore of Pictou Harbour between Logan and Cole points, apparently brings the higher rocks out on the eastern end of this peninsula. On the west side of a deep cove north of Pictou, into which comes a little brook from McKeen's quarry, reddish and grey coarse flags dip 146° < 13°. About 300 yards inside the tip of Loudon Beach is a bank of reddish fine shale and flaggy sandstone, with a very low dip, probably south-easterly. At the base of this beach are other obscurely dipping red rocks. At Cole Point, bluish and greenish-grey coarse and fine sandstone, in low irregular bedding, forms reefs. Then follows a wide cove with a small pond inside; at the mouth of the little brook from this pond, reddish fine sandstone dips at a very low angle; at the western side of the cove, greenish-grey, coarse and fine, rusty weathering sandstone, dips 123° < 4°; and similar rocks, tinged with red, occur at intervals for some distance and are succeeded by red marl in a bank and by red, coarse and fine sandstone in reefs. On these reefs at Logan Point, at a strong spring from the bank, good exposures dip about 32° or somewhat more easterly at a very low angle. At the mouth of Graham Brook, the soil is bright red, and reefs of red shaly sandstone, with green blotches, lie horizontally. For about a mile the shore is sandy and bouldery as far as the lobster factory on the west side of Widow Point, immediately beyond the gut at Doctor Spit; then for half a mile the bank shows large blocks of reddish, crumbly, coarse grit to a deep broken marshy bay, immediately beyond which reddish, coarse sandstone on reefs seems to dip 352° < 10°. At the point half a mile distant are outcrops of reddish-grey, coarse, pebbly, false-bedded grit, nearly horizontal, but with a possible dip north of east; and in a little cove beyond, thick beds of coarse grit dip 312° < 7°. For the next mile and a-quarter blocks of grey usually fine sandstone abound, with one outcrop, however, nearly horizontal; then grey, coarse sandstone dips 22° < 10°, but immediately past a broad point with a large marsh and pond, greenish and grey thick-bedded sandstones dip 93° < 21°, changing at a few feet to 112° < 5°, and succeeded, at 300 yards further, by greenish-grey, more or less impure limestone, striking 7° with apparently a low easterly dip, interstratified with red marl and sandstone. The outcrops nowhere exceed a few yards in width, the gaps being wide; and nearly a mile east of the Millbrook, even these cease and the shore is low nearly to the mouth of Caribou River, east of which a band of limestone, about nine inches thick, dips 347° at a very low angle.

Limestone.

For 400 yards up Caribou River,* reddish and greenish shales in broken banks dip seaward; at 950, grey, fine, flaggy sandstone, dipping 29° < 5°, is succeeded by red rocks. About 150 yards above the bridge on the shore road, grey coarse and fine, rusty-weathering, crumbly sandstones dip 40° < 18°; but with this exception no rocks are found on the left bank for a considerable distance. Then above a little brook at a marsh and lagoon, large blocks of a cream-coloured and whitish compact sandstone and pebbly grit are associated with blackish, coarse, crumbly rocks. It is like a volcanic ash or claystone, and is perhaps in part of volcanic origin. At the copper mine, on the left bank of the river, a large quantity of coarse conglomerate is found with the usual association of pyrite, lignite and grey copper ore, with trunks of trees, apparently underlying the coherent grit mentioned above. Some of the pebbles of the conglomerate are as large as cocoanuts; among them are several of red hematite, and this mineral coats the polished surfaces of many of the pebbles. The conglomerate band is interstratified with dark sandstone and coarse grit, dipping at a low angle into the bank and found at the pits sunk on the little brook above, one of which is said to be ninety feet deep and to have passed through copper ore, but no coal. Thence the conglomerate appears to run to the neighbouring house, to cross the grassy road about half a mile north of its junction with the main road, and to extend on this course for a mile further. North of it on the road the strata are principally red and clayey.

Caribou River. Igneous rock? Copper mines.

On the shore west of the ford to Big Caribou Island, the exposures are good. They consist of reddish, grey and mottled, crumbly sandstones and shales; the grey being often coarse and pebbly, with rusty patches, carbonized plants and streaks of pyritous coal. Among the red are green blotches and layers of conglomeratic rock, passing into impure concretionary limestone. In some of the beds of grey friable sandstone and conglomerate, west of the mouth of Toney River, are coaly streaks, sometimes an inch thick, with large crystals and crystalline aggregations of pyrite; and in one of them is a black streak composed of grains of magnetite. The limestone shows obscure fossils, perhaps small corals, cone-in-cone and other concretions.

Caribou Island.

On the outermost reefs of Point Brulé, reddish, soft, crumbly shales dip 202° < 5°, including a half-inch green band, and overlaid by reddish and grey sandstone in six-inch flags or in thicker beds fit for building stone, but containing "bulls-eyes" and patches of conglomerate. Further west, a greenish-grey, coherent, conglomeratic

Point Brulé.

*Acadian Geol., p. 327; Supplement, 1878, p. 36.

limestone is marked with fossil plants; beyond which rocks chiefly red, dip 141° < 5°, and contain layers of greenish, coherent, compact sandstone marked with plants, and red and green marl with nodules of limestone, among other beds fit for building stone. About half a mile south of Peninsula Point, red sandstone and marl, with green calcareous layers and concretionary limestone-conglomerate, dip 137° < 5°, and are well exposed, with occasional bands of grey sandstone, to the beach along which the road follows. On this beach and for a great distance to the westward, blocks of reddish and grey sandstone are found; then at a bluff point, reddish greenish and grey sandstone dip apparently to the south-eastward at a very low angle. Not far east of the Narrows of Barachois Harbour, red and brown sandstone, flags and shales dip 97° < 7°, and nearer the Narrows, 67° < 3°, red marl being the prevailing rock. On the west side, above the mouth, red marl and sandstone dip 87° < 7°. From the mouth of the Barachois, a high bank of red marl follows the western shore, with two bands of greenish marl not far apart, the uppermost, six inches thick, being an impure knobby limestone, the lower, more than a foot thick, consisting of layers of shaly sandstone and red marl. Further north are blocks of grey and reddish coarse grit. At the north end of Chambers Point are blocks which may indicate the presence of the Cape John limestone. About a quarter of a mile to the westward, reddish, wavy, shaly sandstones, dipping 136° < 5°, are followed by red flags which dip 157° < 5°, some of which are fit for quarrying. And about half a mile further, beds of coarse crumbly sandstone, of a brick red decidedly Triassic colour, like the rocks at the mouth of Graham Brook, still dip south-easterly, and are succeeded by cliffs of reddish and greenish coarse and fine sandstone, in thick rough beds. It is about three-quarters of a mile north-east of the sand-beach and grassy point at the mouth of Tatamagouche River, near which a whitish-green calcareous sandstone, a foot thick, interstratified with red sandstone and marl, dips 140° < 4°. About a mile up the river, at the end of a road to the shore, red or brown sandstone in a quarry at the cliffs dips 71° < 5°.

Limestone.

Tatamagouche.

The rocks of the neighbourhood of Tatamagouche have been described in the two sections of Waugh and French rivers. West of Blockhouse Point are outcrops of red marl with patches of concretionary limestone, light grey, fine, micaceous sandstone, with "bull's eyes," false-bedded, containing carbonized trunks of trees and traces of copper ore, and reddish-grey, coarse, pebbly sandstone.

The shore at the head of Tatamagouche Bay is low. On the Telegraph road, immediately beyond the bridge on Dewar River, indian-red, crumbly sandstone and marl dip 177° < 15°, and are marked with fucoids and what resembles the foot-prints of an animal. The rocks resemble Permian strata, but are also similar to the red Carboniferous rocks of Great Village River. Fossil foot-prints.

A ridge follows the middle of the peninsula towards Malagash Point, and south of this runs a ledge of grey sandstone which has been quarried near a little brook which flows westward across the first road north of the shore road, where the dip is apparently 179° < 52°. The sandstone at the quarry is a grey, fine, thick-bedded variety, marked with broken carbonized plants. A short distance further east red shales dip 167° at a high angle; and the soil has a Permian aspect as far as the road to Scott's Island, on the most southerly point of which are ledges of reddish fine sandstone, seen only at low water; and, on the south-east point, fine grey sandstone and greenish conglomerate. Malagash.

Down Dewar River and along the shore to Scott's Island, no rocks are exposed; about half a mile further east, however, red, evenly bedded flags and shales dip 160° < 10°, and include a band of from one to six inches of calcareous concretionary conglomerate and irregular layers of grey, fine sandstone which contains carbonized plants and traces of green carbonate of copper, which has been worked in the bank. The rocks cannot be distinguished from the Permian of the shores of Brulé. Copper mine.

A few yards further east the angle of dip is lower, and brown sandstones, in beds one foot thick, are fit for building, but in low banks. Then come red marly rocks, like those seen on Scott's Island, near Stewart's house, with a very low northerly dip, changing immediately beyond to 112° < 60°, but possibly broken in the bank, for a few yards further the dip is 142° < 15°; and 180 yards further, brown soft sandstone lies at a low angle. Then a sand beach, with a minute pond inside, occupies the shore for half a mile, and is followed by a sandy cove at the head of which the road comes to the shore, and past it is an obscure outcrop of grey fine sandstone, blocks of which are found as far as the brook or lagoon opposite the Methodist church at Malagash. East of the lagoon, ledges of shale, like that south of Scott's Island, dip 162° < 50°, and, at the east end of the outcrop, at a lower angle. Stretches of marsh and sand then reach nearly to within a mile of Malagash Point, where reefs of grey, bluish-grey, greenish-grey and reddish sandstones dip 157° < 20°, the angle soon increasing to 44°. The bedding of the sandstones is rough, few of the layers being fit for quarry-

ing; they include patches of conglomerate, concretionary limestone and rusty spots, full of carbonized plants, sometimes of large size. Beneath them lie red marls and shaly sandstones, with a band of reddish-grey spotted sandstone and a reef of reddish pebbly grit, like rocks of Toney River, dipping 150° < 41°. At the Cape, a bed of greenish-grey coarse sandstone has a concretionary patch at the bottom, which holds a little copper ore; it dips 151° < 68°, among greenish and purplish papery shales, coarse, grey and reddish crumbly grit, marly beds, with nodules of limestone and layers, two or three feet thick, of bluish-grey limestone, veined with calcite, like the limestone of Caribou, Cape John and Pictou Island. Immediately to the westward, the red sandstones and shales include layers of greenish and reddish, spotted, crumbly sandstone; and on the cliffs at the lobster factory two pits cut a concretionary band streaked with copper ore; almost in contact with which is a seam of coal, at best ten inches thick, but generally interrupted by clay bands, supported by several feet of underclay, underlaid by a thick bed of coarse and fine grey sandstone, with rusty, carbonized plants, and by red sandstone and marl to the marshes of Purdy Island.

Copper mine.

Limestone.

Coal.

The following descending section of these rocks is given by Sir J. W. Dawson*:—

		Ft.	In.
1.	Brownish red sandstones and shales, alternating with grey sandstones, one of them containing pebbles of white quartz, about..	600	0
2.	Dark grey limestone	2	0
3.	Grey and reddish sandstones	50	0
4.	Dark grey limestone	3	0
5.	Grey sandstones	50	0
6.	Reddish sandstones and shales	not well seen	
7.	Grey arenaceous shale; fern leaves and *Cordaites*	6	0
8.	Underclay with *Stigmaria*, and an erect stump with *Stigmaria* roots, penetrating the bed above	3	0
9.	Dark grey limestone	3	0
10.	Alternations of grey and reddish sandstone and shale; in the lower part a bed of coal six inches thick, with *Stigmaria* underclay, about	300	0
11.	Grey sandstone	20	0
12.	Alternations of reddish sandstone and shales and grey sandstone, with thin layers of clay ironstone and a layer of coaly shale, about	300	0

Fossil plants.

Saddle Island. Immediately to the north lies Saddle Island, the north side of which is all rocky; and not far from the west end, grey, thick-

*Acadian Geol., p. 215.

bedded sandstones, with rusty spots, dip 349° < 60°. They are of every variety, are interbedded with greenish argillaceous shale and underlaid by reddish sandstone and shale, with layers of greenish papery shale, which dip, at the eastern point, 347° < 60°. At the western point the highest beds of grey sandstone dip 342° < 60°, and seem to strike in a line for Amet Island. One band is of good grindstone grit and another of grey limestone-conglomerate.

From the west end of the island, sand flats, for the most part dry at low water, extend 217° to the mainland. At this point grey flags, with pebbly patches and concretionary limestone-conglomerate, dip 348° < 55°, and are overlaid by grey sandstone and shale, the former containing many pebbles of white quartz, and a band of limestone-conglomerate which may be that of Saddle Island. Then grey sandstone occupies the coast for a great distance, associated with a reef of grey calcareous shale, with coherent limestone and five feet of reddish and greenish, pebbly, concretionary rock, which carries a little copper ore at the bottom, with traces of coal. About half a mile east of a lobster factory, the dip is 345° < 82°; at and for a quarter of a mile east of the factory, vertical rocks strike 287°; and the next rocks met with, beyond a point and long sand beach, belong to the Carboniferous limestone already described (page 102), which is, however, interrupted further west by unconformable outcrops of the Permian.

Contact with Carboniferous

The coal of Cape Malagash and that of Caribou Island seem to be higher than that of Little Harbour, Merigomish Island and Toney River, and it does not seem probable that any of the seams are continuous. Two borings were made on Caribou Island, and the strata cut by them will be seen in the following record kept by Mr. Fraser, No. 2 lying north-west from No. 1.

Caribou Island.

Besides the borings with the diamond drill made at this and other localities in these rocks, and already mentioned, one at Logan's tannery, of 1,000, and two at Lyons Brook, of about 500 feet each, were made by Mr. Fraser.

Section of Strata in Bore-hole No. 1, Caribou Island.
Cut by diamond drill, March, 1875.

	Feet.	Inches.
1. Surface	15	0
2. Freestone	4	0
3. Red pencil rock	49	0
4. Freestone	60	0
5. Soft dark pencil rock	9	0

	Feet.	Inches.
6. Red soft pencil rock	23	0
7. Fire-clay and pencil rock	13	0
8. Pencil rock	6	0
9. Freestone	8	0
10. Grey hard, coarse freestone	5	0
11. Red pencil rock	5	0
12. Grey fine freestone	11	0
13. Speckled freestone and pencil rock	6	0
14. Red pencil rock	56	0
15. Freestone	31	0
16. Red and dark pencil rock	9	0
17. Red pencil rock	28	0
18. " "	36	0
19. Red pencil rock and marl	15	0
20. Red pencil rock	18	0
21. Red sandstone	10	0
22. Red pencil rock	25	0
23. " "	27	0
Total depth	469	0

SECTION OF STRATA IN BORE-HOLE No. 2, CARIBOU ISLAND.
Cut by diamond drill, April, 1875.

	Feet.	Inches.
1. Surface	20	0
2. Sandstone	7	0
3. White coarse sandstone	20	0
4. Grey fine sandstone	8	0
5. Grey mixed rock-conglomerate	4	0
Coal. 6. Coal [Acadian Geology, p. 343]	..	7
7. Fire clay	15	2
8. Red pencil rock	8	0
9. Red very soft pencil rock	4	0
10. Red pencil rock	1	0
11. Fire clay	7	3
12. Red pencil rock	13	0
13. Fire clay	2	0
14. Brown freestone	10	0
15. Grey freestone	15	0
16. Red pencil rock	2	0
17. Red sandstone	18	0
18. Limestone-conglomerate and red pencil rock	21	0
19. Red pencil rock and clay	27	0
20. Red pencil rock and beds of clay	9	0
21. Brown freestone	19	0
22. Grey freestone	19	0
23. Fire clay	4	0
24. Red pencil rock	209	0
Total depth	463	0

Sections comprising 500 or 600 feet of these rocks, with a limestone near the middle, probably about the horizon of that of Cape John, are well exposed on the shores of Pictou Island and have been described by Principal McKay.* They dip north and south at a low angle from an anticlinal axis which runs about 84° from end to end of the island. A large proportion of the strata is of grey sandstone of the usual variety, certain beds of which have been quarried for grindstones. Pictou Island.

H.—Triassic.

Although Dr. Ells has excluded from the Triassic,† as not clearly distinguishable from the Permian, the rocks referred to this series by Sir J. W. Dawson in Prince Edward Island, he has retained the areas which "are found at intervals along the shores of Minas Basin.‡ They extend for the most part but a short distance inland and have their greatest development in the neighbourhood of Truro and for ten to fifteen miles west. East of that town they occupy the valley of the Salmon River for about six miles and extend northward to the second bridge over the North River, about four miles in a direct line from Truro. Thence they occupy the country westward along the line of the Intercolonial railway and for a short distance north, to the vicinity of the Folly River viaduct, where the contact with the underlying Carboniferous formation is seen about 500 yards above the railroad. From this point the area becomes narrower, the northern boundary gradually approaching the shore of the Basin of Minas which it reaches at Five Islands. The continuity along the coast is broken in the vicinity of Economy by areas of Lower Carboniferous sediments. Below this, towards Cape Chignecto, the Triassic formation occurs only in irregular patches upon the older rocks." Distribution.

The relations of the sedimentary rocks of this formation, with their associated traps, to the older formations have also been described in great detail by Jackson and Alger, Gesner,§ Sir J. W. Dawson,|| and others. The contact with the older rocks is always clear and unmistakable, so that there is no ambiguity with regard to the limits of the formation. Sometimes, particu- Description.

*Trans. N. S. Inst. Sc., vol. VIII., p. 76.

†Geo. Surv. of Can. Rept. of Progress, 1882-83-84, p. 12 E. ; Acadian Geol., Supplement, 1891, p. 10.

‡Geo. Surv. of Can. Ann. Rept., vol. I., p. 6 E.

§Geol. and Min. of N. S., p. 239.

||Acadian Geol., p. 99; Geol. Jour. of London, vol. IV., p. 50, with a map.

larly on the north side of the basin, this junction is a fault, sometimes coarse beds lie at a low angle upon, and fill inequalities in, the underlying rocks of which they are composed. Many of the sandstones are very calcareous. The total thickness of the formation is doubtful.

Valley. In Clifford Brook, east of Valley station, the lowest Triassic rock is a pea-and-nut conglomerate lying horizontally on the red slates of Union. On the road to the Telegraph road east of the manganese mines, and also in the neighbourhood of the mines, many pieces of Triassic sandstone are in the soil and perhaps point to outliers among the Devonian.

From the railway station at Valley across the bridge and out the road to the Telegraph road, the strata are Triassic; and to the eastward along the Telegraph road and for some distance up the river these rocks are also exposed. In Half Moon Hill Brook the contact with the Devonian is well seen, the Triassic being bright red, crumbly, coarse sandstones, scarcely more coherent than the sand of a sand pit, with layers of grit, less bright than the other beds, containing pebbles an inch in length derived from the red argillites. Lower down is a grey, crumbly, flaggy, pebbly sandstone, dipping at a low angle, with thin beds and blotches of light green.

Contact with Devonian.

Farnham's Millbrook. In the branch of Farnham's Millbrook, which flows from Penny's Mountain, are dark brick-red, soft, marly, very fine sandstone, containing patches of grey calcareous sandstone and of coarse conglomerate, with a vertical dip which appears to indicate a fault. In another little brook further west, brick-red sandstone and nut-and-egg conglomerate form ledges which dip 177° at a very high angle.

North River. In Smith Brook, which runs into North River near the village, coarse and fine flaggy sandstone lies nearly horizontal at the contact with the Devonian; and on the opposite side of North River, below the bridge, the contact is again seen.

In Henry Christie's millbrook, red sandstones are exposed, for some distance above the road at Valley, in nearly horizontal bedding, the coarse sandstones containing patches of soft concretionary clay or mudrock, and, near the junction of the older rocks, beds of conglomerate.

Belmont. For a little more than a mile above the bridge, on the road at Belmont, tile or brick-red Triassic sandstones occupy the Chiganois River. They are then succeeded by a breadth of a quarter of a mile of green and grey and red shale, with patches and small seams of coal; these by half a mile of Triassic, before coming

to the great outcrops of metamorphic rocks. Among the lowest beds are layers of nut-and-egg conglomerate, containing veins of calcspar, one of which is a foot thick, the pebbles being of gneissic and quartzose rock. At the mill-dam above Belmont, reddish fine sandstone, crumbly and like that of Truro, dips 191° < 31°, and higher towards the saw-mill, < 55°. The junction here appears to be a fault. Fault.

The dip of the frequent outcrops of Triassic sandstone seen above the railway, in Staples' Brook, is 277° < 15° to 34°, and the beds are fine nearly to the bridge at the post office; where fine sandstones are succeeded by coarse sandstone and conglomerate, with a steep south-westerly dip. Staples' Brook

In Debert River these rocks extend a mile and a half above the railway; and at or near their junction with the older rocks dip down stream at a very high angle, and appear to be affected by a fault, the rocks at the base being finer and more flaggy than usual, but including bright red, crumbly, coarse sandstone and pea-and-nut conglomerate. Debert River.

The Triassic rocks of Pine Brook are well exposed above the railway, presenting as much variety as is anywhere met with. They comprise red soft sandstone, with small patches in which are pebbles as large as nuts; pea-and-nut conglomerate; brick-red nut-and-egg conglomerate, hollowed into a cave thirty feet deep; coarse sandstone and fine conglomerate, with small green blotches; red fine sandstone, massive, but with bedding planes marked by blackish streaks of magnetite, and with patches of green and grey concretionary limestone-conglomerate, seldom more than a foot thick; succeeded by the Carboniferous. Pine Brook. Cave.

In McElman Brook, the contact of the Triassic with the older rocks is at a fork about three-quarters of a mile above the railway, where brick-red, crumbly, coarse sandstone and nut-and-egg conglomerate are irregularly intermixed. McElman Brook.

In the brooks between Truro and the mouth of the Shubenacadie River at Blackrock, Triassic rocks rest nearly horizontally upon the edges of the red rocks of Union at no great distance from the shore. Those on the shore between Salter's Head near Maitland and King Creek (page 96) have been already referred to; and the prevailing low angle of dip is found in the cliffs, which are almost unbroken as far as Noel Bay, the rocks being precisely like those of Truro and Economy—essentially red coarse sandstone, with layers of greenish and grey concretionary sandstone and patches of coarse, pebbly grit. Across Noel Bay is a wide expanse of low Shubenacadie River. Noel.

dyke-land, which presents a curious picture, with its numerous stacks of hay set on high foundations of wooden piles. At Densmore's mills, flinty Devonian slates have a nearly vertical dip, and reappear at several points on the road for the next two miles to Noel village, where the Triassic extends probably to the bridge on the post-road. High unbroken cliffs extend thence round Burntcoat Head into Moose Bay, showing islands and pierced masses of the red Triassic sandstone, hardly distinguishable from the Permian of River John, but as a rule less coherent. A large proportion of the rock at Teny Cape Creek is rusty grey nut-and-egg conglomerate.

The rocks of Walton and the shores to the westward need not here be referred to.*

Surface Geology.

Many points concerning the distribution of the ancient gravel ridges and beaches, the deposits of unstratified and stratified clay, sand, gravel and boulders, which cover to a variable depth the solid rocks, and indicate the action of ice and water during the Post Pliocene period, have been discussed by Sir J. W. Dawson,† Dr. Honeyman,‡ Mr. Poole,§ Dr. Ells,|| Mr. Chalmers and others.

Hogsbacks. A well marked kame or hogsback, composed of coarse gravel and sand, runs from the neighbourhood of McKeen's quarry, east of Pictou. Pictou, across the back road, and was traced by Principal McKay north-westward along the left bank of a little brook nearly to the seashore of Caribou, a distance of about three miles. Other banks of sand and gravel occur in this vicinity, and a remarkable number of boulders, principally of syenite, granite and diorite, are scattered over the face of the low, flat country along the strait. For a great distance below Earltown, the valley of Waugh River. Waugh River, which resembles a Carboniferous glen more than a valley cut out of Pre-Carboniferous rocks, contains a large quantity of drift, derived apparently from Permian rocks, everywhere along its banks; and from near Earltown to far below Mr. Gilbert Sutherland's house extends a well marked sand and gravel hogsback, broken, of course, in places, and represented in others only by

*Acadian Geol., pp. 89 and 258.

†Acadian Geol., pp. 60 to 83.

‡Trans. N. S. Inst. Sc., vol. III., p. 345; vol. IV., p. 109; vol. V., p. 325; vol. VII., p. 138, and other papers.

§Op. cit., vol. VII., p. 388.

||Geol. Surv. of Can. An. Rept., 1885, vol. I., p. 64 E.

knolls or mounds. On the south side of the river, near Donald Sutherland's house, sand and gravel are in hills and ridges. Banks of sand and gravel are also seen where the Salmon River road leaves the Earltown post-road, in the valley which follows the road from Nuttby to Waugh River, and in other valleys of the district, the drift here resembling the soft rocks which lie to the northward. Along Byers Brook and at Farmington are banks of reddish drift, composed largely of Permian debris, which is seen in other places on the northern slope of the mountain, and appears to have come from the north. The fertility of the well wooded hills and of the romantic mountain farms on this slope is in part no doubt due to its presence. Byers Brook.

On the Stewiacke River, down the right bank from Eastville, great banks of drift gravel are seen, and at Middle Stewiacke curious mounds, apparently of gravel, the abundance of blocks of granitic and felsitic rocks, both here, at Green Creek and at Shubenacadie River, being as remarkable as in the neighbourhood of Pictou. Stewiacke.

The gravel pits of Scotsburn, from which ballast was taken for the Oxford and Pictou railway, are of large extent and seem to contain only the debris of rocks of the hills lying to the southward, accumulated as it were in an old lake. The excavations show banks twenty-five feet high, containing comparatively few large boulders. Scotsburn.

On the Portapique River, two terraces on the left bank show for a considerable distance opposite the post office of Montrose. Terraces.

Glacial striæ were observed at the following localities:— Ice grooves.

Pictou, [mentioned by Lyell, Travels in North America, vol. II., p. 179], 53°.

Grant Lake, on the road between the lake and the first house towards Hopewell, 192°.

Foxbrook and McLellan's Mountain (observed by Mr. H. S. Poole) 197°.

West Branch of River John near Loganville, 175°.

Hardwood Hill west of Pictou, three sets of grooves, 147°, 197° and 92°, the last being the most recent and produced probably, according to Mr. Chalmers, by the passage of ice into the neighbouring valley, whereas the others may run from the Cobequid Hills.

Folly Mountain, at the clearings near Archie Slack's, not far west of the foot of Folly Lake, 172°.

Saddle Island, well-marked, on a plane which does not face the sea, 102°.

Old Westchester Mountain road near the county-line, 162°.

Lynn, 169°.

None of the numerous bare knobs of diorite and syenite on the top of the hill on the old Tatamagouche road show ice grooves, though many of them are rounded and irregularly channelled.

Direction of the drift.

Many facts bearing upon the direction of transportation of the drift are given by the authorities mentioned above; and as the determination of this question has a practical application in prospecting or searching for mineral deposits it is of the greatest importance. Mr. Donald Fraser, of Springville, states that blocks of iron ore are most numerous north-east of the beds in Pictou county, but that the drift from the south side of the watershed of Nova Scotia went to the southward. Mr. Alex. McBean, of the Vale colliery, also maintains that the drift has gone north from the high land and that much coal debris is found north of the seams, whereas it frequently happens that the sand and gravel immediately overlying the coal seams contain absolutely no traces of coal. Late explorations made in search of coal immediately north of Logan's north fault revealed an abundance of coal-measures drift, including large blocks of coal, overlying solid red rocks of the millstone grit. And on McLellan's Brook, on the left bank immediately above the fulling mill, drift from the red rocks to the southward is so abundant that it might be supposed to indicate the rock in place were it not that the shales of the coal measures are seen at water level along the pond.

Boulders.

The numerous boulders of white-weathering syenite and granite so abundant in the neighbourhood of Pictou, Haliburton Creek, New Glasgow, Kemptown and other localities have been already referred to. The gravels of Lorne appear to be derived from Devonian slates, many of them ferruginous, and from syenitic and dioritic rocks, together with blocks and pieces of softer, newer sandstone and shale from strata underlying. In Cross Brook, among the Silurian rocks is a large boulder of Carboniferous limestone, already referred to as possibly indicating a Carboniferous outlier. Boulders of syenite and diorite, like those of the mountain to the southward, are abundant on the roads about Staples Brook and the vicinity.

The blocks of gypsum said to have been washed out of the bank at Cape John* seem to be boulders brought from a distance, as no rock of this kind is known in place in the neighbourhood. One is at the lobster factory, another, twelve feet by four feet, lies on the outer shore three miles east of the cape.

On the shores of Minas Basin, large irregular deposits of sand and gravel are met with, but will not here be described.

*Acadian Geol., p. 327.

On both Speid and Maple Lakes, raised beaches were seen. On the north side of the former, at a little brook near the outlet there is said to be a stone weighing ten tons, perched, twenty feet high, on a pivot on another. Raised beaches.

Igneous Rocks.

According to their periods of formation, these rocks may be arranged in three groups, as follows:—

1. Cambro-Silurian.
2. Devonian.
3. Post-Carboniferous, principally Triassic.

These groups differ, as will be seen in the sequel, in the character and composition of their rocks, those of the last being, as a rule, much less massive, crystalline and coherent.

1. *Igneous Rocks associated with Cambro-Silurian strata.*—The igneous materials everywhere associated with Cambro-Silurian strata east of the East River of Pictou, seem to be older than the adjacent Silurian, as described in last report.*

The felspathic schists, agglomerates, porphyries, and other rocks of the neighbourhood of Moose River, require no special mention. The relation of the schists to the massive volcanic rocks is obscure; in Sutherland's River they are associated with fragmental felsites and masses of soapy, serpentinous, fragmental slate. They differ from the Cambro-Silurian slates and do not seem to be an altered form of them, but rather bedded volcanic breccias. They are greenish, pearly, scaly, chloritic and micaceous, full of veins of quartz, and intimately mixed with rocks like those of Baxter's Brook. Soapy slates and mica schists, weathering-rusty, and silvery grey, are found in the French River in the neighbourhood of Blue Mountain, containing so many large veins of quartz that in places they pass into quartzite; with blocks of felsite, hornblende-rock and diorite. In the first small brook below Patrick's are blocks of felsite, but no outcrops. Near Murdoch Lake, massive dioritic rocks are associated with felsitic schists and Cambro-Silurian grits. 250 yards north of the Blue Mountain church, is a pink porphyry, jointed and crossed in all directions, blotched with quartz and spotted with crystals of red felspar. Porphyry and diorite crop out at other points in the same neighbourhood;† and ridges of greenish and dark grey diorite, on

Moose River schists.

Quartz veins.

Blue Mountain.

*Geol. Surv. of Can., An. Rept. 1886, vol. II., p. 99 P.

†Trans. N. S. Inst. Sc., vol. III., pp. 69, 72, 107 and 108; vol. V., pp. 67, 7 and 73.

the mountain road near the church at McLellan's Mountain. Large outcrops of greenish diorite are found on the road through the Ross settlement north of Sunnybrae, associated with Silurian rocks and with flinty Cambro-Silurian slate; and smaller outcrops on Irish Mountain and towards Churchville. In Cameron Brook is a dyke of dark grey amygdaloid, with cavities and veins of calcspar, among greenish flinty conglomerate and black rusty Silurian slate; and at Churchville, a trap precisely similar, coated with hematite, perhaps cuts the Carboniferous conglomerate.

Corrimony. The reddish traps of Corrimony, containing specks of colourless quartz, cut Cambro-Silurian rocks and also the doubtful flinty grit, which may be Medina. Near Dan Urquhart's, massive and slaty fragmental, soapy rock is associated with dark crystalline diorite, light-coloured felsite, chloritic and nacreous rock, cut by quartz veins, and with bluish-grey pyritous trap. In Glencoe Brook, greenish compact diorite and felsite, blotched with quartz and hematite, appear in large outcrops; and at Mount Horeb, a greenish diorite cuts ribbanded slates; and purplish trap and diorite form precipices near the road. Where the boss strikes the River road, the diorite contains scales of specular iron ore; but there appears to be no alteration of the Silurian rocks.

Blanchard. In the west branch of Blanchard Brook* there are outcrops of greenish massive diorite and reddish breccia in contact with which the Silurian appears more altered than usual; the fossil-

Iron ore. iferous iron ore at William Ross's also appears to be cut by the traps and diorites; as well as the Silurian rocks of the iron mine further north.

Sam Cameron's Brook. The igneous rocks of Sam Cameron's Brook are of great variety and interest; they underlie the black slates of the Clinton and the siliceous sandstone of the Medina, and are probably contemporaneous with the Cambro-Silurian. The lowest in the brook are greenish and purplish amygdaloids, with cream-coloured compact rocks; succeeded by claystone and syenite, by a dyke-like mass of volcanic breccia, and by quartzite and light-coloured agglomerate. Higher up, purplish and bluish-grey ash-rocks and greenish chloritic rocks are associated with soapy slates, perhaps sedimentary, and with fine crystalline diorite. Light grey, greenish and cream-coloured, felsitic, splintery slates, of silky lustre, are intimately mixed with and apparently pass into greenish, fine agglomerate slates, and are cut by dykes of dark crystalline diorite. Some of these beds are very coarse, apparently horizontal, and associated with patches of

*Trans. N. S. Inst. Sc., vol. III., p. 63.

agglomerate resembling that of Bear's Brook. Greenish, cream-coloured and reddish, felsitic, soft aluminous shales, containing greenish, soft, steatitic patches, are cut by an irregular vein a foot thick but thinning out, composed of limonite and spathic iron. Iron ore.
There are also light-coloured, compact, ribbanded rocks, the banding of which is vertically 167°, and resembles the colour lines of a slag, but which split more readily along the nearly horizontal lines above described. Scales of specular iron ore are in the joints; and chloritic diorite, breccia and massive felsite are found higher up. Greenish, massive diorite and syenite are found in McLellan's Brook and on the neighbouring hills not far above the contact of the Carboniferous.

The Weaver's or McGregor's Mountain is composed partly of black vesicular trap of doubtful age, with conglomerate in contact with Carboniferous rocks. McGregor's Mountain.

2. *Devonian Igneous Rocks.*—The igneous rocks of John McDonald's (Ogg) Brook (page 35), not far above the East River of Pictou, consist of reddish and greenish massive felsite, trap, syenite and diorite, granular and compact, of serpentinous diorite-breccia and coarse, rusty calcareous agglomerate, with other varieties like argillite or amygdaloid. In the fields near the little branch from John McDonald's (Weaver) are chloritic and quartzose gneiss, felsite and diorite.* East River. Specular iron ore.

Reddish trap cuts dark grey massive argillite near the contact of the Carboniferous and Devonian rocks of Archibald's Brook; while higher up is a massive, grey, calcareous, porphyritic felsite, in part vesicular, in part yellowish-white, decomposed and trachytic, containing spots of specular iron; and at Archibald's bridge, a granular syenitic rock. Blocks of a reddish trap are also found near Alex. McDonald's, at the head of Black Brook, and of coarse diorite at Centredale; while at Sam Cameron's mill is an outcrop of grey, greenish and reddish, massive or laminated and wrinkled felsite-breccia.

In the west branch above Elgin, Upper Devonian rocks are associated with greenish and cream-coloured flinty rock, agglomerate and purple loosely coherent breccia. West Branch, East River.

About Lorne are many large blocks of greenish-grey, white-veined, gneissic diorite, the veins being of compact or granular felsite. Near Cameron's Brook, opposite Jessie Grant's, a hill shows compact and granular flinty quartz-felsite. Near the Marshdale school the trap and diorite, well exposed on the hill, contain traces Marshdale.

*Trans. N. S. Inst. Sc., vol. V., p. 206.

of specular iron ore and have been prospected in several pits. Except on the hill, however, sedimentary rocks are probably in place. The diorite near the limestone is a soft mixture of feldspar, hornblende and chlorite; it is well seen on the Crockett road, and perhaps cuts Carboniferous rocks. Large blocks of chloritic, white-veined, hornblendic rock are found south of Kenneth McKenzie's, at Lorne; also a doubtful outcrop of rusty-weathering, light greenish-grey, calcareous clay-rock, sometimes shaly, resembling a crystalline limestone and full of blotches of pink calcspar.

On the Cross Brook are light grey, slaty, felsitic, epidotic, obscurely fragmental rocks with threads of ankerite and specular iron ore; and in the Big Brook, above John McDonald's road, large blocks of dark, pyritous, finely crystalline diorite with white veins.

Glengarry. Near Glengarry, on the road to Concord Mills, calcareous flinty trap cuts reddish coherent Devonian argillite; west on the railway, are blocks of trappean and fragmental rock; and near the thirtieth mile-post, a pit south of the railway exposed decomposed, felsitic and granular, flinty hornblende-rock. On the road from Glengarry to Lorne by John McDonald's, granitoid, syenitic and felsitic debris appears near the school; and between McDonald's and the road near Cross Brook the land is bouldery with diorite derived from the hills of the vicinity. The blocks of veined diorite near the railway tank are followed on the road westward towards Lansdowne by others of purple trap. The reddish and dark trap of Robert Gordon's Hill, north of Glengarry, occurs between layers of limestone at the quarry, and also cuts a bluish-grey slaty, siliceous rock; near the main road on this hill are reddish porphyritic felsite and trap.

The sandstones in the neighbourhood of the diorite of the Marshdale Hills are slightly indurated, and the greenish and reddish argillites in some places almost porcellanous, but not more so than the strata of Millbrook. The hill between the Crockett road and Jessie Grant's is apparently in great part trappean. At the picnic ground at the north end of the hill, compact and fragmental felsite is intimately mixed with reddish quartz-veined quartzite and greenish porcellanous argillite, knobs of rock coming through the soil on the highest peaks.

West River. In the brook near Limerock, are cliffs of light grey, calcareous, fine and coarse, rusty-weathering, trachytic and fragmental rock, full of grains of chlorite.

On the opposite side of West River, near the head of Six Mile Brook, compact, greenish, felsitic, serpentinous, dioritic rocks are

covered on both sides by Permian, at what may be termed the east end of the Cobequid Hills. The arrangement of the rocks in these hills is stated thus by Sir J. W. Dawson*: "There is a central mass of red intrusive syenite or syenitic granite, usually having a large predominance of red orthoclase, with a moderate quantity of hornblende and quartz. This sends veins into the overlying beds, and is itself penetrated by dykes of diabase. On this central mass rests a great thickness of felsites, porphyries, felsitic agglomerates and diorites, evidently of volcanic origin. Upon these are grey, black and reddish slates and quartzites, with a bed of limestone, and penetrated by metallic veins..... The rocks have been altered and elevated before the Carboniferous period†; but, on the other hand, these altered rocks themselves are in part Devonian, and there is no reason to believe any of them to be older than Upper Silurian." Structure of the Cobequid Hills.

Underlying the Permian conglomerate of Mount Thom is a reddish and grey coarse syenite and greenish and grey gneissic rock; at the west end of Mount Thom, greenish diorite, greenish, reddish and grey granular and porphyritic felsite, quartz-felsite and syenite; while near the Telegraph road, dark green, soft, fine diorite is in contact with greenish-grey slates. Near Bezanson's, a pit fifteen feet deep has been sunk in search of gold, in a grey crystalline diorite, associated with rocks similar to the above; and further north, greenish felsitic rock is veined with calcspar. At Mount Dalhousie, grey and greenish, massive, felsitic rocks include greenish and purple and dark breccia, calcareous, felsitic, chloritic, somewhat pearly, often slaty, like the rocks of Coxheath. On the hill south of Loganville and in the Biorachin are outcrops of grey and black syenitic rock and of all the other varieties of Mount Thom. In some of the little tributaries of the west branch of River John, above Loganville, there is a great variety of these rocks. In one of them from the west they comprise amygdaloid, fine trap, epidotic and compact felsite and breccia, with apparently a southerly dip like the associated fine sediments. Up stream are reddish and grey syenite, greenish grey, nearly compact Coxheath felsite or diorite, with a well-defined bedding or cleavage, which dips 177° < 40°. Mount Thom. Search for gold. Loganville

On the road to McIntosh Lake, and in the brook near the lake, reddish and grey coarse syenite is abundant. Further down stream, greenish diorite is succeeded by greenish-grey, pearly, pyritous felsitic slates, often papery and scaly, showing flakes of different McIntosh Lake.

*Acadian Geol., Suppl., 1878, p. 79.

†Acadian Geol., pp. 561 and 580.

colours, spotted with quartz, serpentinous and chloritic, with calcspar in the joints, and with veins, sometimes three inches thick, of white barren quartz; and where overlaid by the Permian conglomerate, associated with grey massive felsite, quartz-felsite and diorite.

Salmon River.

Dykes of black and light green crystalline hornblende-rock or diorite and of massive greenish-grey or grey felsite cut the Devonian strata of Salmon River, above the fork of Black River, the sedimentary strata being considerably altered near the contact, and having specular iron ore developed from the ankerite veins so abundant in the neighbourhood, as is often the case in proximity to the dykes. The bright red slates at the uppermost and largest of the dykes, resemble those near the manganese mines. No other igneous rocks appear in the river as far as the head of the settlement.

Specular iron ore.

About 100 paces south of the railway station at Riversdale, large blocks of reddish-grey syenite may indicate a boss of this rock, but are perhaps drift. The outcrop of grey, soft, vesicular, calcareous trap about a mile below the driving dam on Calvary Stream has already been referred to. North of Steele's Run, the hills show grey and greenish diorite, syenite and felsite, sometimes slaty and chloritic. On the main road through Upper Kemptown, and on some of the by-roads, are large exposures of red syenite, mixed with blackish diorite, succeeded towards Earltown by fossiliferous rock, mixed with grey amygdaloid. Some of the syenite is coarse; much of it is of a fine colour and probably fit for ornamental purposes.

Ornamental stone.

Diorite and syenite are in contact with Devonian and newer rocks in the Juniper Meadow Brook and other streams of the vicinity, being separated from the latter by faults.

Valley.

On the Telegraph road, about a mile east of Valley cross-roads, is a hill of coarse black diorite, not extending far above or below the road; associated with flesh-red compact felsite, overlaid by Triassic rocks.

North River.

Many rocks of this group in North River have been incidentally described with the Devonian, with which they are in contact. The outcrops of syenite, diorite and trap of McKenzie settlement, of Brian Lynch's, and of the road towards Earltown, are shown on the map. On the Tatamagouche road, in the neighbourhood of the old mountain inn above McCallum settlement, red syenite is abundant in the brooks and extends to the head of Falling Brook, a stream which runs from a large barren or peat bog, winds for some distance without showing rocks, then rushes over nearly

compact syenite rock and plunges into North River, over a cliff, forty feet high, of reddish coarse syenite, succeeded in the river by Devonian sediments, cut by dykes of syenite and diorite.

On the west branch of North River about a quarter of a mile above the saw-mill at McCallum settlement, a bluish-grey calc-veined limestone is seen, dipping first at a low angle, then overturned and ending in contact with a dark greenish-grey crumbly diorite or trap, like that of New Annan, into which it penetrates in wedge-shaped masses, the bedding conforming in places with the line of contact, and small detached pieces of the limestone occurring in cracks in the diorite to a distance of twenty feet from the contact. The greenish, massive, rubbly Devonian rocks which immediately succeed are more flinty and altered than usual: they include ferruginous calcareous bands, light grey flinty sandstone and a grey rusty-weathering quartzite, showing plants converted into anthracite, resembling a Guysboro' quartzite, and succeeded immediately by greenish, fine fragmental, igneous rock. Greenish, quartzose, greatly altered sediments are again seen, including a reddish argillite, full of spots and veins of specular iron ore, cut by a dyke of red igneous rock resembling mud squeezed into them; succeeded by greenish-grey trap and diorite, mixed with small patches of red syenite, which increase until the whole brook is occupied with bright red syenite. Then for more than a mile up stream, the magnificent gorges of the river show mixtures and alternations of dark diorite and reddish or light-coloured syenite; above which near a saw-mill, is a breadth of more than half a mile of sedimentary rocks. Succeeding these, as far as the road crossing, is another belt of light greenish trap, granular, fragmental and porphyritic quartz-felsite and greenish diorite, sometimes exhibiting rough bedding and containing patches of bright red syenite. Fossil plants.

The dykes near the head of Nabiscump Brook consist for the most part of greenish fine diorite and reddish quartz-felsite. The rocks which cut the Silurian in the little brook immediately above Earltown are of considerable variety, including a purplish-grey, fragmental, scaly rock, greenish and dark diorite and syenite, overlaid by Permian conglomerate. Below Earltown falls (which are "fifty feet high, resembling the falls of Foyers in Scotland,") are cliffs of greenish-grey, blackish and dark-reddish diorite and trap, full of veins of calcspar and quartz. The rocks of the falls consist of diorite and trap; but at the base are traces of red soft argillite, probably included masses of the supposed Devonian rocks of the brook to the eastward of the road. Earltown.

On some of the roads about the head of Matheson Brook, are outcrops of slaty or schistose felsite, full of quartz, and of dark trap. Nearer North Earltown, reddish, fine, granular quartz-felsite is mixed with argillite, and with greenish and light grey, striped, compact porphyry, containing grains of quartz. In one of the branches is a cliff of dark reddish and greenish, flinty and soft, calcareous, compact and fine trap, with felsitic, chloritic and dioritic slate, containing veins of quartz upon which a shaft has been sunk in search of gold. Underlying the Permian conglomerate of Moore's Brook, are greenish, slaty, felsitic, soft and rubbly, calcareous rocks, which extend west into Waugh River.

Search for gold.

On the road from Nuttby to Waugh River, the coarse syenite and porphyry of the south side of the mountain are succeeded by the traps of the north side. Where these come from beneath the conglomerate above the falls in Waugh River they consist of light grey and greenish-grey agglomerate and of bottle-green felsitic or dioritic breccia, like that of James River, containing much chlorite and a few blotches of quartz and syenite, and showing in places a minute jointing or lamination. Higher up, similar rocks, containing more quartz, show a kind of scaly foliation which dips 118° <30°, and include flinty diorite and imperfectly crystalline syenite. In one of the tributaries from the west, reddish, fine, coherent sandstone is associated with grey soft trap and greenish flinty diorite.

Falls of Waugh River.

Foliation.

Dark-greenish and blackish trap and diorite, fine and crystalline, with blotches of calcspar, occupy most of McDonald's Brook, and in the clearing near McDonald's house are in contact with red sandstone at a little fall, whence they appear at several points on the road towards the Earltown road. Ferguson Brook, one of the wildest streams of this part of the country, shows cliffs of dark grey and greenish, compact and crystalline trap and diorite cleft in one place into a small cave. In the adjoining tributary of Waugh River from the south, reddish, fine, massive sandstone or quartzite is cut by dark grey, fine, crystalline trap or diorite; and higher up the brook, red argillite is associated with red flinty quartz-felsite and amygdaloid. Other outcrops in this neighbourhood show igneous rocks cutting red sediments which consist of conglomerate, quartzite and argillite.

Cave.

Among the Silurian rocks of Spiedel Hill are grey, greenish and rusty-weathering, compact, porphyritic felsite, with crystals of amber-red feldspar and small spots of colourless vitreous quartz, passing into granular felsite and quartz-felsite. In the little brooks above Gilbert Sutherland's, schistose rocks are exposed, Murray's Brook showing felsites from the road to the river.

Immediately west of Waugh River on McLeod's farm is a dark rotten trap; but for some distance before reaching Mr. Paul McDonald's house, the debris indicates flinty porphyritic felsites, like those of Coxheath, which extend to Little River (Sutherland Stream) at the mill-dam and are well exposed down stream to Bailey's bridge and up stream to Kavanagh's mills. The first rock seen below the mills is light grey fine trap and blackish and red amygdaloid with a tendency to globular structure; succeeded by reddish and greenish, massive, flinty felsite, obscurely porphyritic, sometimes in layers dipping 51° < 40°; greenish-grey and red chloritic and calcareous, fine, softer diorite; compact felsite and porphyritic diorite, with veins of colourless oily quartz, four inches thick, which have been mined; flinty fragmental felsites; and bright flesh-red compact quartz-felsite. About a mile above Bailey's bridge, a greenish, striped, jointed rock, very like a quartzo-felspathic sandstone, probably sedimentary, is immediately followed by the felsites. At Drysdale falls, greenish chloritic and dioritic rocks, soft, slaty and crumbly, are cut into a pillar separated from the mass in the bank. Below the bridge, as already mentioned, these rocks are succeeded by reddish, flaggy, Permian sandstone. Above Kavanagh's mills the brook shows, as far as the little lake at its head, a few outcrops of greenish-grey and blackish trap, with small white amygdaloidal spots, associated, on the Corktown road, with masses of dark green nearly compact diorite. In the east branch of Little River, not far above the fork below Kavanagh's mills, blackish, greenish and reddish, compact and crystalline, soft, calcareous trap, easily broken up to make the fertile soil of this part of the mountains, is well exposed. A short distance higher, bluish-grey and geenish-grey argillites, in flaggy layers, dip 257° < 45° They yielded no fossils, but lithologically are like Silurian. They are underlaid by cream-coloured claystone of igneous aspect, succeeded by massive trap in cliffs. At the head of this branch, grey and blackish amygdaloid and diorite are succeeded by reddish nearly compact quartz-felsite or syenite and light grey rusty-weathering compact felsite, with a few porphyritic crystals.

Bailey's Bridge.

Quartz veins.

Silurian strata.

A brook crosses the road west from Bailey's bridge, 495 paces east of the cross-roads, and shows up stream outcrops of light and dark bluish-grey rubbly rock, probably an altered felspathic sandstone, dipping apparently 207° < 25°; succeeded for a short distance by cliffs of greenish diorite; these in turn, by quartzites and porcellanous argillites.

Dark trap and diorite are seen also to the westward as far as the Tatamagouche road. On the Four Mile brook, the first rocks south

Four Mile Brook

of the Permian are grey, reddish and greenish, flinty, splintery and rubbly felsites, some of which are fragmental, full of quartz veins; greenish compact porphyry; greenish and purple, mottled, soapy, soft, aluminous slates, like those of Louisburg and Coxheath,* scaly and serpentinous containing spots of hematite and a large quantity of calcite. Greenish felsite-slates are found on the roads between this point and the French River.

New Annan. In French River† immediately above New Annan bridge, grey and greenish, rubbly, porphyritic slates and flinty, pearly, papery or scaly

Schists. slates dip 77° < 49° with regular bedding or foliation. A little higher, greenish, much less regular, felsitic slates, containing a vein of white crystalline calcspar, three-quarters of an inch thick, are associated with greenish, light grey and black chloritic schists, in which the veins and blotches of calcspar are sometimes three inches thick: they are greatly corrugated, banded and striped, scaly, pearly and silvery, sometimes nearly horizontal, and hold large masses of quartz. High up the river at a dam, the schists are replaced by black, rusty and crumbly diorite and trap, among which occurs a greenish-grey

Limestone. fine limestone which has been burnt, the relations of which to the igneous rocks, however, require further examination.

Near the head of Byers Brook are outcrops of red flinty quartz-felsite, with grains of quartz, and of dark grey felsites and diorites, magnetic and containing small porphyritic crystals of feldspar and pyrite; and further down, vesicular and amygdaloidal trap. In the fields near William Warwick's, among other varieties of fragmental and Coxheath felsite and quartz-felsite, is a light-coloured slaty

Fireclay. variety that might make a good fireclay, but does not seem to be abundant. At a school on the road to the Florida road, dark friable trap and diorite abound.

Old Tatamagouche road. For some distance south of its junction with the present road near the head of the west branch of North River, the old Tatamagouche road shows rusty-weathering compact felsite; succeeded, at 880 yards from the fork, by dark green diorite, veined with epidote, and bright green and red, mottled, compact and fragmental felsite; and at 1,475 yards, by cliffs of massive porcellanite or altered argillite; while in a brook at 2,850 yards, dark and light grey Devonian shale and quartzite extend nearly to the North River, where the slates are mixed with great masses of dark diorite and small patches of red

*Geol. Surv. of Can., Rept. of Progr., 1875-76, p. 379; 1876-77, pp. 419 and 425; and 1877-78, p. 8 F.

†Geol. Surv. of Can., An. Rept., 1885, vol. I., p. 60 E.

syenite, above a narrow mill-pond at the head of a gorge. Further south on the old road are other outcrops of diorite.

Chiganois River.

On Chiganois River, the first igneous rock seen above Higgins' mill is a dark reddish somewhat compact trap, succeeded up stream by a small outcrop of sedimentary rock; then by reddish coarse syenite which surrounds a patch of red argillite. Grey and reddish syenite and greenish epidotic diorite then form falls, probably thirty feet high, in a rocky, inaccessible gorge; from the head of which the syenite, though including patches of almost pure quartzite, alternates with diorite in unbroken cliffs for a great distance. In places the syenite is bright red; the diorite is greenish, shows gneissic lines; and up stream, grey gneissic rocks underlie massive syenite. At the fork of the river, whitish-grey layered rocks dip 345° < 80°, the bands being of fine gneiss, of quartz and of felsite. The bands of contorted gneiss which occur among the massive rocks resemble those of St. Ann's, Boisdale and Margaree, the dip is regular but contorted and the lamination very fine. Then come dark hornblendic rocks, also gneissic, with massive grey diorite; followed by alternations of coarse syenite and diorite immediately in contact with slates of the iron ore series, which occupy a breadth of more than a mile below Patterson's old mill, above which, syenitic rocks are again seen. At the mill and on the road from it, reddish porphyritic felsite and quartz-felsite abound, whereas on the Tatamagouche road at the end of this road, grey trap is in place. The few rocks seen about Clear Lake are syenitic; but on the road from that lake to Peter McIntosh's at the head of New Annan settlement, flinty felsitic or dioritic rock gives place to dark bluish-grey trap and diorite, found also on the track across the hills to Nelson's Corner and towards Kavanagh's mills. The little brooks immediately west of Chiganois River above the Higgins road also show outcrops of igneous rock among the Devonian. In that nearest the river, these consist of dark grey calcareous and chlorite volcanic ash or mud rocks, and of light grey and purple mottled amygdaloid; and in the second, of blackish diorite, whitish granular diorite and flinty breccia. In the upper part of the main branch of Old Sam's Brook, reddish coarse syenite and dark grey diorite contain calcite, epidote and chlorite, the syenite passing into granular quartzfelsite. The associated sedimentary rocks are reddish slaty flinty sandstone or quartzite and porcellanized red argillite.

Gneiss.

Devonian slates.

In Higgins Brook nearly all the outcrops above the conglomerate consist of syenite, diorite and trap.

Debert River.

The igneous and sedimentary rocks mixed in the Debert River, three-quarters of a mile above the bridge at Cottam settlement, have

been already described: the first seen are traps and diorites, succeeded by whitish coarse diorite containing much quartz, coarse grey syenite with obscure gneissic patches, whitish massive quartz which may be sedimentary, and is usually in contact with or near dark slates altered into schists. Similar alternations extend nearly to McMullin's mill* from which a long logging-sluice runs down the river to Debert station. Near the mill, red syenite is associated with greenish breccia, in contact with greenish, flinty, slaty or porcellanous rocks which show black marks resembling plants, and mixed with silky slates and reddish porcellanite, including a thin band of crystalline limestone. At the mill, greenish epidotic, flinty, felsitic rocks, reddish or purple dioritic slates, often epidotic and chloritic, and reddish and greenish pearly slates have an easterly strike. Above the mill-pond, greenish chloritic schists include a band of what appears to be altered sedimentary rock, bedded conformably with them, and extend to the mouth of Shatter Brook. At the bridge on this brook are greenish, scaly, chloritic, soft rocks; below it, they are succeeded by red syenite cut by a dyke of black diorite, two feet wide, below which pyritous diorite and syenite are mixed to the river. Above the mouth of Shatter Brook, grey and greenish chloritic slates give place to banded and contorted syenitic rock, succeeded by massive syenite and diorite. The banks are then low and the outcrops less imposing, but ledges of red syenite with patches or dykes of dark diorite extend to Debert Lake, the syenite being in places coarse and containing very little hornblende.

Limestone.

Totten's Brook.

On the south side of the marsh at the iron mine on Totten's Brook are small outcrops of mottled, massive, fragmental, granular syenitic and felsitic rocks, stained with films of red hematite and carbonate of copper, and light greenish diorite, blotched with specular iron ore, in contact with very flinty flags or porcellanites. Near the head of the brook is a greenish, soft, granular diorite. In the east branch of this brook, north of the sedimentary rocks, a dark green diorite, sometimes soft and containing traces of specular iron ore, is followed by coarse syenite with patches of green soft diorite.

Pine Brook.

In Pine Brook* not far above the Totten settlement, greenish compact and granular diorite, containing films of red hematite and blotches of white calcspar, in which are dendritic markings of specular iron ore, are associated in the cliffs with mottled greenish and reddish, fine, fragmental breccia; above which appear other rocks of the iron ore series in contact with greenish soft pea-breccia, containing globular

*Geol. Surv. of Can., An. Rept., 1885, vol. I., p. 56 E.

masses of dioritic rock; alternating with dioritic schist, flinty gneissic quartz-felsite, breccias with patches of sedimentary rocks, hornblende schist, striped quartzite, granular quartz-felsite and other gneissic rocks with a steep southerly dip. Near the head of the brook are coarse and fine syenite and diorite and whitish compact quartz-felsite.

Intercolonial railway.

The dykes of diabase and syenite,* which cut the Silurian rocks west of Wentworth station, have been already referred to. Between Wentworth and Folly, reddish, flinty, obscurely granular quartz-felsite and syenite are associated with diorite and porphyritic felsite, as described by Dr. Ells.† Below the outlet of Folly Lake, diorite and syenite are seen in several cuttings along the railway and in the river, succeeded by sedimentary rocks at the first snowshed near the siding, the latter being cut across and in the bedding by dark flinty diorite and reddish compact quartz-felsite, and intermixed with massive igneous rock and with chloritic and mica-schist veins of quartz, sometimes of large size being found in connection with some of the patches and prospected in the hope of obtaining gold. These rocks are well seen near the fork of the river, and are very interesting.

Search for gold.

Above the railway, the iron ore rocks of McElman Brook are cut by greenish, fine diorite, succeeded by light-coloured compact and granular quartz-felsites, flaggy and like gneiss in part, and by greenish-grey massive diorite or hornblende-rock. Blackish very fine diorite cuts the sedimentary rocks in several places up to the head of the brook. On the track from the east branch of this brook past Archie Slack's house to Folly Lake, masses of slaty diorite, chloritic and hornblende schists, greenish and whitish coarse and fine diorite are found with altered sediments.

Londonderry mines.

The syenite, diorite, felsite and allied rocks of the various branches of Great Village River have been already referred to. On the west branch, immediately above the bridge on the Cumberland road, black and grey diorite and felsite are in contact with light greenish and grey flinty slates, probably cut and altered by the former, while down stream the reddish and green slate and massive greenish and grey argillite and quartzite include the great vein of ankerite.

Economy River.

The rocks of this group in Portapique, Bass and Economy Rivers have been described in connection with the Devonian.

---

*Acadian Geol., Suppl., 1878, p. 75.

†Geol. Surv. of Can., An. Rept., 1885, vol. I., p. 57 E.

In Murphy Brook, as already stated, after crossing a great breadth of igneous rocks, purple and greenish altered slates, with quartz-veins, blotches of specular iron ore and hard small concretions, are the finest exposures of the black Devonian shales or slates with associated Guysboro' quartzite, full of matted plants. In a branch of this brook from the westward, one of the veins of quartz in a quartzite, conglomerate and slate, is more than a foot wide, but barren.

Quartz veins.

On the shores of British Lake are outcrops of greenish, massive, nearly compact diorite; and cliffs of greenish and reddish mottled, compact trap or diorite are found on a tributary of the Bass River to the northward. Lower down this river and in the neighbourhood of the Gundalow road, greenish felsite, syenite, diorite and trap are mixed with flinty slates.

Five Islands.

For a short distance above the bridge on the shore road, the North River of Five Islands displays fine outcrops of nearly horizontal Triassic shales. These are underlaid at a saw-mill by reddish, grey and greenish, coherent, fine sandstone and shale; and above them, with a high north-easterly dip, appear light grey, fine, flinty sandstones, with layers of dark shale full of *Naiadites*, and of carbonaceous matter, very like rocks of the North River of Onslow and precisely like the altered rocks of Portapique River. Higher up, the dip changes to 165° < 37°, then to 332° < 33°, and again to 155° < 22°, and dark crumbly argillites, breaking into long knife-shaped pieces, are full of fossil plants, show an inch band of coaly shale and are overlaid by greenish compact sandstone or quartzite, containing ferruginous matter and associated with a greenish shale, like that of the mill-dam, full of *Cordaites*, ferns and other fossil plants and penetrated by minute veins of limonite. Near the seventy-two feet fall occur greenish-grey massive, flinty sandstone or quartzite, nearly vertical, resembling certain iron ore rocks of Great Village River; cream-coloured massive quartzites, with veins of siderite and ankerite; cream-coloured and olivaceous soft shales, with a coaly band, three feet thick, and a large vein of iron ore on top; dark and light grey flinty quartzites and slates in contact with a massive diorite, containing calcspar and hematite. At the top of the fall are greenish and dark slates and quartzites, probably the altered equivalents of the rocks near the mill pond, with greenish diorite-schist, whitish, compact crystalline limestone or marble, spotted with grey, greenish and yellowish, white-weathering, fibrous serpentine, perhaps in a vein, and grey massive diorite. Above the outcrop of marble are others of dark and light-coloured shales or slates, sandstones or quartzites, up to a little brook from

Sedimentary rocks.

Igneous rocks.

Marble and serpentine.

the westward, above which wrinkled slates are intersected by small dykes of diorite and syenite; while still higher these rocks totally replace the slates.

Up the little brook mentioned above, red syenite prevails. From its head, blocks of syenite, diorite and altered slate are found to the the back road at Lynn. Lynn.

In the first large branch of Harrington River from the westward above the Parrsboro' road, coarse syenite and diorite are associated with grey flinty quartzites and red or purple porcellanite, dipping, 288° < 50°. Higher up are blackish diorite or breccia, full of grains of specular iron ore, and cream-coloured, soft, pyritous, brecciated vein-rock, among greenish slates and chlorite-green, wrinkled diorite-schist, with small veins of mixed quartz and calcite, which extend for some distance and are then succeeded by more massive red syenite, reddish and brown granular quartz-felsite and felsite, often porphyritic and epidotic. In a small branch of this brook from the north-east, bright indian-red altered argillite is associated with reddish and greenish trappean rock. Above the fork, reddish epidotic felsite and amygdaloid extend to the wet, mossy lands at the head. In an adjoining brook to the westward, at the Parrsboro' road, grey, flinty, Devonian flags, and black slates, dip 34° < 50°; and above the road contain plants. Where the brook comes over a fall thirty feet high, grey, coarse syenite is exposed; above the fall, greenish-grey schists dip about 177° < 45°, near a mass of red syenite; then light greenish-grey and grey quartzite-flags and dark slates, precisely like the sandstones and shales down stream, but more altered, are cut by ferruginous veins an inch thick, and succeeded by purple porcellanized argillite, light grey soft argillite, greenish, cream-coloured and grey calcareous breccia, replaced in turn by syenite and diorite with small patches of grey slate. Harrington River. Mixed sedimentary and igneous rocks.

At the head of a branch of Moose Creek, immediately to the westward, red syenite, porphyritic felsite and quartz-felsite are well exposed to the bottom of the hill, where light grey, flaggy, flinty sandstone and dark shale, not much altered and containing *Naiadites*, dip 202° < 46°, being, perhaps, separated from the syenite by a fault. Immediately below the contact, a little brook from the left shows grey, coherent flags, dipping 74° < 17°, while at the post-road dark shales and flags dip 134° < 5°, but, a short distance to the eastward, strike in vertical beds 127°. In the branch from the left, a considerable thickness of grey, rubbly sandstone or quartzite and shale dip 155° < 17°. In a little tributary from the north, they show markings of *Calamites*, seem to pass Moose Creek. Fossils.

into flinty, quartz-veined porcellanite and quartzite, and are spotted with specular iron ore; and on the hill these latter give place to red syenite. At the head of the very steep and rocky little branch of Moose Creek, west of those mentioned above, red syenite is well exposed. Down stream it includes a mass, five feet wide, of dark green, fine diorite, immediately succeeded by or mixed with, greenish, compact, soft and hard argillite or rubbly porcellanite; light grey and greenish argillite and quartzite, veined and twisted, dipping 167° < 80°, the veins being mostly of reddish compact and fine grained syenite and felsite; nine feet of massive syenite with a patch of veined, bedded rock; dark red and greenish, nearly compact, fragmental felsite; followed by dark grey Devonian argillite, breaking into cubical blocks, interstratified with greenish-grey sandstone or quartzite, like that of Loch Lomond, with yellow ochre in the joints, dark grey argillite and light grey sandstone, with obscure fragments of plants. About twenty-five yards lower, a band of blackish shale, only partially exposed, has an altered aspect, breaking out in rectangular blocks or in pieces with a woody-fibre cleavage, difficult to split in the bedding, but showing on some layers *Naiadites* and a long, grass-like plant; it dips 157° < 32°, and is succeeded down stream by sandy micaceous flags and dark shales, with *Naiadites*.

Contact with sedimentary strata.

West Branch of Harrington River.

The falls of the west branch of Harrington River at the fork show red felsite and quartz-felsite, massive, compact or finely crystalline. Above a fifty-foot fall, about a mile from the fork, felsite and syenite are in contact with greenish and light grey slate and quartzite, probably greatly altered sediments, succeeded by greenish and dark grey massive argillite, dipping 142° < 36°, and containing minute veins of quartz; these rocks, after occupying the brook for more than half a mile, become mixed with dark and light green and grey diorite and felsite and red syenite, at the upper end of which, coarse, grey, soft, calcareous, dioritic rock, in contact with light grey, altered, flinty argillite, is succeeded by light greenish schistose rock, perhaps, also, altered argillite, and by greenish slates, porcellanites and schists, the whole occupying a breadth of 340 yards, beyond which the brook comes through alders and mossy land in a spruce thicket, in which no rocks are seen for a distance of 1,430 paces to a small rapid about three miles from the fork, at which a compact rock, perhaps an altered argillite, is associated with greenish epidotic diorite. In the level, wet land between the head of this brook and a portable mill near the head of a tributary of Harrington River no rocks were seen; between this mill and the north end of the settlement of Lynn at

Lynn.

Peter A. Lewis's house, are several outcrops of red coarse syenite and greenish diorite; but, immediately north of the house, and also in the fields south-west of George McLennan's, are grey and greenish altered slates. Below Lynn, Harrington River shows in its gorge similar intermixtures of greenish massive and schistose diorite, red syenite and greenish flinty slates, the diorite-schists having, for a great distance, in common with the other laminated rocks, a low dip to the eastward, containing chlorite, epidote, minute veins of quartz, in some places asbestiform fibres, several inches in length. Similar alternations are seen on the road to Five Islands. Asbestos.

The junction of the two series is also well exposed in several of the branches of Boyd Brook. Between the river and the lower bridge on the Lynn road, dark shales and flags and grey sandstone or quartzite dip very regularly 154° <45°; while at the old mill-dam above the road, purple and greenish, mottled, flinty, rubbly rocks, like those of Brian Daly's Brook, have a nearly vertical southerly dip and are underlaid by the light grey and greenish-grey, rusty-weathering, compact, massive and rubbly quartzites of the iron ore series. Higher up the brook, dark slates and flags display obscure carbonized plants; one portion looks like an underclay and has a lenticular patch of coarse grey grit. The lenticular, pyritous and siliceous plates or veins of the rusty rocks may represent the ironstone of the less altered strata; the dip is greatly contorted and scales of specular iron ore are abundant. At two points the rusty-weathering rocks, greatly veined with ankerite and spathic iron, are mixed with what seems to be a fine agglomerate, breccia or claystone, soapy and soft; the second outcrop being thirty yards below a little brook from the eastward. For about 180 paces above this fork, rusty quartzite and purplish-grey argillite are exposed. Immediately north of it, on the Lynn road, grey and reddish quartzites are succeeded by felsitic, dioritic and syenitic rocks like those described above. At forty paces up the little brook from the eastward, red syenite is also exposed for fifty-six paces; then whitish, soft, soapy claystone or breccia, for seventy paces, with lumps of quartzite succeeded by light quartzo-felspathic rock, perhaps sedimentary, with a shale or slate, rich in graphite, which has been prospected by a tunnel. Then for 283 paces are alternations of blackish diorite, greatly altered, purplish, dark and light grey flinty flags, whitish or cream-coloured calcareous flags, dark, flinty, rubbly sandstone and grey soft sandstone or breccia; then 165 paces of red syenite succeeded by masses of light greenish diorite, broken up in a search for asbestos, which occurs irregularly intermixed with Devonian strata. Contact. Graphite mined. Asbestos.

quartz veins. At 155 paces beyond, the hill exposes purple rubbly sandstone or quartzite, interstratified with greenish and dark slates; and other intimate associations of these different rocks have been traced in the fields and brooks of the neighbourhood, as shown on the map.

Moose River. Igneous rocks are in contact with the Devonian of Moose River about a mile above the Parrsboro' road. About 250 paces above this road, dark shales, striking 314° with a vertical dip, are interstratified with flinty flags; while 375 paces higher, the dip is 151°<25°, and continues at this moderate angle for some distance. The sandstones contain small veins of quartz; the shales, nodules of ironstone, rootlets, stems and leaves of *Cordaites;* while both are intersected by veins and blotches of ankerite. About ninety paces below the first appearance of the igneous rocks, greenish-grey, flaggy sandstone or quartzite and dark argillaceous shale, containing small threads of limonite, dip 162°<58°, and some of the finer beds show good specimens of *Cordaites.* Then after a concealed interval, come greenish-grey, massive, white-weathering, felspathic and dioritic rock, passing in places into red syenite; succeeded immediately by grey, flinty, porcellanous slates, cut by veins and blotches of red syenite, a foot thick and downward, and resembling what one would imagine the fossiliferous rocks down stream might alter into. These rocks occur at a brook from the north-east and are succeeded by cliffs of red syenite as far as a large brook from the north-west, immediately above which, greenish compact sandstone dips 162°\/ 68°, interstratified with green slaty or schistose rock, in part apparently dioritic, with flinty flags or compact quartzite, dark grey porcellanized argillite and light grey sandstone or quartzite, full of quartz veins which contain chlorite. About 585 paces above the last little brook, the river comes over a fall into a deep pool, above which is an inaccessible gorge. Slates extend to within 130 paces of the face of the fall and are in contact with greenish diorite and red felsite; and from the fall up to the large driving-dam, indian-red, spotted, soft trap or volcanic-breccia, passing into compact flinty felsite containing aggregations of quartz and red porphyritic crystals, is associated with greenish massive diorite on the hill, the

Falls. gorge being occupied by three falls, one of which is said by Mr. Jones to be 108 feet high and the aggregate of the three more than 200 feet. Above the driving-dam, red and purple porphyry and greenish and reddish amygdaloidal trap extend to the fork.

Most of the tributary from the north-east below the falls, is occupied by red syenite, passing into red, compact, porphyritic quartz-felsite, and dark fine diorite, which in one place has a flat

bedding or lamination, and is succeeded by a patch of greenish and dark grey altered slate, with quartz veins. The brook from the north-west shows syenite and diorite at its mouth, then a considerable breadth of dark and greenish slates, dipping 207° < 40°, in part schistose, mixed with diorite as far as a very pretty twenty-five feet fall, above which bright-red, compact and granular, porphyritic quartz-felsite and felsite occupy the stream to its source.

West Branch of Moose River.

A short distance above the Parrsboro' road, on the west branch of Moose River, great cliffs of red syenite form the mouth of a gorge. Below them, on the left bank, are dirty green and dark diorite, and reddish felsite and quartz-felsite; and not more than seventy paces down stream from the last outcrop of this igneous rock begins a fine exposure of grey glistening quartzite or sandstone, like that of Loch Lomond, veined only with small threads of ankerite, and not more altered than is usual with these rocks at a distance from the syenite; rather massive, with beds of coarse grit, full of fine specimens of the coarser parts of *Lepidodendra*, *Calamites*, *Cordaites* and other plants, with twisted, carbonized and graphitized surfaces; breaking into blocks of irregular shape, and quarried in one place for rough building stone. The dip is not distinct. At the head of a little tributary, which enters from the westward immediately below these outcrops, are knobs of red syenite, upon which in one place rests a dark crystalline diorite, which shows slaty cleavage; and less than two hundred paces lower, rubbly felsitic and dioritic rocks are in contact with dark grey slaty quartzite and porcellanite, full of threads of quartz and calcspar, succeeded by very ferruginous, dark and light grey shale and sandstone or quartzite, the former full of *Naiadites*, *Cythere* and *Cordaites*, the latter showing only broken carbonized plants, resembling the country rock of the iron mines, containing numerous threads of limonite and ankerite, and dipping nearly vertically to the southward. They resemble also the porcellanites up stream, but are less altered; and where soft rocks come in contact with hard surfaces, certain planes are slickensided.

Fossil plants.

Iron ore.

Road from Moose River to Parrsboro'.

Along the Parrsboro' road to the westward, dark shales and flags dip 124° < 73°, and a little further 102° < 70°. They are followed by grey, rusty-weathering, compact, rubbly quartzites, like those of Loch Lomond, including a band of greenish-grey, wavy, flaggy sandstone, which in the next little brook dip 177° < 45°, while higher up the brook the dip is very variable. Up the brook which comes into the head of the pass on the road immediately to the westward, grey sandstone and shale prevail as far as a fall, where red felsite is in place; but above it, at another little fall, is

a very light grey fine sandstone, like an altered form of that seen at the road, but too rubbly to show fossils; beyond which, blackish slaty argillite is found nearly in contact with red and grey friable syenite, penetrated by veins of white crystalline limestone or marble.

Crystalline limestone.

Westward from the head of the pass, the road runs down a brook with a high hill of syenitic and dioritic rock on the north side, while on the south are dark graphitic slates, with rusty veins and nodules of crystalline limestone, interstratified with flinty quartzite, like that of the iron ore series, shown in several of the mountain brooks at and near the contact. Where the road to Parrsboro' leaves that to Prospect, the hill is still close on the right, indicating the boundary of a mass of igneous rock which is at the bridge 107 paces east from the fork of the roads, while up stream the brook shows porphyritic felsites and diorite to its head; and these rocks occupy a great part of the country back to an old mill about a mile west of the foot of Cranberry Lake, where grey and greenish-grey, greatly altered argillite and fine sandstone, dipping 277° < 15°, lie not far from cliffs of red and grey, compact, epidotic quartz-felsite and felsite. Along the south side of the escarpment the felsitic rocks can be followed to Parrsboro' River. West of the river, however, the low land which extends along Diligence River indicates the presence of light grey and greenish-grey, flaggy, rubbly quartzite and micaceous slate, full of quartz veins and dipping obscurely south; and dark and light grey flags and slates extend up to a saw-mill, above which they are intermixed with greenish, massive, epidotic diorite, fragmental felsite and syenite.

Cranberry Lake.

Head of Diligence River.

West Branch, River John.

3. *Post-Carboniferous Igneous Rocks.*—On the west branch of River John above the village are masses of dark grey amygdaloid, passing into dark green diorite, the former prevailing, being veined with calcspar and containing amygdules of calcspar, chlorite and various white zeolites. These rocks seem scarcely to affect the red marl and other Permian sediments with which they are in contact. In Plainfield Brook, near McKay's, are small exposures of very flinty, light grey and brick red, spotted felsite and quartz-felsite, underlaid by light greenish-grey, soft, trachytic rocks; while on the roads in the vicinity diorite and trap also cut the Permian.

But the finest development of the trappean rocks of this age is found overlying, cutting through or contemporaneous with the Triassic, forming Gerrish Mountain, Indian Point, Five Islands, Two Islands, Partridge Island, Cape Sharp, Spencer's Island and other headlands and islands of the north side of Minas Basin

North side of Minas Basin.

described by Gesner,* Jackson and Alger,† Lyell,‡ Dawson,§ Ells,|| and other writers, so fully that they need not here be referred to. A detailed description of the shore between Five Islands and Cape Sharp and a section of the junction of the sedimentary rocks at Two Islands is given by Sir J. W. Dawson.**

Scenery, Climate, Timber, Productions, etc.

Natural history.

The natural history of the district need not be "particularly described, as its flora and fauna are the same with the other portions of the province. The beaver has become extinct, though the effects of his labours may yet be seen in various places," several of the shallow lakes owing their origin to his dams. "Its meteorology exhibits little of interest as distinct from other portions of the province. Like the rest of the north coast it presents a remarkable contrast to the southern, in its almost entire freedom from fog. The mean and extreme temperatures are, however, higher there than here, owing specially to the influence of the Gulf Stream. The ice which comes down from the north in spring lingers long off our coast, cooling the air, so as to retard vegetation and impart a rawness to the east winds at that season, which is trying to the health, particularly to persons under any pulmonary weakness. The autumn, however, is much finer than on the south coast, there being much less wet weather, and the southern gales of that season being felt less severely." ††

Meteorology.

Geography.

References to the geography have purposely been omitted wherever it was possible by the map to indicate the structure in such a way as to assist others in finding the localities examined, minuteness of detail being reserved for the description of the outcrops. For fuller information concerning these and other particulars, the authorities cited above, those given in last report,‡‡ Lyell's Travels in North America, the more recent histories of the province, and the various Transactions of the Nova Scotia Institute of Science may be referred to.

---

*Geol. and Min. of N. S., pp. 229-262.

†Mem. of Amer. Acad. of Arts and Sc., vol. I., 1833, pp. 262-279.

‡Travels in North America, vol. II.

§Acadian Geol., pp. 99-108.

||Geol. Surv. of Can. An. Rept., 1885, vol. I., p. 61, E.

**Jour. Geol. Soc. of London, vol. IV., p. 50.

††Patterson's History of Pictou, p. 21; Cf. also Trans. N. S. Inst. Sc., vol. IV., pp. 429-438, and other papers.

‡‡Geol. Surv. of Can. An. Rept., 1886, vol. II., p. 107 P.

Barrens. Excepting the areas of barren ground shown on the map, most of the land is fit for cultivation. The most extensive barrens lie at the head of the east and west branches of the East River of Pictou, on the West River of St. Mary's, south of the Pictou branch of the Intercolonial railway. In the neighbourhood of Maple Lake, the barren is covered with ledges of Devonian quartzite and slate, upon which blueberry and other small bushes, clumps of second-growth spruce and birch and many bog and marsh plants are noticeable. On Calvary Brook are patches of wet, mossy spruce land, bogs and small, wet barrens. Part of the country underlaid by Triassic sandstone near Debert is a blueberry barren, the soil being sandy, although near the shore it is easily reclaimed by the addition of marsh mud.

Timber. Large quantities of deal, of ship and ton timber and of hemlock bark for tanning are still obtained from the forests, as might be inferred from the large number of driving-dams seen on the streams and rivers, the logging-roads and sluices. But the pines have nearly all disappeared, and spruce is the prevailing soft wood cut.

Scenery. In the mountains and along all the Pre-Carboniferous formations the brooks and rivers cut deeply into the rocks, and are clean and rapid, the land being broken, uneven and hard to work, the hills

Falls. and valleys picturesque and beautiful. Falls of considerable beauty are found on the Moose River, on Economy River,* North, Waugh, Sutherland and other rivers. Near the contact of the felsites and Permian rocks in Four Mile Brook is a fall twenty-five feet high, at the top of which the water comes through a gorge six feet wide; but instead of falling vertically it is dashed against the rocks and spread for twenty-five yards at the base all broken into white spray. Above this fall are others in a rocky gorge through which the brook runs in barren land. In the adjoining brook, called Little River, are the Drysdale Falls, thirty-five feet high, above which rise cliffs thirty-five feet high, and a pool at the foot of which is said to be thirty feet deep. In Fall Brook is a pretty little fall eighteen feet high, from which the brook derives its name.

Meadows. On many of the sluggish streams of the low land there are large hay marshes or meadows, overflowed by freshets. The

Dykeland. dykes by which large tracts of land along the Bay of Fundy are preserved from its turbulent tides have often been described. Many of the old French dykes have been replaced by more modern ones, which cross the brooks at their mouths instead of turning

Sand flats. up along them. The tidal sand-flats of Shubenacadie River are shifting, like other masses of loose material along the Basin. The

*Gesner's Geol. and Min. of N. S., p. 134; Acadian Geol., p. 557.

channel is narrow at low water, and the banks of the river high and rocky by turns.

Caves. On a rough branch of the Millbrook, off the Florida road, is a cave said to be "capable of seating a congregation." In the limestone of Cross Brook is another cave; and at the contact with the Silurian East River. the water of Holmes Brook runs beneath the limestone, to emerge as a strong spring at the Sluice, the original valley of the brook following a different direction. Several other beautiful little streams occur in the vicinity. Calder Lake is a famous resort for ducks and geese, which come to dig up and eat roots, and trout are also caught in it. The roads on both sides of the East River are beautiful; near Bridgeville and St. Paul's they follow a fine intervale, being cut through gravel banks, bordered with wild roses and overhung by large trees.

Waugh River From a crack in the Permian conglomerate of one of the branches of Matheson Brook issues a large spring. The valleys of this brook are very beautiful. The soil of the conglomerate is as rich and fertile as that of Greenhill, Rogers' Hill, Fraser's Mountain and Mount Dalhousie, although the rock is in place so near the surface as to be scratched by the plough and has rendered the land barren in patches after long cultivation. The fertility of the conglomerate land is in striking contrast with the less productive character of the soil of the belt of grey sandstone overlying it, as shown by the farms.

Chiganois River. On the road from Patterson's mills on the Chiganois River, the land is not hilly, but syenitic rocks are frequent in its bed and in other parts of it corduroy has been built across the swamps. The land is poor, fit only to grow spruce and hemlock, an immense quantity of which has been taken from this district; and the same remarks will apply to most parts of this mountain range upon which no farms have been cleared.

Crops. Fruit and wheat do not ripen as well, it is said, on the shores of Minas Basin as on the Gulf shore at Merigomish, River John and Brulé; and at Pictou Island "crops appear to be more luxuriant than on the mainland,"* the soil being generally a sandy loam, which yields hay, grain and vegetables; but there is no fruit raised upon it, the exposure to sea air being unfavourable to its culture.

Botany. A list of plants found in the neighbourhood of Truro, including some found at Stewiacke, Brookfield, Valley, Onslow, Debert, New

*Trans. N. S. Inst. Sc., Second series, vol. I., p. 78; and Patterson's History of Pictou, p. 281.

Annan and Tatamagouche, is given by Dr. Campbell;[a] a Synopsis of the Flora of Nova Scotia, by Professor Sommers,[b] the plants of Pictou county being for the most part given on the authority of A. H. McKay, Superintendent of Education for Nova Scotia; and Notes for a Flora of Nova Scotia, by Professor Lawson.[c] The native trees, fishes, &c., are described by Gesner.[d]

White lilies and violet flags were in bloom in the hay marshes near Centredale on 13th July, 1887, and in Cranberry Lake on 1st September; and the fragrant pretty little pink floating spikes of the water persicaria (*Polygonum amphibium*—var. *aquaticum*) in Forbes Lake on the 5th of August of the same year.

Economic Minerals.

In the foregoing pages reference has been frequently made to the occurrence of various useful minerals and metallic ores among the rocks described. These will now be more fully discussed.

Coal.—Statistics of the condition and production of the various collieries of the Pictou coalfield to 1869 are given in the elaborate report of Logan and Hartley.[e] Since that time this field has been described by Mr. John Rutherford,[f] Patterson,[g] Gilpin,[h] Dawson,[i] Poole,[j] in the annual reports of the Department of Mines for Nova Scotia and in those of the Division of Mineral Statistics and Mines of the Geological Survey[k] and in the Canadian Mining Manual, pp. 91, 133 and 157.

Lorne, Big Brook, Kemptown and West River.

Mention has already been made in the course of this report of attempts to work coal in other localities, as at the Big Brook and Lorne, in graphitic shales or slates. At Kemptown on the north side of the Telegraph road, several shafts and a boring, said to be 137 feet deep, have been sunk on a small seam of mixed coal and shale, which is from two to four feet in thickness. Fragments of good coal were seen among the debris at the pit mouth. This is perhaps the seam opened among the nearly vertical flinty rocks above the

a Trans. N. S. Inst. Sc., vol. VI., pp. 209 and 283.

b Trans. N. S. Inst. Sc., vol. IV., p. 181.

c Trans. N. S. Inst. Sc., Second Series, vol. I., p. 84.

d Industrial Resources of Nova Scotia, pp. 77-151.

e Geol. Surv. Rept. of Progr., 1866-69; Cf. also Acadian Geol., p. 329.

f Trans. North of England Inst. of Min. and Mechan. Eng., May, 1870,; Canadian Min. Manual, Ottawa, 1892, p. 1.

g History of Pictou, 1877, p. 398.

h Mines and Mineral Lands of Nova Scotia, 1880, p. 15; Trans. N. S Inst. Sc., vol. III., p. 281; vol. IV., p. 89; vol. VI., p. 42; Trans. Roy. Soc. Can.

i Acadian Geol., Suppl., 1878, p. 40.

j Trans. Amer. Inst. Mining Eng., vol. XIV., p. 403.

k Geol. Surv. of Can., An. Rept., 1886, vol. II., p. 18, S; 1887, p. 16; 1888, p. 17; 1889, p. 18.

railway between West River station and Riversdale and again in the south branch of the North River below Mingo's.

About ten chains above the road to Delaney settlement on Coal-mine Brook, openings have been made on a coal seam, containing eighteen inches of stony coal, with two or more partings, overlaid by a great thickness of fine sandstone and underlaid by greenish shale or underclay, which also shows a few thin coaly bands. This locality is described by Gesner as worked during the winters of 1834 and 1835.* The present workings at the mine are on the top of a bank a short distance from the brook. The coal is bright and good, with cubical cleavage; but the stone partings exceed in places an inch in thickness. Higher up the stream, dark shales include streaks of bright coal; and about a quarter of a mile above the first seam is another, of at least three feet of carbonaceous shale, from which in places a foot of shaly coal can be obtained: this also has been worked to a small extent; and other coaly streaks occur in a band of rocks perhaps a mile in width. The slope, on the first seam, was 100 feet deep, and laid with wooden rails worked by a horse-gin and pulleys. A small frame house was erected for the miners, a forge and other necessary buildings, $1,500 being spent in development in 1889.† North River coal.

The coal in the grey sandstone or conglomerate, near Higgins' mill on the Chiganois River, is in pockets, six inches wide, but dwindling within three feet to mere threads. That dug some miles down the river was nearly all coaly shale.‡ Chiganois River.

At Debert River in Cottam settlement, bore holes have been put down and several shafts sunk on a coal seam or seams, concerning the thickness of which great differences of opinion have been expressed: for while Dr. Ells states that in the slope it was only twelve to fourteen inches of dirty coal, by Mr. Gilpin it is supposed to be of considerable value.§ The basin is evidently very limited and broken by faults. Immediately above the bridge a coal seam of a thickness of eighteen inches is exposed. Other deposits of no economic value further west have been already referred to, including that of Malagash. Debert River

Malagash

The coal of Caribou Island has also been referred to. Mr. McBean states that in one place it appeared to be four feet thick, but that this thickness was due to a little fault. Caribou.

*Geol. and Min. of N. S., p. 130; Acadian Geol., p. 275.
†Canadian Mining Manual, 1892, p. 119.
‡Geol. Survey of Can. An. Rept., 1885, vol. I., p. 46, E.
§Trans. N. S. Inst. Sc., vol. VI., p. 93.

On the road north of Poplar Hill several deep shafts have been sunk in search of coal; at one of which pieces of coal two inches thick are found among debris of greenish argillaceous shale. The land in the neighbourhood is barren, abounding in blocks of grey and reddish sandstone and shale.

Kennetcook. Coal has at various times been reported to occur at Kennetcook (page 97) and the vicinity. In the second little brook on the right bank of the river, below the bridge on the road to the Gore, a little coal was dug, consisting apparently of streaks and pipes in a grey sandstone full of carbonized plants and *Stigmaria*, limestone being in the river immediately down stream and also at several points above. In this brook and in another below, a quantity of grey soft sandstone dips 107° < 10°–20°. About two miles to the southward, the whitish quartzose sandstone or pebbly grit used for the foundation of the new Presbyterian church is obtained, and beyond it come the auriferous slates of the Gore.

Selma. The coal reported to occur at Selma, is said by Mr. James Fraser, to consist only of thin bands of dark grey shale, with markings of plants, among thick layers of the grey flinty sandstone which forms the barrens of the neighbourhood.

Stewiacke. The search made for coal at the East Brook of Stewiacke, has been described on page 93. Explorations have also been made on the bank of Little River among the Carboniferous limestone.

Little Bass River. In a branch west of Little Bass River, near Robert Young's, a level has been driven on opposite sides of the brook, into a small coal seam, said to be a foot thick, although in this thickness seems to be included a large proportion of dark grey shale, containing masses of pyrite and ironstone. Up stream are other little seams, one of which is two inches thick, and resembles a vein rather than a bed, the inclosing rocks being reddish and grey fine sandstone and shales, greatly broken and underlying unconformably a coarse, reddish conglomerate which is probably Triassic.

Kirkhill. At the Kirkhill limestone quarry, about two miles and a half north-west of Parrsboro', coal has been found beneath nearly vertical, dark, flaggy limestone, associated with grey sandstone and shale, full of large plants. Mr. Tipping, of Parrsboro', states that at the bottom of a shaft seventy-five feet deep, the coal, which was only a few inches thick at the surface, had increased to two feet, and become more regular. In other bands of the limestone, traces of good coal are found, sometimes twisted and more like veins or lenticular masses, than beds of coal. Beneath the coal is a layer of light, soft, argillaceous shale or clay, containing nodules of ironstone, below which is broken sandstone. The coal is good; ignites very readily,

burns with a bright flame, leaving a light porous coke which contains a quantity of white calcareous ash and of reddish ferruginous ash. The quarry lies on the north side of a little hill. The low flat land to the northward shows no rock, and between it and Parrsboro', there is said to be a great thickness of sand and gravel, one well having been sunk sixty feet without reaching bed-rock. On the west bank of Parrsboro' River below the town, other little seams of coal are reported by Mr. Scott Barlow. Parrsboro.

Below Parrsboro', in two branches of a tributary of De Wolf Brook, a seam of coal which has attracted considerable attention, occurs in a conglomerate largely composed of pebbles of red Devonian sandstone and argillite, perhaps an outlier from the main body to the northward. Some of this conglomerate is red, but the greater part, greenish or dark grey; at the mine it is interstratified with layers of rusty-grey, coarse sandstone and soft argillaceous shale, holding carbonized plants, said to make good whetstones. The dip is not well defined, the rock being like a great irregular mass of drift, but is about 2° < 70° According to Mr. Barlow, who examined it in August, 1878, the section is as follows in descending order:— Brookville.

	Feet.	Inches.
1. Conglomerate.....		
2. Shaly coal, top seam.....	1	6
3. Grey argillaceous shale.....	6	0
4. Coaly shale.....	0	6

It has been opened at several points along the brook. Above the last opening is a red conglomerate with bands of soft red marl and sandstone. Below the conglomerate lie sandstone and red and purple argillites which appear in the pebbles; and up the main brook to its source, are light green soft breccias, soapy slates with small and large masses of quartz, and dark grey sandy slates, showing obscure shiny fragments, perhaps of plants, but not well exposed.

In this connection may be introduced an account given by Mr. Alex. McBean, of explorations made by him in 1888, in search of coal at Hallowell Grant.* Here a thickness of 150 feet of black shale, containing twenty feet of curly cannel, mentioned by Campbell, and a little coal, is underlaid by a great thickness of greenish shale, underlaid in turn by coarse sandstone and soft conglomerate. Mr. McBean supposes that there are several bands of this shale arranged in the form of a basin which underlies the limestone of Big Marsh post office, and is perhaps broken on the north side by a fault. The west end of this basin seems to be at the fork of the old Gulf road, and the east Hallowell Grant.

*Geol. Surv. of Can., An. Rept., 1886, vol. II., p. 113, P.

end at the fork of a large brook two miles east of the post office. It does not seem to pass more than half a mile north-west of Big Marsh road or half a mile south-east of McGillivray's road, until it is underlaid by the coarse sandstone and conglomerate. Dunlop's pits are north-east of the post office. A long tunnel is in the brook, half a mile east of the post office; it was driven 150 feet in black shale, cutting at the end a seam from which coal is said to have been taken. At a very small brook west of the long tunnel, the limestone overlies grey and reddish conglomerate. Up the west branch of this brook is the best coal seam in the district, said to be five feet thick and to dip to the westward, but to be broken off both east and west of the brook. A considerable quantity of coal was extracted from it. The dark shales are nearly all curly and polished; the masses of coal are lenticular or crushed. In most cases it is a hard bituminous variety, somewhat shaly, streaked with pyrite; but in places it resembles cannel.

West River. At the Twelve Mile House on the West River of Pictou, a boring was made 280 feet, in search of coal, supposed to be associated with the grey Permian sandstone and other rocks of this neighbourhood.

Blue Mountain. The dark Silurian slates of Blue Mountain have been dug for coal, and in the same neighbourhood the irregular veins of quartz associated with steel-grey, silvery and rusty slates or schists have

Bridgeville. been tested for gold. Near a mill on Archibald's Brook, at Bridgeville, black graphitic* Devonian slates were supposed to contain coal; while half a mile west of the mill, pits were sunk in search of iron ore. Near Hopewell, in somewhat similar rocks, on the farm of Jessie Grant, a shaft was sunk twenty-one feet in 1886, and from it was taken a quantity of black, shiny, graphitic clay-slate, supposed to indicate coal, and mixed with much calcareous and ferruginous vein-matter, and also with hard siliceous layers. Another pit lies about twenty-five yards from the first. About $500 are said to have been spent in exploring here.

Pictou Harbour. On the right bank of Corbett Brook, not far above the railway at Sylvester, a bore-hole in search of coal is said to have struck Permian limestone at a depth of 400 feet. The small coal seams of Pictou, Rear Brook, Abercrombie Point and the vicinity are described by Mr. Poole.†

Albertite.—This mineral is found in small veins and blotches on the west branch of River John, above the village, in somewhat coherent conglomerate and sandstone in the bed of the river and on

*Trans. N. S. Inst. Sc., vol. II., Part IV, p. 70.

†Trans. N. S. Inst. Sc., vol. I., pp. 36-40.

the left bank, the veins ranging from half an inch downward, and being mixed with calcspar and baryte. In places the films are very numerous, and there are blotches among the pebbles of the conglomerate. It is found at other localities in this vicinity but nowhere in large quantities, according to Mr. Donald Fraser, who prospected here for some days.

Magnetite.—The amygdaloid of Gerrish Mountain, Cape d'Or, Cape Sharp, and other points on Minas Basin contains masses and veins of magnetic iron ore, one foot wide and under, "exceedingly irregular in their course and often terminating abruptly, so that little dependence can be placed upon them for mining, although the ore is very rich."

Bog Iron Ore.—Traces of bog iron are found in several places already alluded to. The fields behind the post office at Bridgeville, in the neighbourhood of a limestone quarry, are rusty with this mineral. A very rusty clay or impure bog iron is seen on the west bank of Debert River, above Shatter Brook; but is of no value. Deposits occur, according to Mr. Barlow, at Clarke's Head, Fullerton Lake and other places.

Clay Iron-stone, Siderite, Ankerite, etc.—The almost universal occurrence of veins containing carbonate of iron among the Devonian rocks, has been so often referred to in the course of this report as to require little further notice. They all seem to pass into, or to be mixed with specular iron ore and limonite. The spathic ore of McLaurin's (p. 74) has been described by Mr. Hartley. It is associated with greenish-grey grit, reddish flinty grit and sandstone, more like Cambro-Silurian than Carboniferous, but, perhaps, altered along a fault. It contains pebbles of syenite and felsite and others of reddish flinty grit. A reddish, impure limestone has been quarried and burnt for lime, and the iron ore may be a Carboniferous contact deposit.

East River Pictou.

Limonite.—Mining operations have been vigorously begun by two companies on a vein of limonite* which lies at the contact between the Carboniferous and Pre-Carboniferous rocks on the north bank of the East River of Pictou, above Springville. By one of these, the New Glasgow Iron, Coal and Railway Company, a railway thirteen miles in length has been constructed from Eureka (Ferrona), to Sunnybrae; and blast furnaces and coke ovens

*Gesner's Geol., p. 63; Geol. Surv. of Can., An. Rept. 1886, vol. II., p. 115, P; Gilpin's Mines of Nova Scotia, p. 63; Reports of Commissioners of Mines for 1872, p. 37; for 1874, p. 51; for 1875, pp. 61, 69; Trans. N. S. Inst. Sc., vol. II., pp. 71, 72; vol. IV., pp. 138, 142; vol. V., p. 204.

are being built at the former place.* By the second, the Pictou Charcoal Iron Company, the excellent ore on the Grant farm at Bridgeville is being prospected, 230 feet above the river; and a considerable quantity of it has been used for fettling at Londonderry. It is found here in large masses in the soil and also in place, mixed with traces of baryte, calcite, hematite, and other minerals. A face of twenty-five feet of ore showed at the end of the opening, and more was said to lie beneath the floor. It is hard and very pure, has cavities filled with botryoidal and laminated radiating ore, black or iridescent on the surface. On the west wall are shaly Silurian rocks, whilst on the north is a flinty compact rock. No Carboniferous is found in the cutting, but on the slope of the hill are pits denoting limestone or gypsum. West of this mine, openings have been made on the right bank of Grant Brook. The lowest tunnels run west forty-five feet. Another, thirty-five feet north-east, driven by the Londonderry company, is cut fifty feet east and west, partly in red shale; and a shaft is on the top of the bank seventy feet from the mouth of the first tunnel. Here the ore was found to be soft, spongy and impure, about twelve feet thick, mixed with calcite and manganese ore, chiefly psilomelane. North-west of the ore is a rock which seems to be a soft trap.

Manganese.

Springville.

At McGillivray's, near Springville, a large quantity of iron ore debris is found near the buildings and also on the road near the contact of the Carboniferous; but the parent vein does not seem to have been yet discovered.

Where opened on the land of John S. Cameron in a pit, the vein was found to be twenty-one feet six inches wide. In the drift ten stones of manganese ore to one of iron ore were found, but none *in situ*. At Donald McDonald's, the ore is twenty-five feet thick with much manganese ore on top. At Fraser's (saddler), red slate, like that at Grant's Brook, has been cut in a shaft sixty feet deep, the ore being nearly vertical and from twelve to fifteen feet thick. At Duncan Cameron's, a pit twenty feet deep cut five feet of ore. Higher up the East River, about 125 yards above the fork of John McDonald's (Ogg) Brook, the ore is found to be two feet thick, having on one side Carboniferous limestone, on the other trap. At the Blackrock workings, above McDonald's Brook, and 200 yards above the river road, a large quantity of limonite has been exposed, apparently less pure than that of Grant's, laminated and with the layers separated by seams of clay. These layers are divided crosswise into blocks, and these blocks have *vuggs* containing botryoidal

Fraser's.

Blackrock.

*Report of the Department of Mines, 1891, p. 47; Can. Min. Manual, 1890-91, p. 93; 1892, p. 186.

concretions of limonite. Carboniferous limestone is in great masses along the lower part of the brook, while the "black rock" or massive trap rises a short distance above the workings. A little hematite and specular iron ore is found in the clay on the east side of a drift at the lower workings.*

Drug Brook.

At the bottom of the old dam on Drug Brook, limonite is dug in Devonian slates, but not in such abundance as the boulders found in the drift of the vicinity would seem to warrant. Here and at Cullen's, pits, some of which were twenty-five feet deep, were sunk in 1882, and long tunnels extended from them. The ore is compact, brown, somewhat siliceous, botryoidal and radiated.

Brookfield.

A vein of limonite was found at Brookfield, by Mr. R. E. Chambers, and in 1888 about 1,000 tons were extracted for shipment to Londonderry. The ore is found among red, flinty Devonian slates, but in the neighbouring valleys, Carboniferous limestone and gypsum are largely developed. A large vein of baryte has been worked not far from the mine.

Baryte.

Upper Kemptown.

As already stated, a considerable quantity of limonite has been found among the Devonian rocks of Upper Kemptown, associated with specular iron ore. At Dan Munro's, it has been prospected in several shallow pits. The ore is black, radiated and botryoidal and occurs in greenish, grey, rusty-weathering and purple rocks, in veins six inches and more in thickness.

Londonderry.

Limonite changes in depth.

The veins of Londonderry mines are described by Louis.† The ore, which occurred as limonite on the surface at the first openings, changed, on working deeper, into ankerite and siderite with sometimes a large proportion of carbonate of lime. This fact may explain why little or no black or brown ores are found in the bottom of the ravines cut by the rivers. Wherever they go deep, that is due, Mr. Leckie says, to fractures in the rocks. The same change, it is said, takes place in the deep workings on the East River of Pictou. At the East mines, several large, open cuts were made during the summer of 1891, in veins containing a mixture of spathic iron ore and other carbonates with specular iron ore, the latter being in cracks or joints, veins and spots. Part of the vein is brecciated, containing fragments of the green slate of the iron ore

*Trans. N. S. Inst. Sc., vol. III., page 171; vol. V., p. 31; and Geol. Surv. of Can. An. Rept., 1886, vol. II., p. 115 P.

†Trans. N. S. Inst. Sc,, vol. V., p. 47. Cf. also op. cit., vol. II., p. 112; How's Mineralogy, pp. 84 and 105; Geol. Surv. of Can. Reports of Progr., 1872-3, p. 19 1873-74, p. 229; Gilpin's Mines of Nova Scotia, p. 59.

series, and also apparently of the siderite, so that perhaps the veins which carry the specular ore are of subsequent origin and, as elsewhere, filled by sublimation in proximity to igneous rocks. The "white ore" may be in the same vein siderite, ankerite, dolomite or calcite, and has to be carefully selected. Two of the pits at present worked are those in Gory and Slack Brooks. At one of these a low tunnel was driven, several years ago, in the hope of striking the brown ore; but it cut only white ore. Professor Hind, in his report on part of the Cumberland coalfield, gives many facts concerning the iron mines.

Totten's Brook.

The iron ore of Totten's Brook, as stated above,* lies on the side of a hill north of a little marsh, on the south side of which are outcrops of igneous rock. A long open trench has been made on the iron ore from which has been taken a large quantity of brown and whitish ankerite, containing films and blotches of specular iron ore and vuggs in which are plates of baryte. The vein runs 292°, dipping to the south-west, for 120 feet; then turns to 257° for 210 feet to the end of the trench. It is of variable thickness. For some distance the excavation is four feet and a half wide, but further west much wider. On the footwall are the light green, somewhat soapy argillites, showing films of specular iron ore at the west end; on the hanging wall, a reddish flinty argillite. On both walls and in the vein is a large quantity of yellow "paint." It has been opened again in a little brook to the westward.

Birch Hill and Clifton.

The small veins of limonite at Birch Hill, near Bass River, and the more important deposit at Clifton,† have been described with the Devonian. Tables of analyses of many of the iron ores of Nova Scotia are given by Mr. H. S. Poole in the Reports of the Department of Mines for 1874, pp. 80 and 81; for 1876, pp. 58-60.

*P. 30; Gilpin's Mines of Nova Scotia, p. 60; How's Mineralogy; Geol. Survey of Can., Rept. of Prog., 1872-73, p. 35.

†Report of the Department of Mines for 1880, p. 15.

EXTRACTS from the Laboratory Book of the Londonderry Iron Company, Limited, Londonderry, N. S., General Manager, R. G. Leckie; Analysts: Henry Louis, J. S. Richmond, William Smaill.

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Peroxide of iron	99·39	48·72	71·81	54·18	65·64	90·79		50·35		74·63	86·74	84·29	68·94	49·48	77·91		
Protoxide of iron	0·32																
Protoxide of manganese		0·15	0·28	*1·36	1·55												3·02
Alumina		5·90	3·59		3·90												5·00
Lime		10·44	2·30	12·76	5·05	0·92											
Magnesia		0·78	1·00	2·10	0·80											0·427	
Phosphoric acid									0·03	3·80	0·399						
Sulphuric acid						1·38	1·26										0·57
Volatile matter	Trace.	8·52		18·04	10·24		5·20										
Insoluble matter	0·58	23·96	18·13	5·48	11·97	5·10	3·50	35·80	12·90	11·00	10·28	12·87	5·00	15·00	9·00		26·50
Metallic iron	69·81	34·11	50·27	39·08	46·73	63·55	59·10	35·25	60·69	52·44	60·72	59·00	45·45	34·34	54·54	61·38	47·50
Phosphorus									0·01	1·66	0·17					0·18	
Sulphur						0·55	0·54										0·23

*$Mn._3O_4$

EXTRACTS from the Laboratory Book of the Londonderry Iron Company—*Continued.*

Sample No.	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Peroxide of iron						58·74	58·01	51·44	66·22	63·79			26·39				
Protoxide of iron										23·88							
Protoxide of manganese	Heavy trace.							0·871		0·08	1·81	1·51	12·74				
Alumina								6·70			3·71	6·00					
Lime								0·18		0·11	22·90	16·10					
Magnesia								0·125		3·27	2·88	8·25					
Phosphoric acid	0·414					2·674		1·05		Trace.	Trace.	0·075					
Sulphuric acid	0·196							0·123		Trace.							
Titanic acid	None.																
Water							34·30							6·73	5·63		
Volatile matter						6·07		10·11									
Insoluble matter	10·12				15·35	18·19		25·00		8·83	3·00	2·10	33·50	24·29	16·54	25·66	
Metallic iron	55·74	56·45	41·85	56·00	44·24	41·12	40·61	36·01	46·36	63·23	26·45	25·25		44·18	49·22	36·19	24·55
Phosphorus	0·18					1·17		0·46				0·03					
Sulphur	0·08							0·05									

1. Specular ores. 2. Red hematite from Pictou River. 3. Red hematite, massive, from Nictaux. 4 and 5. Specular and ankerite, Totten's lot, East Mines; average. 6. Pyrites, calcined. 7. Specular ore, 14 samples from West Mines. 8. Specular ore from Parrsboro', Dr. Townshend's samples. 9. Magnetite from Lower Economy. 10. Red hematite from Torbrook. 11 and 12. Red hematite from Torbrook, the latter, the average of seven cars. 13. Red hematite from North River, lump. 14. Red hematite from North River, fine. 15. Red hematite from Cambridge, Hants county, Mr. W. F. Jennison's sample. 16. Best lumps of Torbrook ore. 17. Torbrook hematite; fine ore and rock matter. 18. Torbrook ore (J. T. D., Analyst). 19. Torbrook; average of seven cars. 20. Red hematite from Annapolis. 21. Average of Torbrook ore. 22. Average of 22 samples of limonite, chiefly from West Mines. 23. Brown hematite (mixed with red), from Horton. 24. West Mines. 25. Average of pile from West Mines. 26. Bog ore from Torbrook. 27. Magnetite from Five Islands. 28. Average sample of Totten Hill ore, East Mines. 29. Average sample of Slack's Hill. 30. Manganese ore from vein 4 ft. thick, Nictaux. 31. Average of 41 samples of brown hematite from Brookfield, taken from a very large quantity of the ore used in the furnace. 32. Brown hematite, average of 24 large samples from East River of Pictou. 33. Average of eight analyses of Canfield iron ore. 34. Average of 18 assays of white ores and ankerite. Silica less than one per cent, with traces of lime, magnesia and carbonate of manganese (0·68 to 2·63). When roasted the white ore has 30 to 58 per cent metallic iron.

Hematite.—Most of the samples of this mineral obtained from the various outcrops in the district contain more than twenty per cent of silica and have not been much used for iron making.

Exposures found among Silurian strata in contact with small patches of diorite have been developed a little between the heads of French and Sutherland Rivers. On the road between the church at McLellan's Mountain and the Brookville post office, red hematite was prospected, by Messrs. Holmes and Watson in 1884, by three pits, eighteen feet deep, sunk in grey earthy Silurian sandstone. Iron ore has also been found on the track from Squire Fraser's to the end of the road from the school at McPherson's mills. French River.

At Webster's or South McLellan's Mountain, on the west side of the road, is a large opening on a bed of hematite, eight feet thick, mixed with siliceous rock and traceable for three-quarters of a mile to where it is only two inches thick and does not contain more than thirty per cent of iron. The ore and the adjacent white quartzose grit follow the high land, the Clinton slate being usually denuded. To the eastward between this point and the road it was opened beneath four feet of surface and is twelve feet thick. East of the road are what appeared to be two parallel beds, but Mr. Fraser supposes them to be the same. In the first large cutting east of the road there is a twenty-inch parting of slate in the ore and also at the next pits to the eastward, where the ore is richer, but still contains a large percentage of quartz in grains. Webster's.

At Archibald Fraser's, on the Wentworth grant, on the left bank of Sutherland River, is a bluff outcrop of hematite,* forty feet wide in a north and south direction, apparently separating Silurian from Pre-Silurian slates. On his land east of a little lake, the ore is thirty-three feet wide from north to south and associated with fragmental slates. On the opposite side of the river, near Angus Fraser's house, the ore is in white quartzite, associated with pearly and felspathic slates. Wentworth Grant.

Near the west branch of Blanchard Brook, the bed of red hematite, opened at Fred McDonald's, is in bluish-grey, somewhat massive, quartz-veined, Silurian rock, a trench in which, eighteen feet by twelve feet, exposes three feet or more of ore. Further north at William Ross's an ore bed of considerable but irregular thickness, full of fossils, is associated with dark trap. Still further north at McDonald's,† occurs the large bed. The ore here is lenticu- Blanchard.

*Trans. N. S. Inst. Sc., vol. IV., p. 140.

†Trans. N. S. Inst. Sc., vol. II., part IV., pp. 68-72; vol. IV., p. 140; vol. V., pp. 201 and 205; Canadian Naturalist, vol. VII., p. 129; vol. IX., p. 332; Reports of Department of Mines for 1872, p. 37; for 1874, p. 81.

larly interbedded with Silurian, is full of shells, oolitic, blotched with calcspar and sometimes very pure, although passing in other places, as elsewhere stated, into rock which is merely stained with hematite. From this bed was quarried in 1828 the ore used by the General Mining Association in their blast furnace at Albion Mines.* At Evan McDougall's, hematite has also been found in Silurian rocks.

Newton Mills. Several hundred tons of hematite have been mined at Newton Mills† on Stewiacke River by the New Glasgow Company [p. 92]. The ore is of excellent quality, finely brecciated, and forms another of the contact deposits at the base of the Lower Carboniferous. With the iron ore or passing into it, is a reddish and grey impure limestone, containing shells; and overlying it at many points is a red calcareous conglomerate, containing pebbles of whin and of other rocks. The hematite has in places penetrated into the joints of the underlying slates and reddened them for some distance. An analysis, made for Mr. Graham Fraser by Tallock & Readman, of a sample of this ore showed it to contain:

	In Sample as Drawn.	In Dried Sample.
Peroxide of iron	68·97	69·14
Protoxide of iron	·24	·24
Bisulphide of iron	·29	·30
Oxide of manganese	Trace.	Trace.
Lime	·49	·50
Magnesia	·28	·28
Alumina	5·81	5·82
Silica	22·70	22·75
Phosphoric acid	·02	·02
Titanic acid	None.	None.
Carbonic acid	None.	None.
Combined water	·94	·95
Mixture	·26	.....
	100	100
Iron	48·50	48·63
Sulphur	·15	·16
Phosphorus	·01	·01

Tatamagouche. At Bailey's bridge, on the Little River of Tatamagouche, small veins in the schists show a mixture of calcspar and hematite which has been locally used as red paint.

Specular Iron Ore.—Explorations, made by Mr. H. W. Leslie for the Nova Scotia Midland Company, east of John McDonald's (Ogg)

*Patterson's History of Pictou, p. 425; How's Mineralogy, p. 97; Gilpin's Mines of Nova Scotia, pp. 63 and 67.

†Report of the Department of Mines for 1874, p. 51.

Brook, have developed a considerable quantity of this ore in veins and small pockets in a grey flinty Devonian rock. South of a little brook on the west side, Mr. Leslie has again found the ore and traced it nearly to the old pits on John McDonald's (weaver) land,* although nowhere so abundant as at the latter, where the ore is near the surface, either associated with or immediately north of large outcrops of black slate and quartzite. In the pits nearest the weaver's house, the specular ore contains numerous crystals of pyrite and veins of ankerite. The veins run approximately in the bedding of the rocks about 87°, and have been opened in a long trench and in a number of shallow pits. Search has also been made in the neighbourhood of Archibald's Brook. McDonald's.

The pits near the school at Marshdale are in trap, showing large blotches of specular iron. The Devonian slates of West River, about Watervale, contain ankerite and specular iron, widely distributed, but apparently only in small films and reticulating veins. Marshdale and West River.

On the right bank of Calvary Stream, at the driving dam, several small quartzose or siliceous veins have been developed containing specular iron ore in greenish-grey, wrinkled, more or less pearly, soapy, schistose slates, associated with ribbanded, flinty flags. As on the East River, black slates, lower down the stream, show a large quantity of graphitic matter. The veins of specular iron ore opened to the northward on Steele's Run are described on page 42. In the West Branch of Middle River, below Neil Matheson's mill,† this ore occurs in veins and blotches, sometimes six inches thick, in crystalline aggregations, and also in quartz veins in siliceous, rubbly, Devonian rocks. Calvary Stream. Graphite

Bog Manganese.—Small deposits of this ore, generally more or less mixed with bog iron, are of frequent occurrence but little value. On the hill south of Bridgeville it occurs in nodules and black earth. Concretions of bog manganese have also been found in the neighbourhood of Cameron (Meadows) Brook, not far from the pits mentioned above as cutting the Devonian altered rocks, spotted with crystals of pyrite. Above Glengarry, on a branch of Middle River, on Murdoch McKay's land, several shallow pits have been sunk on a deposit said to vary from six inches to a foot in thickness. Glengarry.

*Gilpin's Mines of Nova Scotia, p. 68; Trans. N. S. Inst. Sc., vol. II., Part IV., p. 71; vol. IV., p. 142; vol. V., p. 206; vol. VIII., p. 509; Report of the American Association, 1879.

†Reports of N. S. Department of Mines for 1881, p. 15; for 1883, p. 23.

Pyrolusite.—The mode of occurrence, uses and localities of this ore of manganese are given by Professor How,* Sir J. W. Dawson,† and Mr. Gilpin.‡

Farnham's Brook.

From the appearance of the rocks at Farnham's millbrook, in which it occurs in pockets in grey and rusty, concretionary, massive Carboniferous limestone, lying unconformably on the Devonian, this ore seems to be a contact deposit. The limestone also contains much disseminated red hematite, which, on weathering, imparts to it mottled shades of colour.

Manganese Mines.

At the manganese mines of East Onslow, a regular shaft has been sunk to a depth of fifty-five feet; but the principal workings consist of an equally deep irregular open cutting in red Devonian sandstones or quartzites, which dip very steeply to the southward, and in which the ore occurs in the joints and bedding, like the specular iron in other places, following one band of the flinty rocks. Between the shaft and the quarry is an argillite or clay-rock which effectually keeps the water of the shaft from passing into the present workings. The ore-joints which are richest, have a steep westerly dip, in some places a foot of pure crystalline pyrolusite being obtained. A large quantity of ore found in the soil and broken debris of the surface was passed through a jig, worked by a twelve-horse-power engine which also pumps the mine. That from the mine is picked and sorted on the surface, separated from the rock and put into parcels, the high grade ore containing little or no impurity, the low grade containing more or less rock. A small quantity of whitish clay-rock is mixed with the ore, which contains also in places particles and wedges of stone which form with it a kind of breccia. The mine has been worked intermittently for twelve or fourteen years, as many as twenty-two men having been employed at one time. Mr. McLennan, the manager, estimates that it has yielded 150 tons of ore.

Tenycape.

The manganese mine of Tenycape lies about a mile south of the main shore road, three-quarters of a mile west of Tenycape Brook. On the road to the mine are outcrops first of dark slates, then of coarse and fine greenish grit, and near the mine, of reddish and grey flinty slate, immediately beyond which is Carboniferous limestone. The deposit seems to be similar to the limonite of Londonderry; it is in veins in the hard rocks, associated with calcspar,

*Trans. N. S. Inst. Sc., vol. I. (3), p. 128; Mineralogy of N. S., pp. 110-126.

†Acadian Geol., p. 273.

‡Mines of N. S., p. 90; Report of the Department of Mines for 1885, p. 72: Trans. Roy. Soc. Can. vol. II., sec. IV., pp. 7-13.

baryte and other minerals; large masses have been found weighing hundreds of tons. The mode of working followed by Mr. Joseph Stephens, the owner, resembles that described above. The ore follows the bedding in a vein of variable breadth, a hard belt being above and soft rock below; and a cutting has been extended several hundred yards along it. Some of the ore is pure enough to use without dressing; but much of it is crushed, washed and jigged.

Copper Ores.—The presence of unimportant traces of copper ore has been indicated in the foregoing descriptions of the rocks of various localities.

In metamorphic rocks.

Small pockets and crystals of copper pyrites are found at several places in the neighbourhood of McLellan Mountain, in or near the Cambro-Silurian igneous rocks. Above the mills at Rocklin, traces of ore are found in dark Devonian slates, also in minute quartz veins on the west branch of Middle River, in a brook near Pembroke, and in other places, and perhaps the pits in the polished, shiny, graphitic shales of the Cross Brook of Lorne, which contain veins and layers of dark and light-coloured limestone and calcspar, with numerous specks of pyrite, were sunk in search of copper ore.

Recent explorations have developed a considerable quantity of copper ore among the felsites near Pinkietown, at the head of the Ohio River, of Antigonish.* Near the head of Six Mile Brook, copper pyrites is found associated with the felsites and diorites of Mount Dalhousie.

In unaltered strata.

Another class of deposits includes those found in concretionary rocks, chiefly Permian, in association with trunks of trees and other carbonized matter. On the West River below Durham, patches of greenish and grey conglomeratic rock in red sandstone have been mined for copper ore, which, like that of Pomquet and other places, consists of stems of plants, in part carbonized in part turned into copper ore and containing besides much concretionary calcareous matter; in Middle River on a little brook below and nearly opposite the Millbrook; and on the East River near Hopewell,† a similar ore is found. Opposite Angus Bailey's house on River John, grey copper ore was prospected in a grey sandstone. In the same neighbourhood on "The Brook," a spotted sandstone, marked with carbonized plants, has been dug for copper; and on the shore opposite the Presbyterian church at River John, and also in Plainfield Brook near the fork, many nodules of copper glance have been found. In Scotsburn

*Geol. Surv. of Can. An. Rept., 1886, vol. II., p. 122 P.

†How's Mineralogy, pp. 71, 72 and 208.

Brook, a pit twenty feet deep is said to have exposed a band of cupriferous sandstone five feet thick: and several hundred dollars were spent in mining here, while as many thousands were proably spent on the French River.* The copper ore of Plainfield, Caribou, Toney River, French River and Malagash is described on pp. 130, 135 and 138. The mode of occurrence of that of Waugh River, about three miles from Tatamagouche, is thus described by Professor M. E. Wadsworth:† "The country rock is a sandstone composed of granitic detritus, and contains clay, fragments of lignite and other carbonaceous materials. Associated with this sandstone are intercalated beds of red shale, some of which is of so fine a quality that it has been used as a mineral paint. All these rocks dip N. 20° E. < 26°. The ore is in nodules and lenticular masses composed of chalcocite or its hydrous carbonate [malachite] scattered through the beds of sandstone and shale. It is so associated with the carbonaceous materials in the rocks that it is believed that the copper was collected by the percolating waters, precipitated and reduced by the organic matter, and thus collected into the masses found at present, many of which are now in part lignite and in part chalcocite. The change to the carbonate is, of course, a still further change, wrought through the medium of the percolating waters."‡

Tatamagouche.

Native copper. The native copper associated with the zeolites and other minerals of the trap of Minas Basin is described by Professor Wadsworth as occurring in the basaltic rocks (melaphyrs and diabases) disseminated in part through them and in part occurring in veins in relations similar to those observed on Lake Superior and produced by the action of percolating waters (whether thermal or not) in collecting the copper disseminated through the old basaltic lavas and concentrating it in whatever suitable receptacles existed in the lavas and their associated conglomerates, and in the fissures traversing them.

Stewiacke. *Galena.*—This ore of lead has been worked to a small extent at Smithfield and Pembroke on the north side of Stewiacke River in Carboniferous limestone, in which it occurs in small veins and disseminated crystals. At Smithfield, galena, pyrite, blende and calcspar are intermixed in what appears to be a brecciated vein at

*How's Mineralogy of Nova Scotia, p. 69.

†Proceedings of the Boston Society of Natural History, vol. XXIII., p. 204.

‡Gesner's Geol. and Miner. of Nova Scotia, pp. 139, 140; Indus. Res., p. 289; Am. Journ. Sci,, 1828 (1), XV., 151-153; Trans. Am. Acad., 1831 (2), I., 289-292; Dawson's Acadian Geol., pp. 327, 345, 346; Report of the Department of Mines of N. S., 1876, p. 63; 1877, pp. 48, 49; 1879, p. 13; 1880, pp. 75-77; Gilpin's Mines of N. S., p. 76; Journ. Geol. Soc., London, vol. IV., p. 511.

the contact of the limestone with quartz-veined Devonian rocks. Here an engine and smelter were erected to work and reduce the ore. At Pembroke a considerable sum of money was spent in searching for galena in a fossiliferous limestone, also near the contact with red and grey Devonian slates.*

Silver.—The erratic search made for silver on the Little River of Stewiacke, on John McDonald's (Ogg) Brook and in other places seems in most cases to have been instigated by the presence of scales of specular iron ore among the rocks.

Gold.—The occurrence of gold on the Atlantic coast in quartz-veins has led to the search for it wherever such veins traverse the newer rocks. Thus those of the Silurian rocks of the East and Sutherland's Rivers and of McLellan's Brook,† and of the Devonian of West River, Riversdale, Folly Mountain, Tatamagouche Mountain and Irwin Lake, have at various times been prospected. On Bailey's Brook, south of West River station, a shaft was sunk thirty feet in blackish Devonian argillite, cut by a vein or band, three feet thick, of whitish, greenish and rusty calcareous clay-rock, resembling a decomposed felsite, containing graphite and calcspar in the numerous planes, and minute crystals of pyrite; and other pits have been sunk in the vicinity.

A company was formed, twenty-five or thirty years ago, to search for gold at the point marked "Gold mine," near the Cumberland line on Church's map of Colchester county; but after a little work the search was abandoned. About forty-five years ago, when the land was cleared of a second growth of trees, some of which were ten inches through, hundreds of pounds of ox bones were, it is said, found beneath the soil. These were supposed to have been left at an old camp ground by the Acadians before their expulsion, the road between their settlements at Masstown and Tatamagouche having, it is said, followed the pass between the Millbrook and Debert River in preference to that taken by the Intercolonial railway. Led by some traditions, this camp was assumed to have been used by the French when mining for gold, grains of which have, it is said, been obtained from boulders and from washing the sand. In the mountain, however, only black crumbly trap and diorite, were seen, with quartz veins like those, also reported to carry gold, on the railway near Folly River. Florida road.

Reference has been already made to the abortive attempts made to work the conglomerates of Brookfield, Glenbervie and other places for gold. ‡

*Report of the Department of Mines for 1887, p. 47.
†Trans. N. S. Inst. Sc., vol. III., pp. 39 and 73.
‡Summary Report of the Geol. Surv. of Can. for 1890, p. 41.

Limestone.—Nearly all the principal localities in which limestone has been quarried, for lime making, for manure or as a flux, have been already referred to in the course of this report and are shown on the map. With very few exceptions it is obtained from the Lower Carboniferous. Among the more important quarries are those of McLellan's Mountain and Brook, and of Bridgeville, Springville, Churchville and Lorne on the East River of Pictou. Near Hopewell, limestone has been worked on Halliday's, Grant's, McDonald's and other farms, but the largest quarry is probably that at Dunbar's, where a light grey and blackish, massive, bituminous and vesicular, compact limestone contains spots of hematite and blotches or veins of calcite and ankerite and yields many corals and shells.*

The quarries of Brookfield are referred to on p. 94; those of Penny's Mountain, on p. 92; of Beaver Brook, on p. 95; and of Kirkhill, on p. 172; they require no further mention.

The Devonian limestones of the West River and Waters' Hill have been described with the Devonian. That of Gordon's quarry, near Glengarry, is mixed with trap and is not like the Carboniferous limestone of the vicinity, but rather crystalline, like that of the East River near Glencoe. It is said to be hard to burn because it melts; it requires a quick fierce heat, but when burnt, makes a good white lime, requiring two bushels of sand for mortar. The crystalline Devonian limestone of Phinney's Brook† is described on p. 71.

A small quantity of the Permian limestone of Cape John has, it is said, been exported to Prince Edward Island.

Dolomite.—An analysis made for Mr. Leckie by Mr. William Smaill, the analyst at Londonderry mines, of a sample of magnesian limestone from the quarry opened by Mr. Jamme west of the old Cumberland road, yielded:—

Protoxide of iron	1·482
Alumina	3·942
Lime	28·750
Magnesia	14·017
Volatile matter	48·913
Silica	2·050
	99·154

*Trans. Roy. Soc. Can., vol. IV., sec. IV., pp. 159-166.

†Gesner's Geol., p. 113.

As already remarked, others of the Devonian limestones are dolomitic. The Carboniferous limestones of East Onslow, Kennetcook and Shubenacadie are described by Professor How.*

Gypsum.—The great workable deposits of gypsum in the Lower Carboniferous have been described above. At a mill erected for the purpose at McQuarrie's plaster quarry near Lorne, 300 or 400 barrels were ground previous to 1885, and either used for the land or boiled for the finish in plastering houses. Another mill on Irwin Brook at Clifton, has also been allowed to fall into ruin. Fine outcrops, said to cover thirty or forty acres, of white and dark gypsum were quarried, about twenty years ago, on the east side of and near the mouth of Wallace Harbour. Statistics of the production of the quarries at present in operation are to be found in the annual reports of the Commissioner of mines and of the Division of mineral statistics and mines. Plaster mills.

Salt.—At Bridgeville a salt spring issues from beneath a cliff of gypsum; and similar springs are found in various parts of the Carboniferous areas.† On the West River of Pictou, about 1813,‡ an attempt was made to manufacture salt at Saltsprings, and a shaft, 200 feet deep, sunk to find the bed of salt; but the company failed and sold the plant for old iron. About ten years later, salt was manufactured from the brine of the spring; but the work was soon abandoned.

Mineral Water.—"A water with a strong acid reaction is reported to exist near Gairloch, Pictou county. Springs, locally famous, are found at Earltown and Shubenacadie."§

Clays.—Among the various deposits of clay, one on the Middle River of Pictou has been utilized by Mr. Cameron of Stellarton, and a large plant established for the manufacture of bricks. It is a thick bed of dark-red clay situated immediately south of Sylvester station on the left bank of the river.

Fireclay.—Various analyses of fireclays from the neighbourhood of the coal seams in the Pictou coalfield are given by Professor How and Mr. Gilpin.|| Mr. Henry S. Poole in one of his reports

*Min. of N. S., p. 155.

†Gesner's Industrial Resources of N. S., p. 264.

‡Patterson's History of Pictou, p. 273; How's Mineralogy of N. S., p. 143; Gilpin's Mines of N. S., pp. 100 and 102.

§How's Mineralogy p. 199.

||Geol. Surv. of Can. An. Rept., 1886, vol. II., p. 125 P; Mines of N. S., p. 113; Trans. N. S. Inst. Sc., vol. IV., p. 144.

as Inspector of Mines,* gives analyses of fireclays from the Deep seam and from Lingan and Springhill, comparing them with ten Scotch and English varieties. "The Nova Scotian clays contain a much larger percentage of alkalies, which are especially detrimental to the quality of a fireclay. The presence of any quantity of iron and lime is generally injurious; though there are noticeable exceptions, Stourbridge of the one, and Pease's West Ganister of the other .....The Dominion imported in 1873-74, fire-brick, for refractory linings for stoves, ovens and furnaces, to the value of $78,040, and fireclay to the value of $10,873..... . The Steel Company of Canada alone imported in 1875 about 2,000,000 fire-bricks for their establishment at Londonderry." Mr. R. E. Chambers states that the quantity used in 1892 by the New Glasgow Iron, Coal & Railway Company in the construction of their furnaces was 850,000; by the Pictou Charcoal Iron Company, 100,000. A dark fireclay has been extracted from a tunnel on the west bank of the East River of Pictou near Stellarton. The tunnel is thirty yards long and the dip of the rock at the end is $327° < 70°$, indicating a small fault, which is also shown in the bank.

The occurrence of a fireclay, resembling that of Coxheath,† among the felsitic rocks of New Annan has been mentioned on p. 156.

Building Stone.—"There is no country, probably," says Professor How, "better furnished with the varieties of stone suited to the purposes of the civil engineer, the builder and the architect."‡ The principal quarries of building stone, which are, for the most part, among Permian strata, have been mentioned in the course of this report. The grey beds of the quarries at Pictou, the Four, Six and Eight Mile Brooks of the West River produce a valuable building and monumental stone. Of the latter the two best are probably those of the Elliott and McPherson quarries on the Six and Eight Mile Brooks respectively. The stone is sold at the Elliott quarry for $17 per cubic yard or 63 cents a cubic foot. McKeen's, about a mile east of Pictou, shows a face of forty feet of good grey freestone. On Rear Brook and at various points on the East River are quarries of grey sandstone and flags.

The sandstone quarried on Toney River, three-quarters of a mile above the shore road, is a striped or banded, dark grey variety, with bedding stripes of lighter colour, the whole having a reddish-

*Department of Mines, Nova Scotia, 1875, pp. 66-68.

†Geol. Surv. of Can. Repts. of Progr., 1879-80, p. 125 F; 1875-6, pp. 423 and 373; and 1873-4, p. 173.

‡How's Min., p. 169; Gesner's Geol. of N. S., p. 141.

grey tinge. It breaks into long blocks two feet thick and downward. Some of the brown stone quarried by Mr. R. E. Chambers from the shore near Toney River was shipped by rail to Almonte, Ont., where it was used in one of the public buildings. The celebrated red freestone quarries of River John, Cape John and Tatamagouche have already been referred to. From that of Mr. Rogers, above the village, a specimen was sent to the Paris Exhibition.

Grindstones.—Many of the grey sandstones referred to above have been largely quarried for grindstones, but require no special mention. The aggregate value of the building and grindstone exported from Pictou in the seven years, 1860–66, is given by Professor How as $25,094; in 1874 188 tons, valued at $1,448, were exported, and in the four years from 1882 to 1885, 929 tons valued at $5,584.

Whetstones, Scythestones, &c.—The excellent scythestone of Birch Hill is a fine, grey sandstone, apparently Lower Carboniferous, with sharp grains of silica, found in the neighbourhood of the East Brook of Stewiacke. Among the Silurian rocks of the hills northeast of Earltown, are bands locally used for whetstones. They are usually dark grey and good, if kept wet or oily. Good whetstones are also found among the same strata at John McKay's (Ross.)

Marble.—The marble of the East River, near the mouth of John McDonald's (Ogg) Brook, has been already described.* Where exposed in the river it is full of rusty blotches. That found in the metamorphic rocks of Five Islands (p. 160) is described by Professor How† as of two kinds—a pure white variety, of excellent grain and great beauty when polished, and a green and white variety. A block shipped to England in 1852 was, on arriving there, pronounced to be unserviceable from being shattered.

Syenite, Porphyry, &c.—Some of the varieties of these rocks met with in the mountains are probably fit for building and ornamental purposes, but none have been utilized. Among them is a syenite of Upper Kemptown, a bright-red, fine grained variety, associated with dioritic rock.

Baryte.—Reference has been made to the frequent association of this mineral with the ores of iron and manganese. It is found also in small veins and crystalline aggregations, mixed with calcspar in Permian rocks, in many of the branches of River John, above John McKay's, near Mrs. Morrison's, on Nabiscump Brook, near Peter River John.

*Geol. Surv. of Can. An. Rept., 1886, vol. II., p. 126 P; Trans. N. S. Inst. Sc., vol. III., pp. 64, 65; vol. IV., p. 466; vol. V., p. 208; How's Min., p. 158.

†Min. of N. S., p. 157.

Gratto's mill, near McBean's house, and at Welsford between the mills and the shop. In one conglomerate the pebbles are held together by a white crystalline calcspar mixed with baryte. It was quarried to some extent in the grey sandstone of Hodson near River John, some years ago, the quantity exported in 1879 amounting to 480 tons, valued at $2,400;* but at present none of the veins are worked.

Brookfield. About six miles east of Brookfield station, or a mile west of Bill Putnam's Brook, and half a mile north of the Stewiacke River, is a deposit described by Professor How,† from which 1,200 tons are said to have been taken prior to 1868 from a shaft or cutting forty feet deep. The ore was in three veins, having an average thickness of eighteen inches, white throughout or with a greenish tinge in part, perfectly free from pyrite and other metallic minerals, but containing traces of graphite. The veins seem to traverse irregularly a grey somewhat argillaceous limestone. Small veins of bright red calcspar also cut the limestone, which is associated with greenish-grey, fine, calcareous sandstone and flags, marked with carbonized plants, and with blackish coarse grit, in which a small streak of coal is reported to have been found. In the neighbourhood of the iron mine at Upper Brookfield, a vein of reddish and white baryte, said by Professor How to be fifteen feet in thickness, is exposed on the side of the hill, mixed with iron ore. These deposits are still intermittently worked.

Five Islands. White and reddish baryte has been quarried‡ in considerable quantity from numerous irregular veins, sometimes three feet wide, or beautiful crystalline masses in the slates on the steep banks of the East and Bass Rivers of Five Islands, perhaps in continuation of the iron ore belt of the Londonderry mines. It is associated with specular iron, and carries a little copper pyrites and fine crystals of dog-tooth spar and calcspar. About five hundred tons had been exported to the United States before 1866.

Graphite.—Graphitic shale occurs in many places, as already stated, but none of the known deposits seem to have been worked with profit. Professor How mentions having examined specimens from a vein at Partridge Island and from Salmon River.

Infusorial Earth.—Many of the lakes in which this material has

*Gilpin's Mines of Nova Scotia, p. 99; Report of Department of Mines, 1879, p. 55.

†Min. of Nova Scotia, p. 160.

‡How's Min., p. 160; Acadian Geol., p. 592.

§Geol. Surv. of Can. An. Rept. for 1886, vol. II., p. 127 P.

been found are mentioned in last report.§ It has also been taken from a little lake east of the Tatamagouche road at Corktown and from a creek or stillwater flowing from it; from a spring or pond in front of Mr. Crowe's house in the same vicinity; and also from a stillwater near the head of the west branch of Economy River.

Sand.—Promising beds of moulding sand are found at Onslow and near the mouth of McLellan's Brook.*

Slate.—In Drug (Truagh) Brook, above the post road, is a bluish-grey slate, like that of Guysboro' Intervale;† in the Middle River above Lansdowne, flaggy Devonian slates have been quarried for buildings; and from the West and Stewiacke Rivers good specimens have been obtained.

Precious Stones.—Many beautiful minerals of the quartz family—amethyst, chalcedony, agate, jasper, opal, &c.—are described by Jackson and Alger, Dr. Gesner,‡ Professor How,§ Marsh,|| Gilpin,** Dawson,†† Hoffmann‡‡ and others, who have also devoted much time to the collection and determination of the various beautiful cabinet minerals so abundant in the trap areas of the Bay of Fundy.

---

*How's Mineralogy of Nova Scotia, p. 162; Trans. N. S. Inst Sc., vol. IV., p. 145.

†Geol. Surv. of Can. An. Rept., 1886, vol. II., p. 128 P.

‡Geol. of Nova Scotia.

§Min. of Nova Scotia, pp. 180 and 202.

||Silliman's Journal, 2nd series, XXV., p. 210.

**Mines of Nova Scotia, p. 117.

††Acadian Geol., p. 114.

‡‡Annotated List of the Minerals occurring in Canada; Trans. Roy. Soc. Can. vol. VII., Sec. III., 1889; Geol. Surv. of Can. An. Rept., 1888-89, vol. IV., T.

GEOLOGICAL SURVEY DEPARTMENT
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

NATURAL GAS AND PETROLEUM

IN ONTARIO

PRIOR TO 1891

BY

H. PEARETH H. BRUMELL, F.G.S.A.

Assistant to the Division of Mineral Statistics and Mines

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1892

OTTAWA, 7th July, 1891.

To ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., &c.,

Director, Geological Survey, Ottawa.

SIR,—I have the honour to submit herewith a report on natural gas and petroleum operations throughout the province of Ontario, bringing down the history of such to the close of 1890.

Accompanying the report are illustrative sections, plans, and a sketch map showing the extent of boring operations in Ontario.

I have the honour to be, sir,

Your obedient servant,

H. PEARETH H. BRUMELL.

INTRODUCTION.

Introduction.

The object of this report is to give in a concise form a description and narrative of boring operations undertaken in the province of Ontario, up to and inclusive of the year 1890. All wells sunk, whether searching for salt, petroleum, natural gas or water, have been included. These operations show that there is in southern Ontario, *i.e.*, that part lying south-west of a line drawn from Georgian Bay to Kingston, a possible thickness of Palæozoic rocks, and including the drift, of 4,200 feet as follows:—

Thickness of Palæozoic rocks.

	Drift	0— 150 feet	= 75 feet	
Devonian	Portage and Chemung	25— 200 "	=100 "	
	Hamilton	about 350 "	=350 "	
	Corniferous	160— 300 "	=230 "	
	Oriskany	6— 25 "	= 15 "	
Silurian	Lower Helderberg, Onondaga	300—1000 "	=650 "	
	Guelph	140— 160 "	=150 "	
	Niagara	100— 130 "	=115 "	
	Clinton	30— 150 "	= 90 "	
	Medina	600— 800 "	=700 "	
Cambro-Silurian.	Hudson River	500— 900 "	700 "	
	Utica	300— 400 "	=350 "	
	Trenton, Black River	600— 750 "	=675 "	

The question of the origin of the hydrocarbons has not been gone into to any extent, though in Part I. of this report the salient points in the many theories advanced are given. It is now earnestly requested that drillers and others interested in boring operations throughout Canada should enter into correspondence with this office, that the information thus available may be made as complete as possible. For this purpose blank forms for records of boring will be supplied, as well as bottles or boxes for the preservation of samples of drillings.

Definition of petroleum.

Throughout this report the term petroleum (rock oil, mineral oil, etc.), is understood to refer to that mineral in its broadest commercial sense, and to include all varieties of the mineral in its fluid or semi-fluid state. The petroleum of Lambton, the only oil-producing county in Ontario, is a dark brown and heavy oil, ranging in gravity from 31½° to 35° Beaume, the heavier oil being obtained in the Petrolea field, while the latter is produced in that of Oil Springs and the smaller pool

of Euphemia. The oil, as produced, has a very pungent odour of sulphur, which it contains in a form as yet undetermined, differing in this respect very materially from the oils of most of the United States fields. I have been unable to obtain any accurate analysis of Canadian oil, but its composition is approximately, carbon 85, hydrogen 15, the proportions varying with any variation in gravity, *e.g.*, the heavier the oil the greater the proportion of carbon. The actual commercial contents of Canadian oil, according to the returns of refiners during 1889, were :—

Illuminating oils	38·7
Benzine and naphtha	1·6
Paraffine and other oils (including gas, paraffine, black and other lubricating oils and paraffine wax)	25·3
Waste, not returned (including coke, tar and heavy residuum)	34·4
	100·0

Definition of natural gas.

Natural gas is understood to consist essentially of marsh gas with small quantities of hydrogen, nitrogen, etc., and to have a gravity compared with air of from ·560 to ·850. According to Prof. Ed. Orton,* the natural gas of Findlay, Ohio, is composed of :—

Hydrogen	2·18	per cent	by volume.
Marsh gas	92·60	"	"
Carbonic oxide	0·50	"	"
Olefiant gas	0·31	"	"
Carbonic acid	0·26	"	"
Nitrogen	3·61	"	"
Oxygen	0·34	"	"
Hydrogen sulphide	0·20	"	"
	100·00		

Specific gravity compared with air, ·585.

First discovery.

As previously stated, the only oil-producing territory in Ontario is in Lambton county, to which district attention was first drawn in 1860 or 1861 by a Mr. Tripp, who owned a farm where now stands the village of Oil Springs. This gentleman, on excavating a well on his property for water, was struck by the appearance of an inspissated petroleum —known locally as "gum beds"—and also by the fact that black "rock oil" accumulated in considerable quantity on the surface of the water. The attention of Mr. J. H. Williams, of Hamilton, was drawn to the spot, and work in search of the oil than began in earnest. It was

* Geological Survey of Ohio, vol. VI., page 538.

found that the deeper the wells were sunk into the Erie clay (which constitutes in a great measure the surface deposits of the district), the greater was the accumulation of oil. Drilling was then resorted to, and wells were bored into the rock. Through lack of experience, drilling was a very tedious operation, the only appliance then in use being the old-fashioned "kicking-rig," operated by the weight of the human body.

Flowing wells.

The first flowing well was struck on the 19th February, 1862, when Mr. James Shaw, of Oil Springs, found oil at a depth of 160 feet in what is now known as the "Upper Vein." Following closely upon this discovery was a rush to the new oil field, and the business passed through the various stages of speculation and finally reached a solid business steadiness in 1867, when the celebrated "King Wells" were sunk in Petrolea. On the discovery of these wells oil at once fell to 20 cents per barrel, but means were found to store the surplus and prevent the almost criminal waste which had attended the discovery of large wells sunk but a few years previously in Oil Springs.

List of large flowing wells.

Dr. Alex. Winchell has given a vivid description of the early workings at Oil Springs.* He also gives † the following list of 33 flowing wells in Enniskillen township and their capacity prior to 1867 :

Depth in feet.	Situation.	Daily flow, barrels.
104	Salis ..... Lot 18, Con. II	600
108	Purdy ..... " 19 " II	1,000
115	Evoy Bros ..... " 19 " II	600
116	Jewry & Evoy ..... " 19 " II	300
116	Fairbanks ..... " 17 " II	500
130	Campbell ..... " 19 " II	200
132	Bennett Bros.	500
136	Chandler ..... " 18 " II	100
155	Jewry & Evoy (same as above, bored deeper) ...	2,000
157	Sifton, Gordon & Bennett. Lot 18, Con. II	150
158	J. W. Sifton ..... " 18 " II	800
158	Shaw ..... " 18 " II	3,000
160	Wanless ..... " 18 " II	200
160	McLane ..... " 18 " II	3,000
160	Ball ..... " 18 " II	250
160	Rumsey ..... " 18 " II	250
160	Whipple ..... " 18 " II	400
163	Sanborn & Shannon .... " 18 " II	2,000

*Sketches of Creation, 1870. Chap. XXV.
†Ibid, note VIII., page 443. Appendix.

Depth in feet.	Situation.	Daily flow, barrels.
163..	Campbell & Forsyth.... Lot 18, Con. II.....	1,000
163..	Wilkes..... " 18 " II.....	2,000
164..	Bradley..... " 18 " II.....	3,000
167..	Webster & Shepley..... " 18 " II.....	6,000
170..	Leavenworth..... " 18 " II.....	500
170..	Culver..... " 18 " II.....	200
173..	Allen..... " 17 " II.....	2,000
175..	Barnes..... " 17 " II.....	300
178..	Petit..... " 19 " II.....	3,000
180..	George Gray..... " 17 " II.....	150
180..	Holmes..... " 19 " II.....	500
187..	McCall..... " 17 " II.....	1,200
188..	Swan..... " 18 " II.....	6,000
212..	Fiero..... " 19 " I.....	6,000
237..	Black & Mathewson.... " 17 " I.....	7,500

Efforts on part of prospectors to find gas.

There are several points in connection with the production and utilization of natural gas, which may perhaps be here usefully referred to, especially the ill-directed efforts on the part of prospectors to procure it and the many thousands of dollars thus spent in regions where the geological conditions preclude all possibility of success and through a knowledge of which this useless expenditure might have been avoided.

In writing on the *anticlinal theory*, Prof. I. C. White states:—"The first explorers assumed that gas could be obtained at one point as well as another, provided that the earth be penetrated to a depth sufficiently great; and it has required the expenditure of several hundred thousand dollars in useless drilling to convince capitalists of this fallacy, which even yet obtains general credence among those not interested in successful gas companies."*

The words "several hundred thousand dollars" do not yet, fortunately, apply to those already spent in useless drilling in Ontario, though that there have been large sums uselessly spent will be acknowledged. Where in a district rocks elsewhere known to be gas-bearing have been proved to be "flooded," and the geological structure is that of a syncline rather than anticlinal, the chances of obtaining gas in paying quantity will be small, and again, in any district where the rocks have, through disturbance, been greatly fissured, it would be useless to expect to find gas, as it would long ago have escaped, or so lessened its pressure as to afford but meagre flows. The value of a

*"*Science*," 26th June, 1885.

knowledge of geology, it seems, is not recognized by the average practical driller, who is influenced more by a "promising" (?) contour than by geological facts.

Waste of gas.

Attention has time and again been called by United States writers on the subject, to the almost criminal waste of gas by consumers and by owners of wells, the production of which is consumed only by themselves. For instance, many owners think it necessary to consume the *whole* daily flow of their well, never recognizing the fact that the rocks so long the reservoir of the gas contain only a limited supply that may with due economy be made to last the longer. Lime burners and brick manufacturers particularly allow much more fuel to be consumed than is necessary, because they think it costs nothing. The fact that the supply is diminishing may cause them to be more careful in the future, though the loss will then be irreparable, as a well has a certain life which can be prolonged only by care and economy. The indiscriminate lighting of towns and villages by torches is another danger to any gas district, as great quantities are thereby consumed with no better result than would be obtained through the use of a small pressure burner. Experience, however, will be the only teacher, and it is to be hoped that the lesson will be learned as cheaply and as soon as possible.

There are many other points of interest to the gas producer, information on which may be found in the reports of the Geological Surveys of Ohio, Pennsylvania and other states wherein gas is an important product. Attention is particularly directed to the report of the Geological Survey of Ohio, vol. VI., by Prof. E. Orton.

Appendices.

With the present report the following appendices are given :—

A.—Table for the conversion of specific gravities into their corresponding gravities according to Beaume's hydrometer;

B.—Cost of "drilling-rig" complete, at Petrolea, Ont., F. O. B.;

C.—Bibliography.

Acknowledgments.

My acknowledgments are due to the many drillers and gas and oil producers throughout Ontario, who have so kindly assisted in the preparation of this report, more especially to Mr. Jas. Kerr, Secretary Oil Exchange, Petrolea; E. Coste, Manager Provl. Nat. Gas Co., Buffalo; D. A. Coste, Buffalo; J. C. McRae, Port Colborne; J. S. Hyland, Walkerville; Peter McEwen, Goderich; M. J. Woodward, Major Savage, Wm. Harris, Jas. McCort and E. Rawlings, of Petrolea.

PART I.

BRIEF EXTRACTS FROM WRITINGS REGARDING THE ORIGIN OF THE HYDROCARBONS, MORE ESPECIALLY PETROLEUM AND NATURAL GAS.

Theories of Inorganic Origin.

Theories of inorganic origin.

M. Berthelot.

Among the principal writers on the theories coming directly under this heading may be mentioned M. Berthelot, and later, M. Mendeljeff. In December, 1886, M. Berthelot published a paper* wherein he says :—

"If in accordance with an hypothesis recently announced by M. Daubré, it is to be admitted, that the terrestrial mass contains free alkali metals in its interior, this hypothesis alone, together with experiments that I have lately published, furnishes almost of necessity a method of explaining the formation of carbides of hydrogen. According to my experiments, when carbonic acid, which everywhere infiltrates the terrestrial crust, comes in contact with the alkali metals at a high temperature, acetylides are formed. These same acetylides also result from contact of the earthy carbonates with the alkali metals even below a dull-red heat.

"Now, the alkaline acetylides thus produced could be subjected to the action of vapour of water; free acetyline would result if the products were removed immediately from the influence of heat and of hydrogen (produced at the same time by the reaction of water upon the free metals) and the other bodies which are found present. But in consequence of the different conditions the acetyline would not exist, as has been proved by my recent experiments.

"In its place we obtain either the products of its condensation, which approach the bitumens and tars, or the products of the reaction of hydrogen upon those bodies already condensed ; that is to say, more hydrogenated carbides. For example, hydrogen reacting upon the acetyline, engenders ethylene and hydride of ethylene. A new reaction of the hydrogen either upon the polymeres of acetyline or upon those of ethylene would engender formenic carbides, the same as those which constitute American petroleum. An almost unlimited diversity in the reaction is here possible, according to the temperature and the bodies present.

"We can thus imagine the production by a purely mineral method of all the natural carbides. The intervention of heat, of water, and the alkali metals, together with the tendency of the carbides to unite with each other to form matters more condensed, are sufficient to

*"*Les Annales de Chimie et de Physique.*"

account for the formation of these curious compounds. Their formation could thus be effected in a continuous manner, because the reactions which give birth to them are continually renewed. This hypothesis is susceptible of further development, but I prefer to dwell within the limits authorized by my experiments without wishing to announce other than geological possibilities."

M. H. Byassan.

In 1871 M. H. Byassan, in a paper read before the French Academy, on the origin of petroleum, states that "by causing carbonic acid and water to react under very simple conditions, (he) obtained a small quantity of an inflammable liquid nearly indifferent to sulphuric acid, and with an odour analogous to that of carbides of petroleum."

M. Mendeljeff.

In 1877 M. Mendeljeff read a paper before the Chemical Society of St. Petersburg, wherein he puts forth views very similar to those of M. Berthelot. A résumé of his paper was, in the same year, published,* from which the following is an extract:—"These reflections have led the author to the supposition that petroleum is in no place of organic origin. In speaking of the hypothesis of La Place upon the origin of the earth, in applying Dalton's law to the gaseous state in which all the elements constituting the terrestrial globe ought to be found, and taking into consideration their relative densities, M. Mendeljeff recognizes the necessity of admitting a condensation of metals at the centre of the earth. Among these it is natural to presume iron would predominate, because it is found in great abundance in the sun, in meteorites and basalts. Admitting further the existence of metallic carbides, it is easy to find an explanation not only for the origin of petroleum, but also for the manner of its appearance in the places where the terrestrial strata, at the time of their elevation into mountain chains, ought to be filled with crevices to their centre. These crevices have admitted water to the metallic carbides. The action of water upon the metallic carbides at an elevated temperature and under a high pressure has generated metallic oxides and saturated hydrocarbons, which, being transported by aqueous vapour, have reached those strata where they would easily condense and impregnate beds of sandstone, which have the property of imbibing great quantities of mineral oil.

"This explanation of the origin of petroleum finds support from the following facts: The predominance at the surface of the earth of elements having a small atomic weight; the appearance of petroleum in directions corresponding to great circles; the relation remarked by several naturalists, particularly by M. Abich, between petroleum and volcanic manifestations.

---

*"*Bulletin de la Société Chimique de Paris.*"

"In order to make this question clear, it is indispensable to study the different transformations of petroleum, its decomposition into marsh-gas and non-saturated hydrocarbons; of determining the chemical nature of mineral oils of different origin; also that of the saline water that ordinarily accompanies petroleum. Researches of this kind, in connection with profound geological studies, can alone render justice to the hypothesis stated above."

Other writers.

Following closely upon these statements of research and opinion, may be mentioned the investigations of Messrs. Friedel and Crafts, Clœz, Landolph, Coquand, Grabrowski and others, all of whose experiments show rather the possibilities than the probabilities regarding the origin of hydrocarbons.

Prof. R. C. Taylor.

Prof. R. C. Taylor,* while not expressing himself regarding the origin of petroleum, cites many instances wherein oil occurs intimately connected with rocks of eruptive or highly metamorphosed character. Of the Island of Havana, he writes: "Petroleum leaks out in numberless places in this delightful island from amid the fissures of the serpentine, and perhaps has deep-seated sources."

Tar Point, Gaspé.

The occurrence of petroleum, in the amygdules of a trap dyke at Tar Point, Gaspé, is mentioned as follows:*—"This dyke, which does not occur in the centre of the fold, but about 200 yards to its north-east or precipitous side, has a breadth of ten or twelve yards, with a direction N. 83° W. Its colour is dark grey, weathering to a rusty red, and it is traversed by numerous horizontal and vertical joints, and abounds in large and small druses, which, as well as the joints, are often lined with chalcedony; sometimes, in the case of the druses, presenting botryoidal surfaces, and at others, encrusted with crystals of quartz and calcite. These cavities as well as others which are not thus lined with chalcedony, are filled with petroleum; this, in some instances, has hardened to the consistency of pitch."

S. F. Peckham's review of Berthelot's theory.

Mr. S. F. Peckham reviewing the theory advanced by M. Berthelot, writes: †"The theory of M. Berthelot appears to me to derive less support from observed facts than any which has been proposed. It was doubtless formed with reference to the petroleums of Pennsylvania, which are among the purest mineral hydrocarbons of any found in large quantities. The very small proportion of nitrogen existing in these oils might perhaps be accounted for as an accidental constituent of the limestone, or as being mechanically mingled with the watered vapour. Neither supposition is at all probable, since nitrogen possesses

*"Statistics of Coal," Philadelphia, 1885.

*Geology of Canada, 1863, p. 402.

†Proceedings of the American Philosophical Society, vol. X., 1867, pp. 455.

such slight affinities. It adds nothing to its support to admit that the alkali metals do exist in the interior of the earth in the free state. The very great difference observed between the varieties of the petroleum cannot be explained upon any hypothesis that regards them as the results of the same process acting upon light materials ; neither should it be expected that a process yielding an almost 'unlimited diversity' of products, under slightly varying circumstances, would furnish a uniform result over a very wide area. Samples of Pennsylvania petroleum of the same density, when gathered from widely separated localities, furnish identical results upon analysis; so, too, do California petroleums, though gathered from localities fifty miles apart; and yet the two varieties of oil are exceedingly unlike. 'It is, moreover, altogether erroneous to attempt to explain the causes of geological facts by the aid of supposed analogies with the complex apparatus of physical cabinets, whose existence in nature could scarcely be conceived by the boldest and most unrestrained imagination.'" (*a*).

Theories of Organic Origin.

Theories of organic origin

The organic origin of hydrocarbons is at the present time conceded by the majority of geologists and chemists, but an inorganic origin may, perhaps, be admitted in certain exceptional cases.

Theories under the above heading must again be divided; many adhering to the opinion that hydrocarbons are the result of (1) the primary distillation of vegetable or animal remains, while others contend that they are the products of (2) a secondary distillation or decomposition of organic remains made at some period subsequent to their deposition.

Dr. Ed. Orton.

Dr. E. Orton,* thus defines these different opinions: "The first view is, that petroleum is in large part derived from the *primary decomposition of organic matter* that was stored in, or associated with, the strata that now contain it. According to this view, the decomposition was mainly effected *in situ*, and the product resulting is, therefore, mainly indigenous to the rock in which it is found. The last feature is seized upon in most popular statements, and a *theory of indigenous origin* is made to include most beliefs of this class. It must be borne in mind, however, that no author is to be found who holds strictly and consistently to such indigenous origin, but the name can still be used as a general designation without harm."

(*a*) Quotation from Bischof: "Chemical and Physical Geology."

* Geological Survey of Ohio, vol. VI.

"The second view is, that petroleum is derived from the *secondary decomposition of organic matter* stored in the rocks. It supposes the original vegetable and animal matter to have suffered a partial transformation and to be now held in the rocks as hydrocarbon compounds, from which, *by a process of distillation*, oil and gas are derived. The so-called bituminous shales are counted the chief sources of these products. After distillation it is held that the gas and oil are mainly carried upward by hydrostatic pressure to some overlying porous stratum that serves as a reservoir. This class can be conveniently grouped under the name of the distillation theory."

Theory of Origin by Primary Decomposition.—Hunt's Theory.

Theory of primary distillation.—Hunt's theory.

Among the most prominent exponents of the former or indigenous theory may be mentioned Dr. T. Sterry Hunt, who, in a long series of articles on the subject, endeavours to prove that gas and oil are, with few exceptions, indigenous to limestones alone, though also found adventitiously in sandstones, shales, and conglomerates. Among the most important producing strata he includes the limestones of the Trenton and Corniferous formations.

He writes: * "The fact that intermediate porous strata of similar mineral character are destitute of bitumen, shows that this material cannot have been derived from overlying or underlying beds, but has been generated by the transformation of organic matters in the strata in which it is met with."

And again: † "It has already been shown that the petroleum of Canada occurs in two district horizons; the one in the limestones of the Trenton group, and the other in those of the Corniferous formation. To this it must now be added, that the petroleum of Gaspé probably belongs to an intermediate position, and is to be referred to limestones of Upper Silurian age."

Also: ‡ "In opposition to the generally received view, which supposes the oil to originate from a slow destructive distillation of the black pyroschists, belonging to the middle and upper Devonian, I have maintained that it exists, *ready formed*, in the limestones below."

He writes: § "Concretionary nodules holding petroleum have also been observed in the Marcellus and Genesee slates, while the higher Devonian sandstones in New York and Pennsylvania are often impregnated with petroleum, and from these, and from still higher

* Canadian Naturalist, Vol. VI., p. 242.

†Geology of Canada, 1863, p. 786.

‡ American Journal of Science, Vol. XLVI., 1868, p. 360.

§ American Journal of Science, Vol. XXXV., 1863, p. 167, 168.

strata, issue the oil springs of those regions. It is probable, however, that the source of the oil in these superior strata is to be found in the Corniferous limestone, from which the petroleum of Western Canada is undoubtedly derived. * * * In the township of Rainham, on Lake Erie, the shells of *Pentamerus aratus* are sometimes found to have an inner cavity, lined with crystals of calcite, and filled with petroleum. Coralline beds impregnated with petroleum are found in Wainfleet and in Walpole, in the latter instance immediately beneath a layer of chert, but I have more particularly examined them in the township of Bertie, which is on the Niagara River, opposite Buffalo. Here, in a quarry are seen massive beds, slightly inclined, composed of a solid crystalline encrinal limestone, which appears not only destitute of petroleum, but from the water, by which it is impregnated, to be impermeable to it. In some of these beds are large corals of the genus *Heliophyllum*, the pores of which are open, but contain no oil. Two beds, however, one of three, and one of eight inches, which are interstratified with these, are in great part made up of species of *Heliophyllum* and *Favosites*, the cells of which are full of petroleum. This is seen, in freshly broken masses, to be absent from the solid limestone, which forms the matrix of the corals, and resembles in texture the associated beds. As the fractured surfaces of the oil-bearing beds become dry, the oil spreads over them, and thus gives rise to the appearance of a continuous band of dark oil-stained rock, limited above and below by the lighter limestone, from which, however, it is separated by no planes of bedding. The layer of three inches was seen to be twice interrupted in an exposure of a few feet, thus presenting lenticular beds of the oil-bearing rock. Besides the occasional specimens of *Heliophyllum* without oil, disseminated in the massive limestone, a thin and continuous bed of *Favosites* is met with, which is white, porous, and free from oil, although beds both above and below are filled with it. * * * The facts observed at this locality appear to show that the petroleum, or the substance which has given rise to it, was deposited in the beds in which it is now found, at the formation of the rock. We may suppose in these oil-bearing beds an accumulation of organic matters, whose decomposition in the midst of a marine calcareous deposit, has resulted in their complete transformation into petroleum, which has found a lodgment in the cavities of the shells and corals immediately near. Its absence from the unfilled cells of corals in the adjacent and interstratified beds, forbids the idea of the introduction of the oil into these strata either by distillation or by infiltration. The same observations apply to the petroleum of the Trenton limestone, and if it shall hereafter be shown that the source

of petroleum (as distinguished from asphalt) in other regions, is to be found in marine fossiliferous limestones, a step will have been made towards a knowledge of the chemical conditions necessary to its formation. * * * It would appear that the Devonian sandstones of Pennsylvania and North-eastern Ohio are filled with oil, which has risen from the limestone beneath, while, over a great portion of Western Canada, this limestone was ages ago denuded, and has lost the greater part of its petroleum."

Chicago limestone.

Again, in writing of a dolomite of the Niagara formation, met with near Chicago, Illinois ("Chicago limestone"), he again very plainly states his views, as follows :—"A layer of this oleiferous dolomite, one mile square and one foot thick, will contain 1,184,832 cubic feet of petroleum, equal to 8,850,069 gallons of 231 cubic inches, and to 221,247 barrels of 40 gallons each. Taking the minimum thickness of 35 feet assigned by Mr. Worthen to the oil-bearing rock at Chicago, we have in each square mile of it 7,743,745 barrels, or in round numbers, 7,750,000 barrels of petroleum. * * * * With such resources existing ready formed in the earth's crust, it seems to me, to say the least, unphilosophical to search elsewhere for the origin of petroleum, and to suppose it to be derived by some unexplained process from rocks which are destitute of the substance."

Other writers on theory of primary distillation.

In Dr. Hunt's voluminous writings on the subject, much more may be found showing him to have been consistent in his assertions, but the above extracts have been thought sufficient to illustrate the views held by him. Similar opinions are held by many other American and European geologists, among whom may be mentioned Messrs. Stafford, Lesley, Binney, Aiken, Bright, Prestwich, Winchell, White, Whitney, Jones and Wall.

The last named writes* :

Wall on Trinidad asphalt.

"The asphalt of Trinidad is almost invariably disseminated in the upper group of the "Newer Parian." When *in situ* it is confined to particular strata, which were originally shales containing a certain proportion of vegetable *debris*. The organic matter has undergone a special mineralization, producing bituminous in place of the ordinary anthraciferous substances. This operation is not attributable to heat, nor of the nature of distillation, but is due to chemical reaction at the ordinary temperature and under the ordinary conditions of the climate. The proofs that this is the true mode of generation of the asphalt repose not only on the partial manner in which it is distributed

* "Geology of a part of Venezuela and Trinidad." Q.J.G.S., Vol. XVI., p. 467.

in the strata, but also on numerous specimens of the vegetable matter in process of transformation and with the organic structure more or less obliterated. After the removal, by solution, of the bituminous material, under the microscope a remarkable alteration and corrosion of the vegetable cells becomes apparent, which is not presented in any other form of the mineralization of wood. A peculiarity attending the formation of the asphalt results from the assumption of a plastic condition, to which property its frequent delivery at the surface is partly referable. * * * * Sometimes the emission is in the form of a dense oily liquid, from which the volatile elements gradually evaporate, leaving a solid residue. * * * * The phenomenon of salses or mud-volcanoes, consisting of the solution of inflammable gas, accompanied by the discharge of a muddy fluid and asphaltic oil, is perhaps closely related to the activity just described, as carburetted hydrogen may be disengaged in the direct formation of asphalt."

Theory of Origin by Secondary Decomposition or Distillation.

Theory of secondary decomposition or distillation.

Among those intimately connected with the second or distillation theory are Messrs. J. S. Newberry and S. F. Peckham, both of whom advance somewhat different opinions, acknowledging, however, the great principle of a secondary distillation of organic remains stored in the rocks of the earth's crust. The former contends that the distillation is continuous and at a low temperature, while the latter equally strongly maintains it to be the result of distillation accomplished of a necessity by heat; citing as an example of this, the oil and gas of Pennsylvania, whose origin he accounts for by distillation through the agency of heat generated during the elevation of the Appalachian Mountains.

Newberry's theory.

J. S. Newberry's Theory.—In 1859, in a paper on the "Rock Oils of Ohio*," Newberry states his views very distinctly in the following words: "The precise process by which petroleum is evolved from the carbonaceous matter contained in the rocks which furnish it is not yet fully known, because we cannot in ordinary circumstances inspect it. We may safely infer, however, that it is a distillation, though generally performed at a low temperature. * * * * * When, however, carbonaceous organic tissue is buried in moist earth or submerged in water, oxidation does not at once ensue, or at least takes place to a limited extent, measured by the amount of oxygen present. In these circumstances bituminization takes place. This pro-

* "Ohio Agricultural Report," 1859.

cess consists mainly in the union of hydrogen, from the tissue itself or its surroundings, with a portion of the carbon, to form carburetted hydrogen, which perhaps escapes, and the hydrocarbons constituting the bitumen, which usually remains as a black, pitch-like mass, investing the fixed carbon. By this process peat, lignite, and coal are formed, which are solids, and doubtless some liquid and gaseous hydrocarbons which escape. Now, when we heat these solid bitumens artificially at a sufficiently high temperature, if in contact with oxygen, combustion ensues, and water and carbonic acid are formed from them. At a lower temperature they are converted into gaseous hydrocarbons; still lower, to oils."

Again he says*: "The origin of the two hydrocarbons is the same, and they are evolved simultaneously by the spontaneous distillation of carbonaceous rocks. * * * * * * * * * * Where the oil and gas-producing rocks, and those overlying them, are solid and compact, decomposition of the organic matter they contain takes place very slowly and the escape of the reacting hydrocarbons is almost impossible. Where they are more or less shaken up, decomposition takes place more rapidly; reservoirs are opened to receive the oil and gas, and fissures are produced which serve for their escape to the surface. Near the Alleghanies all the rocky strata are more or less disturbed, and here along certain lines, the liquid and gaseous hydrocarbons are evolved in enormous quantities. As we come westward, however, we find the rocks more undisturbed, and the escape of oil and gas, through natural or artificial orifices, gradually diminished." Again, in the same volume, page 158, he says: "We have in the Huron shale a vast depository of solid hydro-carbonaceous matter, which may be made to yield from ten to twenty gallons of oil to the ton by artificial distillation. Like all other organic matter this is constantly undergoing *spontaneous* distillation, except where hermetically sealed deep under rock and water. This results in the formation of oil and gas, closely resembling those which we make artificially from the same substance; the manufactured differing from the natural products only because we can not imitate accurately the processes of nature. * * * A line of gas and oil springs similar to that already referred to, follows the outcrop of the Cleveland shale; a carbonaceous stratum in the overlying Waverley group, but the quantity of liquid and gaseous hydrocarbons generated here is much less than that evolved from the Huron shale, because one is 50, the other 300 feet in thickness. Again, the emanations of oil and gas from the Lower Silurian rocks at Collingwood, Canada, and on the upper

*Geological Survey of Ohio, Vol. I., 1873, pp. 192-193.

Cumberland River, Kentucky, are associated with similar deposits of black shale which represent the Utica slate of New York."

The foregoing extracts have been thought sufficient to illustrate Mr. Newberry's theory, which may be summarized as follows:—Oil and gas are the result of a *continuous and spontaneous distillation* of the bituminous matter of certain shales, from which the greater part of the two hydrocarbons is obtained.

He acknowledges, however, that the bitumen of the Chicago limestone is indigenous to the rocks in which it is stored. Of the Corniferous formation, he states, very distinctly,* that from the limestones of this formation but little oil has ever been obtained. This statement is evidently a mistake, as it is from wells in this limestone that the oil of Enniskillen township has been obtained for the past twenty-seven years; while efforts to find it in the underlying strata have not proved successful, though test-wells have been sunk at several points in both the Petrolea and Oil Springs fields.

Peckham's theory.

S. F. Peckham's Theory.—The following extracts from S. F. Peckham's report on Petroleum† have been made with the intention of placing before the reader this gentleman's view regarding the origin of hydrocarbons. That his statements are to a certain extent contradictory, or in need of further explanation, is evident. He writes in the above-mentioned report:

"It is not the effects of heat, as represented by volcanic action, that have produced petroleum * * * Bitumens are not the product of the high temperatures and violent action of volcanoes, but of the slow and gentle changes at low temperature due to metamorphic action upon strata buried at immense depths. * * * The alteration, due to the combined action of heat, steam and pressure, that involved the formations of the Appalachian system from Point Gaspé, in Canada, to Lookout Mountain, in Tennessee, involving the Carboniferous and earlier strata, distorting and folding them, and converting the coal into anthracite and the clays into crystalline schists along their eastern border, could not have ceased to act westward along an arbitrary line, but must have gradually died out farther and farther from the surface."

"The great beds of shale and limestone containing fucoids, animal remains, and even indigenous petroleum, must have been invaded by this heat to a greater or less degree, and that 'chronic evaporation' of Prof. Lesley must have been the inevitable consequence."

---

* Geological Survey of Ohio, Vol. I.

†"Tenth census of the United States." Vol. X.

"Too little is known about petroleum at this time to enable any one to explain all the phenomena attending the occurrence of petroleum on any hypothesis; but it seems to me that the different varieties of petroleum, from Franklyn dark oil, near the surface, to Bradford and Clarendon amber oil, far beneath the surface, are the products of fractional distillation, and one of the strongest proofs of this hypothesis is found in the large content of paraffine in the Bradford oil under the enormous pressure to which it is subjected."

"The fact that the eruptive rocks of Lake Superior and the metamorphic rocks farther east prevail to such an extent that that vast inland sea has been supposed to be the crater of an extinct volcanic lake lends the strongest support to an hypothesis that regards the vast accumulations of petroleum in western Canada as due to the invasion of strata on the borders of this heat-centre, in which the petroleum is indigenous, by a sufficiently elevated temperature to cause its distillation."

"It appears to me that mud volcanoes and hot springs are properly regarded as the phenomena attending the gradual subsidence of metamorphic action in the crust of a cooling earth, and that petroleum or maltha is but the accident of such phenomena, when strata containing organic matter are still invaded at a great depth by a temperature sufficient to effect the distillation of their organic content."

Prof. J D. Dana.

The explanation of the origin of petroleum given by Prof. J. D. Dana* adds considerable weight to the evidence adduced in support of the theory of secondary decomposition or distillation. He says:

"The conditions favourable to the formation of naphtha, as shown by the characteristics of the deposits in which it is found native, are the following: (1) The diffusion of organic material through a fine mud or clay; (2) the material in a very finely divided state; and (3) as a consequence of the preceding, the atmosphere excluded as far as possible from the material undergoing decomposition. There is reason to believe that no more heat was required than what was afforded by the natural climate or temperature of the region and the process of fermentation."

"Shales, the most common oil-bearing rocks, were originally the fine mud of deep or shallow seas; and the limestones were the same, only the mud was calcareous in nature, like the coral mud of many a coral lagoon, as the author has elsewhere described, after personal examination. These shales ordinarily contain few fossils of any kind, and very rarely distinct vegetable remains. It may be questioned

*"System of Mineralogy," 5th edition, page 725.

whether tough fucoids (sea-weeds), or the branches and leaves of ordinary plants imbedded in such clays, would ever become so subdivided or disorganized as to make the requisite emulsion with the mud free from any vegetable forms; and it is more probable that the vegetable material present was either delicate water-plants or was derived from abundant infusorial or microscopic vegetable life. The limestones, on the contrary, are sometimes full of fossils, but these are animals; and, as the solid parts which make the fossils are to a large extent ground up to make the mud that becomes the limestone, the organic material these hard parts contain, as well as that of the fleshy parts and oils, would be diffused through the mud or earth in the very condition demanded.

"The light native oils do not occur in coal beds, which were made from thick beds of vegetable debris.

"In the above-mentioned circumstances, with the deposits under pressure from superincumbent beds, the atmospheric air almost totally excluded, the organic material might undergo decomposition through the reactions of its own elements alone."

PART II.

RECORD OF BORING OPERATIONS AND NOTES ON THE DISTRIBUTION OF NATURAL GAS AND PETROLEUM IN ONTARIO, UP TO THE CLOSE OF THE YEAR 1890.

Wells in Eastern Ontario.

Well near Bainsville, Glengarry County.

Throughout that part of Ontario, east of Whitby on Lake Ontario, and Pembroke on the Ottawa River, several wells have been fruitlessly sunk for gas or oil. Bainsville.

The most easterly of these borings was made near Bainsville during the years 1865 and 1866, on lot 21, concession 2, Lancaster township, Glengarry county. It was sunk to a depth of 500 feet in search of oil and was unsuccessful, though small flows of gas were said to have been met with. The surface deposits, thirty feet thick, consisted of clays and sands overlying a gravel bed from which a copious flow of very pure, fresh water was obtained. I am indebted for information regarding the well to Mr. Alex. Campbell, of Bainsville, who was,

unfortunately, unable to supply data regarding the rocks encountered; it is, however, presumed that they consisted chiefly of limestones of the Trenton formation.

Wells at Caledonia Springs, Prescott County.

Caledonia Springs.

Since 1805 gas has been known to occur in the mineral springs of this neighbourhood, though no deep borings have as yet been made in quest of it. In connection with "The Grand Hotel" (Sanitarium) are several springs from which the mineral water used in the hotel is obtained. These springs have been opened up and the water is now taken from tanks into which it constantly flows. One of these, known as the "Gas Spring," is seen to be in a constant state of ebullition caused by the escape of gas.

Dr. Sterry Hunt describes this spring as follows*:—"One of these is known as the Gas Spring, from the quantity of carburetted hydrogen gas which it evolves, and which is roughly estimated at 300 cubic inches per minute." About 3,000 cubic feet per diem.

No search has yet been made in the neighbourhood for larger quantities of gas, though several drive wells have been sunk, in a number of which gas has been observed. The surface deposits are about 100 feet thick, resting immediately on the Trenton limestone.

Well at Ottawa, Carleton County.

Ottawa.

During 1888 two companies applied for the franchise from the city of Ottawa to lay pipes to transport natural gas for lighting and other purposes. The claims of the rival companies were vigorously upheld till the spring of the following year, when the controversy was finally settled by the action of the Premier Gas Co., which in May, 1889, commenced boring operations on the north side of Patterson's Creek near the southern limit of the city. In April, 1890, the company, after many reverses, had succeeded in sinking a well 1,005 feet deep; but neither gas nor oil having been obtained the work was then suspended. It is said that oil in small quantities was observed at 900 feet. Sulphurous water was struck at 320 feet and salt water in great quantity at 550 feet. Casing was carried to a depth of 820 feet, though, owing to some defect, the water was never effectually shut off, but rose to the surface and flowed over in a weak stream.

No very accurate record of the boring was kept, and but few specimens were obtained, those available being as follows:—

* Geology of Canada, 1863, p. 535.

Specimen from 30 feet—Limestone, light blue.
" " 35 " " shaly, dark blue.
" " 82 and 110 feet—Limestone, light blue.
" " 120, 140 and 150 feet—Limestone, shaly, dark blue.
" " 160, 180 and 185 " " light blue.
" " 190 feet—Limestone, soft, shaly (thin laminæ) arenaceous.
Specimen from 195 to 220 feet—Limestone, light grey.
" " 225 feet—Limestone, dark blue.
" " 230 " " light grey.
" " 240 " " " " with chert.
" " 250 " " " "

Between 250 and 310 feet a streak of sandstone similar to that at 310 feet is said to have been traversed, though of what thickness is unknown.

Specimen from 310 feet—Sandstone, fine grained, highly calcareous.
" " 315 " Limestone, with pyrite and fragments of *Leptæna sericea* and *Orthis*, sp.
Specimen from 335 feet—Limestone.
" " 350 " " dark blue, with pyrite and *Orthis*, sp.
Specimen from 380 feet—Limestone, blue, with quartz.
" " 475 " " light blue, with pyrite in abundance.

Below this point, it is said that nothing but light blue limestone was found, which may possibly be of the Black River formation.*

Well at North Gower—Carleton County.

North Gower

Some twenty years ago an unsuccessful attempt was made to obtain oil near this village. No data are at hand regarding this well, beyond the fact that neither gas nor oil was found.

Well near Pembroke—Renfrew County.

Pembroke.

During the summer of 1888, a well was sunk some four miles west of Pembroke, in the township of McKay. The enterprise was unsuccessful, however, neither gas nor oil being obtained. No information is at hand regarding this boring, the precise position of which is uncertain, as the township has not yet been surveyed.

NOTE.—I informed persons connected with the undertaking, before operations were commenced, that there was no probability of their getting either petroleum or natural gas, but almost certainly saline water.—A. R. C. SELWYN.

Well at Deseronto—Hastings County.

Deseronto.

While drilling in the yard of the hotel owned by W. Jamieson, Esq., of Deseronto, gas in small quantities was found in the limestone at a depth of thirty feet; the well is only sixty feet deep. At fifteen feet, the thickness of the surface deposits, there was a strong odour of gas, and from the lower thirty feet a sufficient quantity was obtained to support a small flame at the mouth of the casing.

Well at Whitby—Ontario County.

Whitby.

A well was sunk in 1888 in the town of Whitby by a company composed of citizens of that place under the title of "The Whitby Gas and Water Company," with a capital stock of $10,000. The boring was made on lot 28, 7th double range, west of Brock street, and was carried to a depth of 728 feet as follows:—

Surface	50	feet.	
Shale	70	"	Utica.
Limestone	600	"	Trenton.
"Arkose" beds	8	"	to granite.

Small quantities of gas were found at 400 and 700 feet. At the time of my visit the well was flooded to the top of the casing and it was found impossible to get an accurate measurement of the flow; it is, however, safe to estimate it as being under 2,000 cubic feet per diem.

Wells in York County.

Well at Highland Creek.

Highland Creek.

I have been unable to obtain any authentic account of operations at this point, and give the following as the result of inquiries made at different times and of various persons. The information obtained shows that a well was sunk near this village, during either 1866 or 1867, to a depth of 682 feet, penetrating the Trenton limestone to a depth of 434 feet, in which formation it is reported that large quantities of gas were struck.

The record of the well is reported as follows:—

Surface (blue clay)	48	feet.
Shale (black)	200	" Hudson River and Utica.
Limestone	434	" Trenton.

The fact that the well was at once abandoned shows that there was, as is usual in this district, but a small flow of gas.

Well at Copland's Brewery, Toronto.

In 1882 a well was sunk for water in the yard at Copland's brewery on Parliament street, Toronto, where, at a depth of 1,200 feet, granite was struck. No good water was found. Toronto.

The record is as follows:—

Surface.....	40 feet.	
Limestone.....	150 "	Hudson River.
Shale.....	405 "	Hudson River and Utica.
Limestone.....	585 "	Trenton.
"Arkose" beds...	20 "	to granite.

The driller, Mr. W. Harris, of Petrolea, reports that neither gas nor oil was found.

Well at Ontario Bolt Works, Swansea, Toronto.

An unsuccessful attempt to obtain gas was made during 1888, or 1889, on the east side of the Humber River, about three-quarters of a mile from the lake shore, and about the same distance north of the bolt works. The well, sunk by the Ontario Bolt Company, reached a depth of 703 feet; sixty feet below the summit of the Trenton limestone. During the winter of 1890-91 this well was continued to a total depth of 1,261 feet, or 16 feet into the Archean rocks, the drillings showing these to consist of crystalline limestone with mica, pyrite and a serpentinous mineral. Throughout the first 700 feet considerable flows of saline and other mineral waters were noted; neither gas nor oil was found. Swansea.

The record shows the following section:—

Sand.....	65 feet	Surface deposit, 107 feet.
Quicksand.....	15 "	
Hardpan.....	27 "	
Grey shale.....	440 "	Hudson River and Utica.
Black "	40 "	
Grey "	56 "	
Limestone.....	107 "	Trenton.
Soapstone.....	5 "	
Limestone.....	480 "	
Fossil rock.....	10 "	
Crystalline rocks..	16 "	Archæan.

Elevation above tide, 347 feet.

Several other wells have been sunk to and into the Trenton limestone in and around Toronto, from none of which has gas been reported, though it is known to occur in small quantities about eight miles west, and at Highland Creek, about fifteen miles east of Toronto.

Well at Mimico.

Mimico.

During the summer of 1889, a well was sunk by the Ontario Government at Mimico, a village some eight miles west of Toronto. The well, begun in search of water, was carried as an eight-foot shaft to a depth of fifty feet, or forty-three feet into the blue shaly limestones of the Hudson River formation. A four-inch boring was then begun, in anticipation of finding gas. It reached a total depth of 1,060 feet, only small quantities of gas being obtained at the depths of 425, 575 and 1,052 feet. A flow of water was struck at twenty-five feet, but too small, however, to be of economic importance; the well was then cased to a depth of 100 feet, beneath which point it was quite dry. The record, according to the driller, is as follows:—

Surface	7 feet.		
Blue shale.....	493 "	}	Hudson River and Utica.
Brown "	223 "		
Limestone	337 "		Trenton.

WELLS IN SIMCOE COUNTY.

Wells at and around Collingwood.

Collingwood.

At Collingwood the Trenton limestones outcrop and constitute the entire series of measures through which the various wells were sunk, the total thickness being in the neighbourhood of 600 feet; these rocks are to the south capped by Utica shale, which forms the base of the Blue Mountains, a range of hills lying to the south-west of the town. The limestones on the shore and throughout the town show little or no dip, though on approaching the Blue Mountains they have a slight dip to the S.S.W. The Utica shales, at a point a few miles west of Collingwood, cover the Trenton and further west are succeeded in turn by the Hudson River and Clinton formations.

No. 1 Well.—This well, on lot 16, west side of Peel street, was bored during the spring of 1888, to a depth of 553 feet, at which point granite was reached immediately underlying the limestone, which was 543 feet thick, under ten feet of surface deposits. Gas was struck in small quantities at 140 and 160 feet from the surface, but on being torpedoed the well rapidly filled with water. This inflow was ineffectually contended with and the well finally abandoned.

No. 2 Well.—This well is also within the town site on lot 21, east side of Oak street. It is 542 feet deep; soil two feet, Trenton limestone, 540 feet. Gas was struck at 160 feet, having a daily flow of 4,000 cubic feet. Two dwelling-houses, those of Messrs. Carpenter and Stewart, were at the time of my visit being lit and partly heated by it. The well was practically free from water.

No. 3 Well.—About half a mile to the south-east of No. 2 a well was sunk to a depth of 464 feet, penetrating the Trenton limestone to the depth of 460 feet and affording but a small quantity of gas, which was struck at 175 feet. Like No. 2 it was almost entirely free from water.

The above-mentioned three wells were sunk at the expense of a syndicate of residents for the purpose of obtaining gas to illuminate the streets. They were sunk at but small cost, there being no casing necessary.

Well at McDonell's Mill.—In the rear of the Hurontario flouring mill, in the eastern part of Collingwood, Mr. Charles McDonell, the owner, bored for gas in the Trenton limestone, to a depth of 351 feet; at 150 feet, a small quantity of gas, about 2,000 cubic feet per diem, was obtained.

Oil Shale near Collingwood.

Oil shale and works near Collingwood.

It may not be amiss to mention here the shale distilling works at one time in successful operation near Collingwood, the ruins of which may still be seen near the road a few miles to the west of the town. On lot 23, concession 3, township of Collingwood, Grey county, there is an exposure of Utica shales, consisting of a bed of pyro-schists of about seven feet in thickness, which afforded some three per cent of crude oil. Dr. Sterry Hunt, writes in the following terms of the enterprise: *

"This rock is highly calcareous, containing more than one-half its weight of carbonate of lime. When ignited in a closed vessel it loses 12·4 per cent of volatile and combustible matter; of which from three to four per cent are condensable into an oily liquid. This, when rectified, yields oils fitted for burning and for lubricating purposes, and probably also a portion of paraffine.

"In 1859, works for obtaining these oils were erected on the locality of this shale, near the town of Collingwood. Twenty-four longitudinal cast-iron retorts were set in two ranges and heated by means of wood, of which twenty-five cords are said to have been required weekly. The shale, broken into small fragments, was heated for two or three hours, from eight to ten charges being distilled in twenty-four hours. In this way, it is said, from thirty to thirty-six tons of shale were distilled daily, and made to yield 250 gallons crude oil, corresponding to about three per cent of the rock. By further continuance of the heat, a small additional proportion of oil was

* Geology of Canada, 1863, pp. 784-85.

obtained from the rock; but it was found more economical to withdraw the charge after two hours and a half. The bed of shale available for the purpose adjoins the works, and was furnished, ready broken, at twenty cents the ton. The cost of the crude oil from the shale was stated by the manufacturers to be fourteen cents the gallon. When rectified and deodorized, it gave from 40 to 50 per cent of burning oil, and from 20 to 25 per cent of pitch and waste, the remainder being a heavy oil fitted for lubricating purposes. After two or three unsuccessful trials, and the repeated destruction of the works by fire, they were at last, in 1860, got into successful operation, and a ready market was found for the oils."

Well at Orillia.

Orillia.

An ineffectual attempt was made, some years ago in Orillia, to obtain water by means of an artesian well. At a depth of 300 feet granite was struck and operations ceased; the surface deposits measured 170 feet, the remaining 130 feet being in the Trenton limestone. No gas was encountered in this well and but small quantities of water.

Wells in Barrie.

Barrie.

Numerous "drive" wells have been sunk in this town, in all of which an abundance of fresh water has been found; it rises to a height of about twenty feet above the level of Lake Simcoe. These wells have an average depth of 250 feet, the deepest being 276 feet; in none of them has gas been noticed.

Wells at Beeton.

Beeton.

In either 1882 or 1883, "The Lilley Well" was sunk, in the northern part of the village of Beeton, to a depth of 1,400 feet, of which but a very imperfect log has been obtained; it is presumed, however, that the drilling pierced the Trenton limestone.

Considerable quantities of gas were obtained from a soft sand rock at the base of the surface deposits, and smaller quantities throughout the rock to a total depth of 500 feet, none being found, however, below that point. The well was cased into the harder rock, thus shutting off the larger flow of gas; no water was struck till near the bottom of the boring where there was a small flow of salt water, probably from the Trenton.

The well was ultimately plugged and abandoned.

The log as reported by the driller is as follows :—

Surface.....	321	feet.	
Soft sand-rock	25	"	"Medina," from which was greatest flow of gas.
Limestone.....	850	"	
Shale.....	204	"	Probably Utica and lower part of Hudson River.

Gas at Beeton.

For many years gas has been known to exist, in and around Beeton, though no well-directed efforts have as yet been made to obtain it beyond the sinking of several drive-wells, which in every instance showed the existence of a more or less useful flow of gas. One, known as "Jones's Well," was sunk in Jones's brickyard adjoining the railway station to a depth of 190 feet, where a bed of gravel, three feet thick, was found immediately overlying the rock. In this well the flow of gas was so great as to blow the pipe out of the hole, rendering the well practically useless. The flow has for some years been unremitting, boiling up through a pool of water, where being ignited, the gas burns fiercely.

In many places throughout the neighbourhood, water-wells sunk in the surface clay, to even a small depth, have been rendered useless by the influx of carburetted hydrogen gas.

Wells in Grey County.

Well at Delphi.

During the month of July, 1888, a well was sunk at this place on lot 5, concession 26, Collingwood township, about six miles west of Collingwood and close to the shore of Georgian Bay. The boring was commenced in the Utica shales, which immediately underlie the drift deposits, and continued to a depth of 587 feet or 539 feet into the Trenton limestone, the record being as follow :— Dephi

Surface, red clay.....	8	feet.	
Black shale	40	"	Utica.
Blue limestone	539	"	Trenton.

Gas was met with at a depth of 95 feet from the surface, having a daily flow of about 6,000 cubic feet; a flow considerably in advance of that of any other well in the district. It has, however, not yet been utilized, notwithstanding the fact that the well is but one hundred yards distant from Field's Hotel, a large summer resort.

Well at Thornbury.

Thornbury. A well was sunk at this place during the year 1888, of which unfortunately but few data are at hand. The facts ascertained are that a well was sunk at Andrews' mill to a depth of about 550 feet, in which was encountered a very considerable quantity of water, which was not shut off and the well was finally abandoned. A small show of gas was reported from this boring.

Well in Halton County.

Well near Milton.

Milton. The following mention by Dr. T. S. Hunt, is made of a well sunk near Milton:—

"A well near Milton, on the tenth lot of the first concession of Trafalgar, was sunk through soil, 47 feet; red shale, 200 feet, then through bluish shales, with hard layers, 159 feet, making in all 406 feet, and probably ending in the Hudson River formation."

From inquiries made in Milton it was ascertained that neither gas nor oil was noted.

Wells in Wentworth County.

Well in Flamborough Township.

Flamborough. At some time previous to 1866, a well was sunk on lot 8, concession 8, of Flamborough East, reaching a depth of 465 feet, the boring at that depth being in the Medina formation. In a thin layer of sandstone at a depth of 340 feet from the surface, and eighty-five feet in the red shales, a small quantity of petroleum is said to have been obtained. The drilling was begun in either the base of the Guelph or summit of the Niagara formation, the whole of which, with the underlying Clinton, was probably traversed.†

Well at Insane Asylum, Hamilton.

Hamilton. This well, sunk some years ago at the Asylum for the Insane, south of Hamilton, is on lot 17, concession 5, township of Barton, at an elevation of about 300 feet above Lake Ontario. The bore was commenced on the Niagara limestones, and reached a depth of 1,318 feet, being then near the summit of the Utica formation.

* Progress Rept. Geol. Surv. of Can., 1866, p. 252.

† Ibid. p. 251.

The driller's record is as follows :—

Surface.....	14	feet.	
Limestone ...	70	"	Niagara and Clinton.
Sandstone....	7	"	"Grey band" "
Red shale....634		"	Medina.
Blue " 593		"	Hudson River and Utica, with probably the lower part of the Medina.

Neither gas nor oil was noticed in this well.

Well in Hamilton.

A well was sunk in the yard of the Royal Hotel, Hamilton, about 1,000 feet deep, of which, unfortunately, no record or information is available. The formations penetrated are, however, assumed to be the same as in the well at the Insane Asylum mentioned above, the difference in elevation being about 250 feet, while the rocks rise at a slight angle towards the city and from the last mentioned well. Hamilton.

Well at Dundas.

During 1874 a well was sunk in the valley below the railway station at this place to a depth of 1,500 feet, and was, during the following year, carried to a total depth of 1,650 feet. The boring was made in search of oil, but was unsuccessful; small quantities of gas were, however, found at various points throughout the boring. The record of it, kindly furnished by Mr. James Kerr, of Petrolea, is as follows :— Dundas.

Surface	80	feet.
Red shale.....	400	"
Blue "	550	"
Black "	400	"
Limestone.....	220	"

It is difficult to correlate the various strata, mentioned above, with the formations that must have been passed through in this well, at least, as these formations are at present known in Ontario. The 400 feet of red shales are undoubtedly of Medina age, which probably also includes a part of the 550 feet of blue shales next met with while the lower 220 feet are undoubtedly Trenton, leaving 400 fee and part of the 550 feet to represent the Hudson River and Utica.

It is to be regretted that samples of drillings were not obtained, as this well, on account of its depth and position, would give an excellent record of the details of the formations in this part of the province.

Well in Barton Township.

Barton.

During the years 1864 and 1865 a company known as "The Barton Oil Co.," was formed to prospect for oil, which project was carried out by drilling a well on lot 11, con. 7, township of Barton, unfortunately, however, without success. At 873 feet the drill was in bluish shale, which probably represents the upper beds of the Hudson River formation. The boring was begun in the Niagara limestones, which, with the underlying Clinton limestones and shales, continued for 250 feet.

The record was as follows:—

Limestone with a little shale..	250 feet	Niagara and Clinton.
White sandstone.....	5 "	Grey band. ?
Red shale with bluish bands..	595 "	Medina.
Bluish and greyish shales.....	23 "	

Small quantities of oil were obtained at 700 and 780 feet, as well as a considerable flow of water from the latter depth.

Well at Mount Albion.

MountAlbion.

Some years ago an incorporated company, known as the Emerson Natural Gas Light and Fuel Co., presided over by Mr. E. O. Emerson, of Olean, Pa., drilled for gas at Mount Albion. The boring was carried to a depth of 1,500 feet without finding gas or oil, and was finally abandoned.

WELL IN LINCOLN COUNTY.

Well near St. Catharines.

St. Catharines.

This well was sunk by the St. Catharines Natural Gas Co. during the year 1888, on "Broderick's farm," lot 4, con. 3, township of Louth, the record being as follows:—

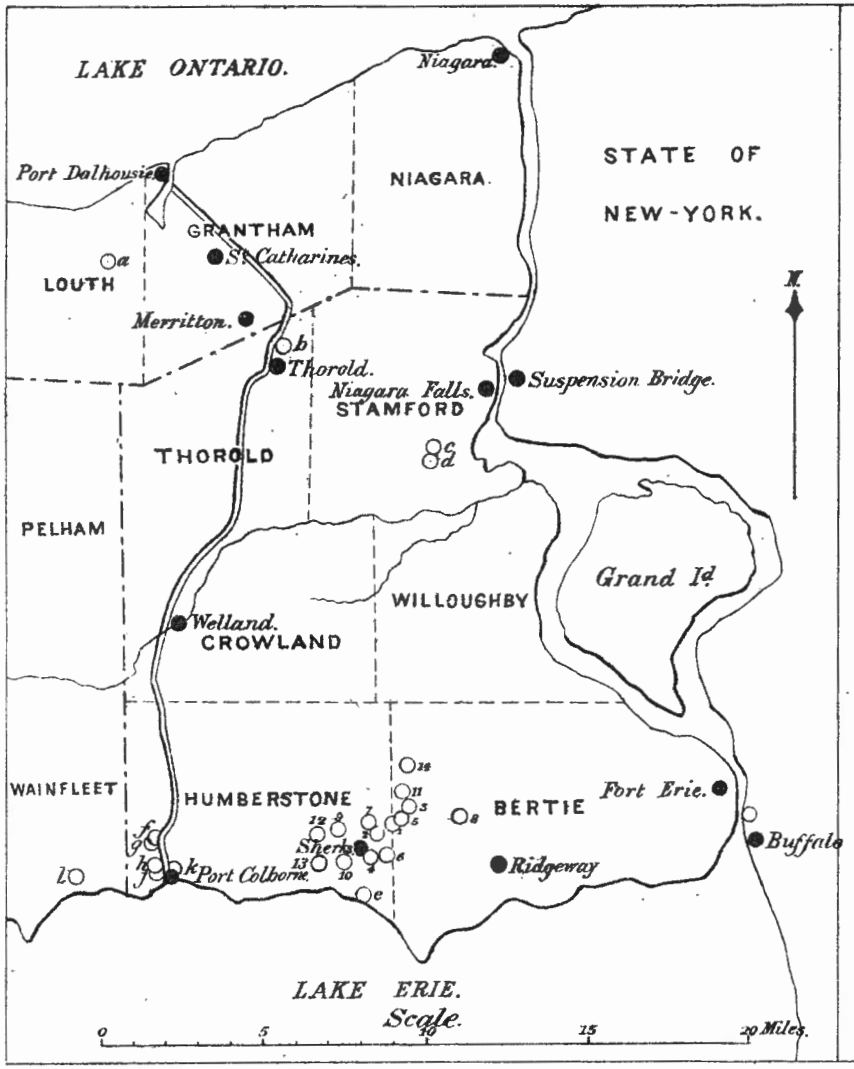
Surface.....	90 feet.	
Red shale.....	548 "	Medina.
Blue "	700 "	Hudson River and Utica.
Black to blue shale.....	168 "	Hudson River and Utica.
Limestone.....	667 "	Trenton.
White quartzose sandstone..	27 "	
	2,200 feet.	

Large quantities of fresh water were met with in a bed of gravel seven or eight feet thick at a depth of fifty-seven feet from the surface, and at 220 feet saline waters were met with, below which point

Geological Survey Department.
Canada.

ALFRED R.C. SELWYN, C.M.G., LL.D. F.R.S &c. DIRECTOR.

Plate 1.



SKETCH PLAN OF THE

NIAGARA PENINSULA

Shewing location and depth of wells.

Provincial Natural Gas and Fuel Co's Wells.

Nº 1	——	*846 feet.*
" 2	——	*851 "*
" 3	——	*836 "*
" 4	——	*875 "*
" 5	——	*842 "*
" 6	——	*897 "*
" 7	——	*840 "*
" 8	——	*841 "*
" 9	——	*851 "*
" 10	——	*870 "*
" 11	——	*816 "*
" 12	——	*843 "*
" 13	——	*900 "*
" 14	——	*Unfinished.*

a. St. Catharines Well — 2200 feet.
b. Thorold Well — 2430 feet.
c. Niagara Falls South No. 1 Well — 840 feet.
d. " " " " 2 " — 1000 "
e. Carroll Bros. Well — 917 feet.
f. Hopkins, No 2 Well — 800 feet.
g. Ed. Near Well — 800 feet.
h. Mutual Co Well — ? feet. Cronmiller and White — 800 feet.
j. Pt. Colborne Natural Gas, Light & Fuel Co. No. 1 Well — 1500 feet.
k. " " " " " " Richardson Well — 770 feet.
l. Reebe Well — 820 feet.

Drawn for photo-lithography by L. N. Richard. B.A. Sc.

To illustrate report on Gas and Oil operations in Ontario by H.P. Brumell.

Vol. V, Part G.

the hole was found to be dry, though the casing was carried to 272 feet. A small pocket of gas was opened at 275 feet or 185 feet in the Medina, from which formation further south, in the townships of Humberstone and Bertie, are drawn the great supplies of the Provincial Natural Gas and Fuel Co. This small flow of gas soon ceased, and no more was found till the sandstone underlying the Trenton was pierced, where, at a depth of 2,185 feet a flow of about 4,000 cubic feet per diem was obtained. The well was eventually torpedoed with two hundred pounds of nitro-glycerine without beneficial results.

The derrick-house floor stood about 297 feet above mean tide level, the Trenton being, therefore, 1,209 feet below.

Wells in Welland County.

Well at Thorold.

During the spring of 1888 a company was formed of citizens of Thorold. Thorold.
Thorold, under the title of "The Thorold Natural Gas Company," the object being to bore for natural gas. In furtherance of this intention a well was begun and finished in the same year, reaching a point 525 feet into the Trenton limestone, and 2,430 feet from the surface, traversing in this distance the Clinton, Medina, Hudson River and Utica formations.

The record of boring is as follows:—

Surface	43 ft.		
Dark brown limestone	7 "	Clinton	77 ft.
Shale	70 "		
Red sandstone	30 "	Medina	930 "
Shale	57 "		
Grey sandstone	30 "		
Shale	813 "		
Shale	700 "	Hudson River	700 "
Shale	155 "	Utica	155 "
Limestone	525 "	Trenton	525 "
	2,430		2,430

Brine was met with at 284 feet, and was cased off, the casing extending to 312 feet, below which water was not found in sufficient quantity to necessitate further casing. A very small flow of gas, not sufficient to be of use commercially, was struck at 2,430 feet, which would be near the base of the Trenton.

This well is 517 feet above tide, making the summit of the Trenton, therefore, about 1,388 feet below. The Medina formation, which is

generally in Ontario the most productive of gas, is here found to be barren.

Wells at Port Colborne.

Port Colborne

No. 1 Well.—Port Colborne was the first town in Canada to use natural gas. Early in 1885 a company was formed under the title of "The Port Colborne Natural Gas, Light and Fuel Company," of which Mr. C. McNeal, of that place, was president, and Mr. D. Hughes, secretary and treasurer. Boring was at once begun at No. 1 well, on Charlotte street, in the village, and in August, 1885, the gas was lighting Mr. D. McGillivray's store. The boring reached 1,500 feet, or 770 feet into the Medina formation, in the upper shales and sandstone of which the principal flow of gas was obtained.

The record of boring shows:—

Surface	12	feet.	
Grey limestone.....	13	"	Corniferous.
" "	7	"	Onondaga and Lower Helderberg; small flows of gas at 150, 252 and 415 feet.
Dolomite	3	"	
Shale and dolomite ..	55	"	
Dolomite and gypsum.	57	"	
Dolomite	108	"	
Shales and dolomite with gypsum	185	"	
Shaly dolomite.....	30	"	Guelph and Niagara
Brown dolomite and dark blue shales towards bottom ..	188	"	
Marls and dolomite ..	72	"	Clinton.
Red shales with thin bands of white sandstone	50	"	Medina; main flow of gas 764 feet.
Red and white sandstone	53	"	
Soft red shales with bands of grey and green	667	"	

Casing was not used except as a conductor through the surface deposits. Fresh water was struck at twenty-six feet and strong saline water with sulphuretted hydrogen at 452 feet, the water being eventually shut off by means of an inch and a-quarter pipe resting in a rubber packer some distance below the lower water seam and above the main gas seam, which affords a daily flow of about 25,000 cubic feet. This well has been drawn on steadily since August, 1885, the gas being used to light a number of shops and in McNeal's hotel.

No. 2 Well.—This well, drilled by Mr. M. Richardson, is in rear of his factory, east of the Welland canal, in the village of Port Colborne, and distant about one mile from No. 1 well. The boring reached a depth of 770 feet, being then in the red shales of the upper part of the Medina. Gas was struck at 762 feet, having a daily flow of about 25,000 cubic feet per diem. This gas is used to heat and light several private residences in the immediate vicinity. I believe that this well has since been connected with the company's mains. Salt water was not met with in this boring. Port Colborne

No. 3 Well.—This well, drilled by Mr. S. Hopkins, and known also as "Hopkins's well," is in the village, a short distance north of No. 1. The depth reached was 771 feet, gas being struck at 765 feet. Water has given great trouble here, and at the time of my visit had so far gained on the gas as to render the well useless and cause its abandonment. I was informed that the great trouble arose from the water having been imperfectly shut off, the packer having stuck in the casing. This well, which had probably as large a flow as either of the other two, has, however, I believe, been since resuscitated and connected with the company's mains.

It will be seen on reviewing the above that Port Colborne has, from three wells, a daily flow of gas of about 70,000 cubic feet, all of which is obtained from the upper beds of the Medina at a depth of from 762 to 765 feet below the surface, and about 175 feet below tide level.

Mutual Co.'s Well.—This well was sunk on lot 29, concession 1, township of Wainfleet, in conjunction with the Port Colborne Natural Gas and Fuel Co., for the purpose of increasing the supply of gas for the village. No data are available beyond the fact that the flow of gas obtained was small, amounting to only 5,000 cubic feet per diem.

Well west of Port Colborne.

During 1866 a well was sunk about one mile west of Port Colborne by a company under the direction of Mr. L. G. Carter, of Port Colborne, of which, however, I was unable to obtain reliable information but was led to believe that the boring was made to a depth of about 800 feet when the tools were lost and the hole abandoned. At the time of drilling, the well is reported to have afforded large quantities of gas, Mr. Jefferson Steele, on whose property the well was sunk having used it for some years in his dwelling. The company was formed to explore for oil, for which purpose the well was sunk, no oil was obtained. At 800 feet the drill would be in the Medina sandstone from which the gas probably comes. West of Port Colborne.

Wells at Niagara Falls South.

Niagara Falls South.

During 1888 two wells were sunk near this place by a local company from which small flows of gas were reported.

No. 1 Well.—This well was sunk on McGlashan's farm, lot 158, Stamford township to a depth of 840 feet; the following section shows that this was 490 feet below the summit of the Medina formation :—

Surface	43	feet.	
Limestone	143	"	Niagara.
Shale	24	"	
Shale	140	"	Clinton.
White quartzose sandstone	24	"	Medina.
Shale and sandstone	466	"	

Casing was carried 117 feet into the Niagara limestone or to a depth of 160 feet from the surface effectually shutting off all water. Gas, having an estimated flow of 4,000 cubic feet per diem, was struck at 215 feet, in the upper beds of the Clinton formation.

No. 2 Well.—This boring was made immediately south of No. 1, on lot 172 of the same township and was carried to a depth of 1,000 feet. Unfortunately no record of the rocks traversed was obtained. The boring was cased to a depth of 280 feet and gas in similar quantity to that obtained at No. 1, was found at 380 feet presumably in the upper sandy strata of the Medina formation.

Wells of the Provincial Natural Gas and Fuel Company.

Provincial Natural Gas and Fuel Company.

During the spring of 1890 the above company was incorporated with a capital stock of $500,000, with Mr. Peter Maclaren, of Perth, president, and Mr. Eugene Coste, manager. This company had existed during the previous year under the provisional title of the Lincoln and Welland Natural Gas Company, and while under the latter title the company commenced operations. On the 15th of July, 1889, drilling was begun on what was to be known as No. 1 well, after which drilling was carried on steadily until thirteen wells were completed, from the smallest of which the flow was 47,000 cubic feet, and from the largest a flow of 8,500,000 cubic feet per diem.

The log and elevation of No. 1 well are an index to those which followed, the rocks traversed and the elevation of each being almost identical.

No. 1 Well is on lot 35, concession 3, township of Bertie, county of Welland, and is 371 feet above Lake Ontario, and 618 feet above tide level. The boring was begun in the Corniferous limestone and

continued to a depth of 846 feet, at which point the drilling was 111 feet in the Medina sandstones and shales. Provincial Natural Gas and Fuel Co.

The drillings show the following record:—

Surface	2	feet.	
Dark grey lime	23	"	Corniferous.
Grey and drab dolomites, black shales and gypsum	390	"	Onondaga.
Grey dolomite	240	"	Guelph and Niagara.
Black shales	50	"	Niagara.
White crystalline dolomite, grey towards bottom	30	"	Clinton.
Red sandstone	55	"	Medina.
Red shales	10	"	
Blue "	5	"	
White sandstone	5	"	
Blue shale	20	"	
White sandstone "Gas rock."	16	"	

Fresh water was cased off at 284 feet, and at 548 feet salt water was met with; the hole was afterwards cased to a depth of 596 feet, below which point there was no water.

Gas to the extent of 1,000,000 cubic feet was struck at 836 feet, though on the well being "shot" the flow increased to 2,050,000 cubic feet per diem, at which figure it now stands.

It will be seen on referring to the log that the source of supply lies in the second streak of white sandstone in the upper beds of the Medina formation.

No. 2 Well.—This well is on lot 2, concession 2, township of Humberstone, and was sunk to a depth of 851 feet. As the record of the rocks in this well is almost identical with that of No. 1, it has not been thought necessary to give it in detail. A summary of it is: surface deposits, 6 inches; depth to summit of Medina, 735 feet; gas struck, 842 feet; salt water struck, 550 feet; casing, 600 feet; capacity of well, 375,000 cubic feet per diem.

No. 3 Well.—On lot 1, concession 15, township of Bertie, was drilled to a depth of 836 feet and affords gas to the extent of 600,000 cubic feet per diem. Surface deposits, 5 feet; summit of Medina, 715 feet; gas struck, 820 feet; salt water struck, 540 feet; casing, 590 feet.

No. 4 Well.—On lot 3, concession 1, township of Humberstone; 875 feet deep; capacity, 2,200,000 cubic feet per diem; surface deposits, 17 feet; summit of Medina, 760 feet; gas struck, 863 feet; salt water struck, 565 feet; cased to summit of Medina, 760 feet.

Provincial Natural Gas and Fuel Co.

No. 5 Well.—On lot 34, concession 3, township of Bertie; 842 feet deep; capacity, 8,500,000 cubic feet per diem; surface deposits, 8 feet; summit of Medina, 725 feet; gas struck, 833 feet; salt water struck, 550 feet; cased to 582 feet.

No. 6 Well.—On lot 1, concession 1, township of Humberstone; 897 feet deep; capacity, 70,000 cubic feet per diem; surface deposits, 30 feet; summit of Medina, 770 feet; gas struck, 880 feet; salt water struck, 570 feet; cased to summit of Medina, 770 feet.

No. 7 Well.—On lot 3, concession 2, township of Humberstone: 840 feet deep; capacity, 3,000,000 cubic feet per diem; surface deposits, 18 feet; summit of Medina, 725 feet; gas struck, 824 feet; salt water struck, 540 feet; cased to summit of Medina, 725 feet.

No. 8 Well.—On lot 27, concession 3, township of Bertie; 840 feet deep; capacity, 47,000 cubic feet per diem; surface deposits, 4 feet; summit of Medina, 715 feet; gas struck, 819 feet; salt water struck, 540 feet; cased to summit of Medina, 715 feet. This well, with the exception of No. 14, has the smallest capacity of all those sunk by the company, and was immediately plugged and abandoned.

No. 9 Well.—On lot 7, concession 2, township of Humberstone, reached a depth of 851 feet. Capacity, 3,500,000 cubic feet per diem; surface deposits, 32 feet; summit of Medina, 730 feet; gas struck, 836 feet, or four feet in the second white sandstone which was 19 feet thick; salt water struck, 550 feet; cased to summit of Medina, 730 feet. A slight change in the thickness of the beds is noticeable in this well. The first white sandstone which, in No. 1 well, is five feet thick, has in this instance a thickness of twenty feet, beneath which is found twelve feet of dark shale instead of twenty feet as in No. 1.

No. 10 Well.—On lot 6, concession 1, township of Humberstone, 870 feet deep. Capacity, 4,500,000 cubic feet per diem; surface deposits, 12 feet; summit of Medina, 750 feet; gas struck, 855 feet; salt water struck, 560 feet; cased to summit of Medina (750 feet).

No. 11 Well.—On lot 4, concession 14, township of Bertie, 816 feet deep. Capacity, 300,000 cubic feet per diem; surface deposits, 14 feet; summit of Medina, 695 feet; gas struck, 800 feet; salt water struck, 495 feet; cased to 709 feet.

No. 12 Well.—On lot 9, concession 2, township of Humberstone, 843 feet deep. Capacity, 5,500,000 cubic feet per diem; surface deposits, 20 feet; summit of Medina, 730 feet; gas struck, 828 feet; salt water struck, 525 feet; cased to 732 feet. The Clinton dolomite was struck at 695 feet and continued to a depth of 732 feet, showing thereby a thickness of thirty-seven feet, a slight thickening when com-

pared with that as shown in No. 1 well. The gas-rock or second bed of white sandstone in which the well finished was met with at 825 feet, being therefore penetrated a distance of eighteen feet. Provincial Natural Gas and Fuel Co

No. 13 Well.—On lot 9, concession 1, township of Humberstone, 900 feet deep. Capacity, 300,000 cubic feet per diem; surface deposits, 15 feet; summit of Medina, 745 feet; gas struck, 855 feet; salt water struck, 570 feet; cased to 749 feet.

No. 14 Well.—This well, on lot 6, concession 15, township of Bertie, was at the time of my last visit—13th March, 1891—not completed, having reached a depth of only 1,600 feet, the drill being then in the shales of the Hudson River formation. A small flow of gas was noted at 705 feet in the red sandstone at the summit of the Medina formation. The gas-rock of the district, struck at 762 feet, continued for a distance of sixteen feet and was found to be barren.

This well indicates very closely the probable boundary of the gas-field on its north-eastern side, and will be watched with considerable interest as it is the intention of the company to carry it to the Trenton limestone, and thereby test at this point the gas-producing properties of that formation.

It will be seen on reference to the foregoing that this company has an available supply of 30,895,000 cubic feet of gas per diem, made up as follows:— Daily production.

No. 1 Well	2,050,000	cub. ft.
" 2 "	375,000	"
" 3 "	600,000	"
" 4 "	2,200,000	"
" 5 "	8,500,000	"
" 6 "	70,000	"
" 7 "	3,000,000	"
" 9 "	3,500,000	"
" 10 "	4,500,000	"
" 11 "	300,000	"
" 12 "	5,500,000	"
" 13 "	300,000	"
	30,895,000	cub. ft.

A contract having been made between the above-mentioned company and a certain Buffalo gas company, mains were being laid during the latter part of 1890, and it is confidently expected that before many months Buffalo will be largely supplied from this field. Gas will also probably be supplied to those Canadian towns and villages in the immediate vicinity of the latter company's wells.

Since the discovery of so large a gas field, many individuals throughout the county have drilled for and obtained gas in quantity, in nearly all instances from the same strata as in the company's wells. The most important of these independent wells are: The Carroll, Edward Near, Hopkins's No. 2, Cronmiller and White, and Reebe.

Carroll's Well.

Carroll's.

This well, on lot 4, concession 1, township of Humberstone, was begun on the 19th March, 1890, and reached a depth of 917 feet, or twenty-two feet into the red shales immediately underlying the productive white sandstone bed. Gas was struck at 883 feet, having a daily flow of 990,000 cubic feet. This supply is used in the firing of limekilns operated by Messrs. Carroll Bros., as well as for general heating and illuminating purposes in and around the lime works.

Edward Near Well.

Edward Near.

A well was sunk by Mr. Edward Near on lot 29, concession 2, township of Humberstone, to a depth of 800 feet, wherein, at 675 feet, and in the white sandstone, gas to the extent of 415,000 cubic feet per day, was found. It is being drawn upon for the lighting and heating of the village of Humberstone.

Hopkins's No. 2 Well.

Hopkins's No. 2.

This well, on lot 28, concession 2, township of Humberstone, reached a depth of 800 feet, gas to the extent of 400,000 cubic feet per day being obtained at 670 feet.

Cronmiller and White Well.

Cronmiller and White.

Near the village of Port Colborne and close to the brewery operated by Messrs. Cronmiller and White, a well was sunk by that firm to a depth of 800 feet, the drilling terminating in the red shales immediately underlying the gas-bearing sandstone. Gas having a flow of 6,000 cubic feet per diem was found at 675 feet.

Reebe's Well.

Reebe's.

On lot 6, concession 1, township of Wainfleet, a few miles west of Port Colborne, a well was sunk by Mr. John Reebe to the depth of 820 feet, and just into the red shales beneath the gas-bearing sandstones of the wells in the two townships to the east. Drilling was com-

menced at the base of the Corniferous, when the following series of rocks were traversed :—

Drab and grey dolomites, shales and gypsum	390	feet.	Onondaga,
Dolomite, grey	240	"	Guelph & Niagara.
Shale, black	55	"	Niagara.
Dolomite	30	"	Clinton.
Sandstone, red	45	"	Medina.
Shale, red and blue	40	"	
Sandstone, white	20	"	

Casing was carried to a depth of 630 feet, effectually shutting off all water ; and gas, having a daily flow of 400,000 cubic feet, was obtained at 685 feet at the summit of the Clinton dolomite. Although this well was carried down to and through the usual gas-bearing sandstone, no further supply of gas was obtained. The gas produced at the well is being used for burning lime in kilns operated by the owner.

It will be seen on reference to the above "log" that the strata in the upper part of the Medina differ somewhat from those in wells further east, where there are shown to be two beds of white sandstone separated by twenty feet of blue shale. It is to be regretted that more accurate records or specimens of the drillings are not available from wells drilled at intermediate points to indicate which of these beds is missing. It is presumed, however, that the white sandstone at the bottom of this well corresponds with the "gas rock" of the wells east of Port Colborne.

Several other wells of minor importance have been drilled throughout this county, of which no information is available.

Wells in Waterloo County.

Well at Waterloo.

This well, in the town of Waterloo, was sunk during 1867 to a depth of 1,120 feet, of which the record is as follows :— Waterloo.

	Feet.	
Surface	130	
Limestone	40	Onondaga, 77 feet.
Gypsum	17	
Shale	20	
Limestone	340	Guelph, Niagara and Clinton.
Shale, blue	114	Clinton and Medina.
Shale, red	459	Medina.

This well sunk for salt was very unsuccessful, only bitter saline water being met with at 800 and 900 feet. These depths would indicate that the water seams were contained in the red shales of the Medina, which elsewhere in Ontario are noted for these peculiar saline waters.

Elevation of the well above tide about 800 feet.

A well in Waterloo, presumably this one, was afterwards deepened to 1,800 feet by Mr. John McEwen, the record of which is, unfortunately, not available.

In 1883 another well was sunk at this place by Mr. John Savage, of Petrolea, whose record and papers regarding it have been mislaid. He, however, assured me that neither gas, oil nor salt was met with.

Well in Berlin.

Berlin.

In the town of Berlin and about half a mile east of the Grand Trunk Railway station, a well was unsuccessfully sunk for water to the depth of 1,250 feet, by the gentleman last named. The rocks traversed are, according to the driller, as follows:—

Surface	187	feet.
Limestone	320	"
"Hard rock"	40	"
Limestone	200	"
Shale, red	180	"
Shale, green	160	"
Slate, blue	170	"

The casing was carried to a depth of 303 feet, and at the depth of 540 feet there was a strong flow of mineral water; whether saline or otherwise, I was unable to ascertain; neither gas nor oil was noted.

I have found it impossible to correlate the rocks said to have been met with in this well with those traversed in the well at Waterloo, but a short distance to the north-west. The drilling was, however, undoubtedly begun in the Onondaga formation, represented by the upper part of the 320 feet of limestone, and, like at Waterloo, terminated in the Medina.

Elevation 1,080 feet above tide.

Wells in Wellington County.

Well at Erin.

Erin.

A well was sunk at this place in 1888 by Mr. John Fraser, of Petrolea, which reached a depth of 800 feet and of which the following record, only, is available:—

Limestone	95	feet.	Niagara.
Shale	100	"	Clinton.
" blue, and sand	25	"	Medina.
" red	480	"	
" blue	100	"	Hudson River.

The lower 100 feet of shales are ascribed to the Hudson River formation, though of this there can be no certainty, from the fact that between the shales ascribed to the Clinton and those presumed to be the Hudson River there is but 505 feet of shales to represent the Medina formation which, further south, has an average thickness of 750 feet.

Neither gas nor oil was found in this well.

Elevation above tide 1,038 feet.

Well at Eden Mills,

Eden Mills.

Regarding this well Dr. T. S. Hunt, writes as follows:—*

"Another boring, at Eden Mills, on the first lot of the first range of Eramosa, was sunk 159 feet in limestone and shales, before encountering the red strata of the Medina, which were penetrated 350 feet, making a depth of 509 feet. Some white or light coloured bands were met with in the upper part of the red rocks, and at 250 feet from the surface, in what was described as a layer of black slate, a spring of saline water was encountered."

Wells in Brant County.

Well at Brantford.

Brantford.

During 1888 a well was drilled 1,118 feet deep by the Waterous Engine Company in the yard at their works on Dalhousie street, Brantford. The boring was made in search of gas but was unsuccessful, a very small flow, only, being obtained, though at what depth I was unable to ascertain. The boring commenced in the Onondaga, or rather in the drift immediately overlying that formation. Only an imperfect record of this well was obtained, the interpretation of which is probably as follows:—

Surface	63	feet.	
Limestone, &c.	457	"	Lower beds Onondago and Guelph, Niagara and Clinton, if present.
Blue shale	5	"	530 Medina.
Red "	25	"	
Sandstone	40	"	
Red slate	460	"	
Dark red and blue shale	68	"	probably to summit of Hudson River.

*Geol. Surv. of Can., Rept. of Progr., 1866, p. 251.

There was a small flow of sulphurous water, at 200 feet, and at 300 feet the same was found in large quantities; it was, however, effectually cased off and no further water was met with.

Elevation 707 feet above tide.

Well in the Township of Brantford.

Township of Brantford.

In the year 1888 a well was sunk on lot 16, concession 15, township of Brantford, in search of gas, which however, was unsuccessful, small quantities only being obtained. The boring reached a depth of 2,160 feet, or 210 feet beneath the summit of the Trenton limestones. Only an incomplete log, as below, and very little information was obtained respecting it :—

Surface	45 feet.		
Limestone	400 "	} To base of Medina.	
" shales, &c	525 "		
Blue shale	980 "	Hudson River and Utica.	
Limestone	210 "	Trenton.	

Heavy flows of water were found at points between 200 and 300 feet, accompanied by small quantities of gas, and a small flow of the latter was again obtained, unaccompanied by water, at about 1,950 feet, undoubtedly from the upper beds of the Trenton. The quantity was not, however, sufficient to be of economic importance. Casing was carried to a depth of 520 feet, beneath which the hole was comparatively dry.

Elevation above tide, about 672 feet.

Well at Paris.

Paris.

During the year 1865 a drilling was made at Paris in search of petroleum. I have been unable to obtain any later information regarding this well, of which Dr. Sterry Hunt, writes as follows :—*

" One of these (borings) is in the town of Paris, where, after 10 feet of soil, there were met 146 feet of thin bedded limestones, with shales and gypsum, beyond which, in August last, they had penetrated 99 feet in a white granular rock, a specimen of which was found to be pure dolomite, probably belonging to the Guelph formation."

Assuming that the lower ninety-nine feet be dolomite of the Guelph formation, the record to 255 feet would be as follows : —

Surface	10 feet.	
Limestone, &c	146 "	Onondaga.
Dolomite	99 "	Guelph.

What the result of this boring was is not stated.

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 250.

Well at Cathcart (Sydenham).

At the time that the last described boring was accomplished a well had been sunk at Sydenham (now Cathcart), of which Dr. T. S. Hunt,* writes as follows:— Cathcart.

"A few miles to the south-west of this (Paris), at Sydenham, a boring was said to have been sunk through clay 140 feet, shale and gypsum 260 feet, after which a harder rock, doubtless the same as at Paris, was encountered."

Wells in Oxford County.

Wells at Tilsonburg.

During 1861 and the succeeding years numerous wells were sunk in and around Tilsonburg in search of oil, with, unfortunately, but little success. Oil was met with in the Corniferous limestone immediately underlying the drift deposits, but never in sufficient quantities to be considered of economic importance. In the township of Dereham, near Tilsonburg, two wells were sunk during 1861, the record kept of one of them showing, surface (clay) thirty feet, succeeded by ninety-six feet of Corniferous limestone. Oil was first found on the surface of the rock, and again at fifty-five and sixty-eight feet beneath the surface, oil from the latter depth being accompanied by water and, at intervals, by large quantities of gas. Tilsonburg.

In 1865 and 1866 a well was sunk by Messrs. Hibbard and Avery, of Tilsonburg, to the depth of 854 feet. It was reopened in 1873, and the drilling carried to a depth of 1,450 feet in the vain hope that the bore would penetrate the thick salt beds found to the north-west. Mr. Lionel Smith † says: "A brine of increasing gravity was the result, which is now, I am informed, 50° to 60° by salometer; but no salt bed was reached, as they are evidently near its edge, but not over it." In 1877 the drilling was carried, by the same company, to a depth of 1,750 feet.

Dr. Sterry Hunt examined specimens from this well, of which he writes as follows:§—"The rock, beginning at 36 feet from the surface, is a pure limestone, and specimens from 97, 100, 150 and 196 feet have a similar character. One from 210 feet is a granular dolomite, while others from 261, 273, 290 and 305 are limestones. At 365 feet is a granular dolomite, while specimens from 420 and 454 feet, are compact varieties of the same rock. At 560 feet a limestone is again met with,

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 251.
† Ibid., 1874-75.
§ Ibid., 1866, p. 250.

and a dolomite at 600, while the latest obtained specimen, at 890 feet, has the same composition."

The record of this well may be rendered as follows—the first 890 feet being on the authority of Dr. Hunt and the remainder as given to me by the driller :—

Surface.....	36 feet	
Limestone.....	160 "	Corniferous.
Dolomites and limestones	694 "	Probably Onondaga.
Red marl.....	35 "	Onondaga.
Dark shale.....	825 "	

The Corniferous is evidently traversed in the first 160 feet of rock, and is succeeded by the Onondaga, having a thickness of about 890 feet. That this is the case is evidenced by the fact that at 890 feet there were met with thirty-five feet of red marls, which, according to Dr. Hunt, form the basis of this formation. The succeeding 825 feet, termed by the driller "dark shale," probably includes all those rocks comprising the Guelph, Niagara, Clinton and part of the Medina. specimens are, unfortunately, not available, and the record of the lower part of this well must, of necessity, remain a matter of conjecture.

The Hamilton shales are wanting at Tilsonburg, though it is reported that in drilling a well about two miles south-west of the town "soapstone" was found to overlie the Corniferous for a depth of eleven feet.

During 1865 and 1866 several companies sank wells in Dereham and adjoining townships without success, though, in several of the wells, small quantities of oil were obtained. One of these, the "Lyndop and Chandler," afforded some seventy-five barrels of oil before being abandoned. Oil and water are still flowing from this well, and a specimen, collected by the writer during 1890 shows the oil to be very dark and of heavy gravity.

In all some twelve or thirteen wells were sunk, averaging, with the exception of the "Hibbard and Avery," a depth of about 500 feet.

In 1888 and 1889 drilling was again commenced, without, as in previous years, any economic result. Four wells were sunk, one to 400 feet and three reaching 200 feet, in all of which traces of oil were found, and from the 400 feet well, a strong flow of sulphur water was obtained.

More or less gas was noticed in all the wells bored, arising, in every instance, from the Corniferous limestone. The history of the rise and fall of the oil excitement at Tilsonburg is brief. It seems that, for

many years, the Indians of the district resorted to a well-known oil spring, a short distance south-west of the town, where they collected the black oil, for medicinal purposes. The attention of oil producers was directed to it and as early as 1861 drilling operations were begun in and around the town. The first well was sunk, in 1861, by Messrs. Watkins, Miles and Craigie, who drilled and soon after abandoned a well which afforded small quantities, only, of oil. In 1865 and 1866, Messrs. Hibbard and Avery, Lyndop and Chandler and others commenced operations, with what results has already been shown; after this operations ceased till 1873, when the Tilsonburg Salt Co. reopened the old Hibbard and Avery well, deepening it to 1,450 feet and afterwards in 1877 to 1,750 feet. Drilling was again undertaken, in 1888 and 1889, for what purpose I was unable to ascertain, though of the results there can be no doubt.

Well at Burgessville.

Burgessville. During the year 1887, a joint-stock company was formed at this place for the purpose of sinking wells in search of gas and oil. A well was begun and finished during the year which reached a depth of 605 feet. Neither gas nor oil was found. At the depth of 185 feet beneath the surface a strong flow of sulphur water was met with; this water has been flowing continuously ever since and with no apparent diminution in quantity. No record of the boring was kept beyond the fact that the surface deposits had a thickness of 165 feet. I am indebted to Mr. E. H. Snyder, of Burgessville, for several specimens, which, on examination, proved to be as follows :—

Specimen from	280 feet.	Light blue shale, slightly calcareous.
" "	300 "	" with gypsum.
" "	367 "	Cream coloured dolomite.
" "	400 "	Light brown "
" "	550 "	Dark blue shale.

All of these specimens are probably of rocks belonging to the Onondaga formation.

Wells at Norwich.

Norwich. Two wells have been drilled at or near this place of which but scant information is available. The deeper of the two sunk in 1885, on the property of Mr. George A. Cook, reached a depth of 2,000 feet; the drilling was done by Mr. Duncan Sinclair. Fresh water, which is now being utilized, is said to have been struck at 800 feet.

The other well is much shallower, reaching a depth of only 500 feet, wherein at 150 feet from the surface a small flow of oil accompanied by water was noted. The surface deposits were eighty feet thick.

Well at Harrington.

Harrington.

A well was, some years ago, sunk at the village of Harrington, but no particulars of the drilling could be obtained, beyond the fact that nothing of economic value was found.

Well at Woodstock.

Woodstock.

It is reported that a well was also sunk at Woodstock, at about the same time as the above, though no information relating to it could be obtained.

Wells in Norfolk County.

Norfolk County.

Numerous wells have, within the past twenty-five years, been sunk in this county, in every case, however, proving failures, when sunk in expectation of obtaining gas or oil in economic quantity. Small flows of gas were met with in several of those sunk in the northern part of the county, more especially in that drilled on Big creek, near Lyndoch. This well, was sunk in 1869 or 1870, and reached a depth of 600 feet, the surface deposits showing a thickness of about 100 feet, below which black shales, probably of Hamilton age, were found; beyond this no data have been obtained relating to the rocks pierced. From a depth of about 600 feet a strong flow of sulphur water, accompanied by a small quantity of gas, was obtained. This flow, of gas and water, has been continuous.

Among other wells, in this county, may be mentioned one sunk at Port Rowan, which reached a depth of 400 or 500 feet. No gas or oil was obtained.

Wells in Elgin County.

Well at Vienna.

Vienna.

A well was sunk here, about twenty-five years ago, about which I have been unable to obtain direct information. Dr. Hunt states* that this well was sunk at a point about forty feet above Lake Erie, and that the Corniferous limestone, was met with beneath 240 feet of clay. This is in the area supposed to be covered by the

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 250.

Hamilton series, the shales of which are, however, wanting at this point.

Well at Port Stanley.

Port Stanley.

At about the same time that the boring at Vienna was made, one was also made at Port Stanley, to a depth of 298 feet. The record is as follows :—

Surface	172	feet.	
Black and brown shale..	30	"	Probably all Hamilton.
Light coloured shale.. .	16	"	
Limestone	80	"	

What the result of this boring was has not been ascertained.

WELLS IN MIDDLESEX COUNTY.

Well at the Insane Asylum, London.

Insane Asylum, London.

Some years ago a boring was made on the grounds of the Asylum which reached a depth of 2,250 feet, probably terminating in the upper portion of the Hudson River formation. The first rock met with is a limestone, at or near the summit of the Corniferous, as the shales, indicative of the Hamilton, found in the well at the sulphur spring in the western part of the city, are missing.

The record of the boring, kindly furnished by Mr. W. Harris, of Petrolea, is approximately as follows :—

Surface	130	feet.	
Limestone, hard	200	"	Corniferous.
" soft	270	"	Onondaga with Guelph and Niagara, if present.
" hard	100	"	
"	600	"	
Salt and shale	100	"	
Black shale	200	"	Clinton.
Red "	500	"	Medina.
Limestone and shale	150	"	Hudson River.

In referring to the above log it will be seen that salt and shale, having a combined thickness of 100 feet were found, but how much of this was actually salt I have been unable to ascertain.

The elevation of the well is about 880 feet, above tide. In reply to numerous inquiries respecting the depth at which the Trenton limestone would be reached, it may be stated that assuming the base of the Medina here to be 1,220 feet below tide level and that the Hudson River and Utica have a thickness of 800 feet, the Trenton would

be reached at about a depth of 2,020 feet below tide or 2,900 below the surface.

The depth at which gas, if present, would be found, is probably not less than 2,900 feet, as the rocks to be traversed in that distance between the bottom of the above mentioned well, and the summit of the Trenton, are not usually gas-bearing.

Well at Sulphur Spring, London.

Sulphur Spring, London.

Previous to 1865 a well was sunk at this place which afforded, and to the present day affords a copious supply of sulphur water. The well was drilled to a depth of 765 feet, the rocks pierced being as follows:—

Surface, clay.....	70 feet.	
Soft grey shale.....	20 "	Including a band of hard black bituminous shale.
Limestone.....	600 "	
Soft magnesian marl..	75 "	

This boring was begun in the Hamilton shale which, as will be seen on referring to the above, has a thickness here of about twenty feet, beneath this the Corniferous was traversed, probably within a distance of 300 feet from the surface, as at that point the rock proved to be a true dolomite, probably of the Onondaga series; assuming that such is he case the Corniferous here is, at the most, 210 feet thick.

Sulphur water was found at 114 feet, having a flow of about 1,000 gallons per hour.

Sunnyside Well.

Sunnyside well.

Of this well, on lot 13, concession 4, township of London, Dr. Sterry Hunt writes as follows*:—"Another—(well)—known as the Sunnyside well, on lot 13, range 4, of London, gave clay 103 feet, beneath which were a few feet of soft shale, reposing on limestone. This was bored for 400 feet, at which depth the rock is a pure limestone, as were several other specimens from various depths, although one from 371 feet was highly magnesian."

Well at Strathroy.

Strathroy.

The following record is given of a well on lot 20, concession 5, in the township of Adelaide, known as the "Strathroy Well." *

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 249.

Work was suspended at 300. feet, the record to that depth being :—

Surface	100	feet.	
Soft shale	50	"	Hamilton.
Hard limestone	150	"	Corniferous ?

Whether work was resumed, and what the result of this boring was, I have been unable to ascertain.

Well at Glencoe.

Some years ago a well was sunk at this village under the supervision of Major John Savage, of Petrolea, to whom I am indebted for the following log :— Glencoe.

Surface	134	feet.	
Limestone	100	"	Hamilton.
Soapstone	162	"	
Limestone, white	80	"	
"	486	"	Corniferous and Onondaga, probably 200 feet of Corniferous.
Sandstone	38	"	Onondaga.
Limestone, hard	260	"	
Gypsum	5	"	
" Hard rock "	15	"	
Gypsum	3	"	
" Hard rock "	7	"	
Salt and shale	104	"	Probably terminating in the Guelph.
" Hard rock "	116	"	
Total depth	1,510	"	

In the thirty-eight feet of so-called sandstone there was a strong flow of mineral water of what description I am, however, unable to state. At 1,290 feet salt and shale were pierced, having a combined thickness of 104 feet.

The drilling was, in all probability, begun in the so-called " upper lime " of the Hamilton formation, and terminated in the base of the Onondaga or summit of the Guelph. Throughout the log the term " hard rock " undoubtedly means dolomite, and " soapstone " the shales of the Hamilton formation.

Wells in south-west part of Middlesex.

Throughout the south-western portion of Middlesex numerous wells have been sunk to a depth of about 550 feet in search of oil, unfortunately, finding only very small quantities. South-western Middlesex.

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 248.

One well in the township of Metcalfe, lot 24, concession 13, gave the following record :—

Surface (clay)	48	feet.	
Black shale	75	"	Portage.
Soapstone, etc	273	"	Hamilton.
Limestone	104	"	Corniferous?

Records of two wells sunk in the township of Mosa, have been preserved. One of these, on lot 5, concession 7, showed :—

Surface (clay)	50	feet.	
Black shale	10	"	Portage.
Soapstone, &c	230	"	Hamilton.
Limestone	262	"	Corniferous?

Another, on lot 3, concession 4, gave :—

Surface (clay)	88	feet.	
Black shale	6	"	Portage.
Soapstone, &c	243	"	Hamilton.
Limestone	177	"	Corniferous?

Well at Parkhill.

Parkhill.

In 1884 a well was sunk at Parkhill, by a syndicate of citizens of that place, under the title of the Parkhill Salt Works Company, to the depth of 1,300 feet, passing through one salt-bed and into the second to a depth of twenty feet. The surface deposits showed a thickness of about 170 feet, and were immediately underlain by limestone.

All the documents, etc., belonging to the company were destroyed by fire, and therefore no detailed record of the well could be obtained, a loss very much to be regretted as this well, by its relative position and depth, would have proved a useful factor in working out the details of the geology of the western peninsula of Ontario.

Owing to the decline in the price of salt the block, at the time of my visit, had not been completed, and the well, therefore, was not made use of.

Wells in north-west Middlesex.

North-west Middlesex.

During the earlier years of the oil excitement numerous wells were sunk throughout the townships of McGillivray, Williams (east and west), and Adelaide in Middlesex, and Bosanquet and Warwick in the county of Lambton. Of those in Middlesex few reached a depth of 500 feet, and but small quantities of oil were anywhere obtained.

The following record of a well sunk near Ailsa Craig station on the Grand Trunk Railway, is from the report of the Geological Survey for 1866 :—

Surface (clay)	75	feet.	
Limestone, soft	185	"	Hamilton.
Limestone	113	"	

A small quantity of oil was obtained at 275 feet from the surface.

Another well, near the above, showed, according to the driller, the following section :—

Surface	65	feet.	
Limestone	5	"	
Soapstone	6	"	
Limestone	80	"	Hamilton.
Soapstone	50	"	
Limestone	144	"	

At a well recently sunk in Biddulph township, about five miles north-east of Lucan, 100 feet of surface deposits rested on limestone which was penetrated 260 feet, in all 360 feet. The limestone, probably of Corniferous age, afforded an abundant supply of fresh water.

Neither gas nor oil was met with.

Well at Sylvan.

Sylvan. A well was bored in 1888 on lot 15, concession 15, township of West Williams, to a depth of 200 feet, of which 175 feet was surface. At 180 and 195 feet from the surface gas was met with in large quantities, rendering the well, which was sunk for water, valueless. It was the intention, at the time of my visit, however, to bore deeper in expectation of finding a larger quantity of gas. I have not heard whether this has been done or not.

I have been informed by several drillers, who have operated in this district, that in nearly all the wells sunk in the townships of Williams, Bosanquet, Warwick and McGillivray, gas was obtained in no inconsiderable quantities. In these cases, as the wells are shallow, the gas would necessarily emanate from the base of the Hamilton or summit of the Corniferous formation.

Wells of the Salt Region.

Wells at Goderich.

Goderich. Of the wells sunk at this place the most important is undoubtedly that bored by Mr. Henry Attrill in 1876. Work was begun on the 10th of March of that year and bed rock reached on the 15th of April

at a depth of seventy-eight feet nine inches, the record of the superficial deposits being as follows :—

Gravel	14	feet	0	inches.
Blue clay	31	"	0	"
Boulders	10	"	0	"
Gravel	4	"	0	"
Boulders	13	"	0	"
Sand and clay	6	"	9	"

The boring was then continued by means of a 2½ inch diamond drill to a depth of 365 feet from the surface to which point the well was cased, excluding all water. Below this the drilling was continued to a depth of 1,517 feet, a two inch diamond drill being employed. The drilling was completed on the 6th of December, 1876.

The record of the drilling has been summarized by Dr. Sterry Hunt, as follows :*—

Dolomite, with thin limestone layers	278	feet	3	inches.
Limestone, with corals, chert, and beds of dolomite	276	"	0	"
Dolomite, with seams of gypsum	243	"	0	"
Variegated marls, with beds of dolomite.	121	"	0	"
Rock-salt, 1st bed	30	"	11	"
Dolomite, with marls towards the base	32	"	1	"
Rock-salt, 2nd bed	25	"	4	"
Dolomite	6	"	10	"
Rock-salt, 3rd bed	34	"	10	"
Marls, with dolomite and anhydrite	80	"	7	"
Rock-salt, 4th bed	15	"	5	"
Dolomite and anhydrite	7	"	0	"
Rock-salt, 5th bed	13	"	6	"
Marls, soft, with anhydrite	135	"	6	"
Rock-salt, 6th bed	6	"	0	"
Marls, soft, with dolomite and anhydrite.	132	"	0	"

It will be seen on referring to the above that in a thickness of 388 feet, or from the top of the first salt bed to the base of the sixth, there is a thickness of rock-salt traversed amounting to 123 feet. This well is the deepest in the district, reaching, as it does, the sixth bed, while in the most of the other wells the bore ceases in either the first or third.

The other wells at Goderich and immediate vicinity are :—

Platt's Well,	operated by	Jno. S. Platt.
Ontario "	"	North American Chemical Company.
Saltford "	"	Peter McEwen.

*Geol. Surv. of Can., Rept. of Progr., 1876-77.

Dominion Well, operated by Jos. Kidd, jr.
Ogilvie and Hutchison Well, operated by Ogilvie and Hutchison.
International Well, not in operation.
Star Salt " "

Platt's Well was sunk about 1875, reaching a depth of 1,075 feet. Salt was struck at 990 feet from which depth the brine is now being pumped. Platt's well.

The Ontario Well was sunk in 1867, the depth attained being 1,127 feet or two feet lower than the base of the first salt bed. Ontario well.

The Saltford Works Well, drilled in 1865 by Mr. P. McEwen, was the first well sunk in Ontario for the production of salt, and has been one of the most successful, having been operated continuously by the present owner. The "block" and well are situated in Saltford, a suburb of Goderich, on the north side of the Maitland river. The drilling was completed at the base of the first salt bed, a depth of 1,000 feet. Saltford.

The Dominion Well, sunk about 1868, reached a depth of 1,120 feet. Dominion well.

Ogilvie and Hutchison Well, situated on the Lake shore in the harbour, is the most recently completed, the boring having been made in 1882. The depth attained was 1,100 feet, reaching, it is stated, the third salt bed. Ogilvie and Hutchison well.

The International Well was sunk in 1874 by Mr. Joseph Kidd, Sr., and has a depth of 1,170 feet. The well is on the Lake shore at the southern boundary of the town and the "block" was at one time the largest in Ontario, but owing to the failure of Mr. Kidd it has not been in operation for some years. The record of this boring is, according to Mr. P. McEwen, the driller, as follows:— International well.

Blue clay, limestone boulders	100 feet
Limestone boulders, and gravel	40 "
Sandstone and limestone alternate beds	510 "
Hard flinty limestone	300 "
Blue shale, thin streaks of red shale	84 "
Gypsum	6 "
Brown limestone, soft	14 "
Rock salt, 1st bed	19 "
Brown limestone, very hard	30 "
Rock salt, 2nd bed	24 "
Blue shales and clays	3 "
Rock salt, 3rd bed	32 "
Brown limestone, lighter than preceding	8 "
	1,170

But little remains to be written of the salt wells in Ontario as there has been very little activity in the way of boring since that undertaken by Mr. Attrill at Goderich. In the report of the Geological Survey for 1866, page 263 may be found Dr. Sterry Hunt's article on "Brine springs," again in that for 1866-69 he reports on "The Goderich salt region" and in the report for 1876-77 there is an article by him on Mr. Attrill's exploration in the Goderich salt region. In the report of the survey for 1874-75, Mr. Lionel Smith writes on the Canadian salt industry.

WELLS IN HURON COUNTY.

	Depth. Feet.	1st Salt. Feet.	Year sunk	Elevation above tide
Wingham	1,185	1,090	(?)	1,012
Brussels	1,244	...	1872	1,120
Brussels, ¾ mile south	1,000	970	1873	1,095
Blyth	1,215	1,125	1879	1,080
Clinton	1,239	1,151	1867	927
Seaforth	1,135	1,035	1870	1,009
Hensall	1,206	1,090	1880	900
Exeter	1,251	1,135	1881	875

Wingham.

Wingham.—This well, operated by the Gray, Young and Sparling Company, at Wingham, is on the south-east corner of lot 41, concession 13, East Wawanosh, and reached a depth of 1,185 feet. The record of boring is as follows :—

Surface	96	feet.
Grey limestone	100	"
Dolomite	250	"
Dolomite with gypsum and limestone	275	"
Limestone with blue shale and dolomite	369	"
Rock-salt	30	"
Limestone	65	"
	1,185	"

Brussels.

Brussels.—This well was described by Mr. J. Gibson in an article entitled "Salt Deposits of Ontario." * The following is the log as given by him :—

Surface	16	feet.
Limestone	100	"
Limestone, magnesian	266	"
Limestone, with chert	180	"
Soapstone	353	"
Dolomite, grey	97	"
Dolomite	168	"
Sandstone, dark brown	64	"
	1,244	"

* *American Journal of Science*, vol. V., 3rd series.

The first limestone is probably of Corniferous age, beneath which is found the Onondaga series of magnesian limestones, dolomites and shales, and the sandstone—so-called—is, in all probability, referable to the Guelph series of dolomites which are usually light to dark brown and arenaceous in appearance.

Saline waters were met with at 1,012 feet, and at 1,200 feet traces of oil and gas were noticed.

This well is apparently just outside the edge of the salt basin and defines very closely its geographical limit at this point, as, at a distance of only three-quarters of a mile south-west of the town, salt was struck in considerable quantities in the well now being operated by Mr. F. C. Rogers.

Blyth.—The following is the driller's record of this well: Blyth.

Surface	104 feet.
Limestone	300 "
(?)	346 "
Shale, black	100 "
Hard rock	170 "
Shale	105 "
Rock salt	90 "

Considerable gas was obtained in the black shales at a depth of 850 feet. No further information regarding the well has been obtained.

Clinton.—The "Stapleton Well," owned and operated by Mr Henry Ransford, was drilled by the owner in 1867, and I am indebted to him for the following record of boring:— Clinton.

Surface	67 feet.
Limestone	413 "
Limestone, cherty and dolomite	204 "
Limestone	176 "
Limestone, cherty and dolomite	36 "
Shale, limestone, gypsum and marls	255 "
Rock salt, first bed	15 "
Shale, gypsum and salt	48 "
Rock salt, second bed	25 "
	1,239 "

Seaforth.—The following record of boring at Messrs. Coleman and Gouinlock's "block," is taken from Mr. Gibson's article, already referred to:—* Seaforth.

* *American Journal of Science*, vol. V., 3rd series.

Surface	25 feet.	
Limestone, dark grey	400 "	
" magnesian	310 "	with chert.
Shales, limestone and marls	250 "	
Gypsum, salt and shale	50 "	
Rock salt	100 "	
	1,135 "	

Boring finished in salt.

Hensall.

Hensall.—I am indebted to the proprietor and driller, Mr. George McEwan, for the following information regarding his well. The boring was made in 1880, in the southern part of the village of Hensall, to a depth of 1,206 feet, drilling being stopped in the salt strata :—

Surface	88 feet.
Limestone, hard	150 "
" soft	75 "
Dolomite	25 "
Limestone (magnesian ?)	462 "
Shale	230 "
Marly shale	60 "
Salt and shale	116 "

WELLS IN BRUCE COUNTY.

—	Depth, feet.	First salt, feet.	Year sunk.	Elevation above tide.
Teeswater	1,180			
Kincardine	1,007	947		607
do	957		1868	607
Inverhuron	1,007		1872	587
Port Elgin	1,000			587
Southampton	1,255		1868	587

Inverhuron.

Inverhuron.—The following, taken by Mr. J. Lionel Smith, is all the information available : * " A well has since been sunk at Inverhuron, nine miles north of Kincardine, on the shore between Port Elgin and the latter place. The driller, J. S. McEwan, reports that the strata for 895 feet were identical with those at the Kincardine well, and that they then encountered blue shale and gypsum, slightly impregnated with salt ; after which came Niagara shales, and at 1,007 feet, hard limestone, holding black water with an offensive odour."

Port Elgin.

Port Elgin.—Fruitless attempts to obtain salt at this place were made in 1869 and 1870. No information is available beyond that to be found in "The Geology of Canada," 1866-69, wherein Dr. Sterry Hunt states that at a depth of 890 feet the boring was being carried

*Geol. Surv. of Can., Rept. of Progr., 1874-75.

through red shales. These shales are probably of Medina age, as the well was begun in the base of the Onondaga, which appears on the surface at Southampton, five miles further north.

Southampton.—To the courtesy of the driller, Mr. Wm. Morrison, I am indebted for the following record of this well:— Southampton.

Surface	233	feet.
Sand rock	18	"
Sandstone and limestone	150	"
Limestone, dark grey and white	200	"
" soft, light-coloured	99	"
Shales, blue and red	96	"
Limestone, white	34	"
Shale, blue and red	225	"
Shale, blue	200	"
	1,255	"

Kincardine.—The following record of a well at this point is furnished by Dr. Sterry Hunt*:— Kincardine.

Sand and gravel	91	feet.
Limestone and hard strata	509	"
Shale, red	23	"
" blue, with red bands	117	"
Limestone	30	"
Shale, blue and red	125	"
Rock salt	14	"
	909	"

Another given by Mr. Lionel Smith † was that of a well sunk by Messrs. Gray and Scott. This well was completed in 1873, at a depth of 1,007 feet, as follows:

Surface	89	feet.
Sandstone and limestone, alternate layers	28	"
Limestone	179	"
Sandstone, white, fine grained	29	"
Limestone, dark coloured	276	"
Shale, red	14	"
" blue	115	"
Limestone, hard blue	164	"
"Cherty rock"	5	"
Rock salt	12	"
Shale, blue, clay and salt in alternate layers	36	"
Rock salt	60	"
	1,007	"

* Geol. Sur. of Can., Rept. of Progr., 1866-69.
† Ibid., 1874-75, p. 286.

Wells in Perth County.

Three wells were sunk for salt in this county, at Dublin, Mitchell and Listowel, respectively, in none of which places, however, was the venture successful, brines of a low degree of saturation only being obtained, nor was rock salt noted.

Dublin. *Dublin.*—This well, sunk in 1873, reached a depth of 1,396 feet. No record was kept of the operation, and the only facts ascertained are that, beneath a surface covering of about seventy-five feet, limestone, having a thickness of 520 feet, was pierced. At 600 feet gypsoliferous marls were met with, after passing through which the Niagara limestone was reached.

Mitchell. *Mitchell.*—At this place a boring was made of which Mr. Lionel Smith, writes as follows* :—

"At Mitchell, eleven miles south-east of Seaforth, a well was bored to 2,008 feet. After passing through shales belonging to the base of the Onondaga formation, the Niagara limestone was reached, and at 1,570 feet, red shale 300 feet thick, belonging to the Medina formation."

Listowel. *Listowel.*—Some years ago a well was drilled at Listowel for salt by Mr. John McEwen, late of Goderich. The boring attained a depth of 1,200 feet, when, having reached a point below the usual salt horizon, the well was abandoned. Further data are not at hand beyond the fact that a copious supply of brine of a very low degree of saturation was encountered, though at what depth was not stated.

Well at St. Mary's.

St. Mary's. A well was sunk at this place about the year 1863 which reached a depth of about 700 feet. At this point small traces of petroleum were said to have been observed. But little information has been obtained of this well, the only reliable data available being some notes by Dr. Sterry Hunt. † The bore was begun on the Corniferous limestone which outcrops at this place, and specimens were obtained from various points between 100 and 500 feet; these were found in every instance to be magnesian limestones approaching, at times, pure dolomites.

Well at Stratford.

Stratford. During 1890 a well was sunk at this place in search of gas by the Stratford Natural Gas Company, a company composed princi-

* Geol. Surv. of Can., Rept. of Progr., 1874-75, p. 288.
† Ibid., 1866, p. 249.

pally of citizens of the place, and of which Mr. Jas. Trow, M.P., was president. The drilling reached a depth of 2,386 feet without finding gas. Data regarding the rocks pierced are not at hand, the only information available being the fact that the Trenton limestone was struck at 2,360 feet and that salt water in considerable quantity was found at 2,384 feet, or twenty-four feet below the summit of the Trenton.

Wells in Lambton County.

It is not the intention to enter into the history or the extent of drilling operations in this county nor to enlarge upon the fact of its being and having been the only oil producing territory of the Dominion, but to give merely a brief account of some of the most typical and more important wells sunk.

The oil of Lambton county is, in the main, obtained from two distinct pools known as the Oil Springs and Petrolea fields, both in the township of Enniskillen. The larger of the two—the Petrolea field—with an approximate area of twenty-six square miles, extends W.N.W. about nine miles and E.S.E. about four miles from the village of Petrolea; while the Oil Springs field covers about two square miles and includes the south-eastern part of the village of Oil Springs. The pools are divided by a very distinct synclinal structure, the upper beds of the Hamilton being overlain by the black pyroschists of the Portage formation; these black shales have at Oil City, between Petrolea and Oil Springs, a thickness of forty feet, immediately beneath which is found the upper limestone of the Hamilton series.

Wells at Petrolea.

Petrolea. The oil horizon of Petrolea lies at a depth of from 450 to 480 feet beneath the surface of the main part of the town, the oil being pumped in all instances from what is known as the "lower vein" at a point about sixty-five feet in the Corniferous limestone. The following record may be taken as typical of the wells sunk in the Petrolea field.

Well sunk near Imperial Refinery, Petrolea :—

Surface	104	feet.	
Limestone (upper lime)	40	"	Hamilton.
Shale (upper soapstone)	130	"	
Limestone (middle lime)	15	"	
Shale (lower soapstone)	43	"	
Limestone (lower lime)	68	"	
Limestone, soft	40	"	Corniferous.
" grey	25	"	

Numerous deeper wells have been sunk in the expectation of finding deeper seated oil, unfortunately, however, in all cases proving to be failures, as no further oil-bearing rocks were found below those from which the present supply is drawn. The most important, on account of its greater depth, is undoubtedly that sunk near the Imperial refinery and known as the "Test Well," of which the following record has kindly been furnished by the driller, Mr. E. Rawlings:

"Test Well," Petrolea.

Surface	104	feet.	
Limestone	40	"	Hamilton.
Shale	130	"	
Limestone	15	"	
Shale	43	"	
Limestone	68	"	
" soft	40	"	Corniferous.
" grey	25	"	
" "	135	"	
" hard, white	500	"	With hard streaks of sandstone from 2 to 5 feet in thickness.
Gypsum	80	"	Onondaga. (Including the Oriskany, if present.)
Salt and shale	105	"	
Gypsum	80	"	
Salt and shale	140	"	
Total depth	1,505	"	

Elevation above tide, 667 feet.

Wells at Oil Springs.

Oil Springs.

The following record may, in the same way, be taken as illustrating the wells of the Oil Springs pool:—

(East side of field.)

Surface	60	feet.	
Limestone (upper lime)	35	"	Hamilton.
Shale (upper soapstone)	101	"	
Limestone (middle lime)	27	"	
Shale (lower soapstone)	17	"	
Limestone (lower lime)	130	"	

(West side of field.)

Surface	80	feet.	
Shale (upper soapstone)	116	"	Hamilton.
Limestone (middle lime)	27	"	
Shale (lower soapstone)	17	"	
Limestone (lower lime)	130	"	

Oil is found in both of these wells at 370 feet from the surface, or about sixty feet below the summit of the Corniferous limestone. Salt water occurs in each at 252 feet, beneath which point they are comparatively dry.

Of deep wells sunk in the Oil Springs field, no data are available beyond those found in the report of Dr. Sterry Hunt* wherein he writes :—"At Oil Springs, on the second range of the same township (Enniskillen) we may cite a well on lot 19 which gave clay 42 feet, shale, etc., 182 feet, at which depth a copious flow of oil was obtained. After this became exhausted, the boring was continued for 595 feet further, through limestone, of which the inferior portion was tender and friable. Specimens from the bottom, and from fifty feet above, were found to be a granular dolomite, though regarded by the borers as sandstone. Another boring at Oil Springs, known as the "Test Well," was sunk in lot 18 of the second range, to a depth of one thousand feet. From the record it appeared that there were found, clay 77 feet, grey shale, etc., 300 feet, below which only hard rock was found, until near the bottom, when soft shales were again met with. In this well, small portions of oil were said to have been found by the sand-pump, at depths of 210 and 400 feet in the solid rock beneath the shales." Numerous descriptions of shallow wells, throughout this territory, may also be found in the above-mentioned report.

Operations have been carried on continuously since the sinking of the first deep well in Oil Springs by Mr. James Shaw, in 1862. During the first few months after the discovery of oil, wells of enormous capacity were struck, reaching in the case of the Black and Matthewson a daily flow of 7,500 barrels, other large wells being the Fiero, Swan, Webster and Shepley, Petit, and many others, a list of most of which will be found in Dr. Alexander Winchell's "Sketches of Creation." *Appendix, Note VIII.*

In a personal letter from Mr. Isaac Waterman, of Petrolea, I am informed that there are in the oil territory of Enniskillen township between 2,700 and 3,000 wells pumping and affording oil, the total output from which amounts to about 600,000 barrels of 35 imperial gallons per annum.

Well at Wyoming.

Wyoming. Eight miles to the north of Petrolea a well was sunk on lot 15 of the 1st range of the township of Plympton, near the village of Wyoming, of which the following record was obtained :—

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 246.

Surface	104	feet.	
Black shale	4	"	Portage.
Limestone	40	"	Hamilton.
Shale	130	"	
Limestone	15	"	
Shale	43	"	
Limestone	68	"	
" soft	40	"	Corniferous.
" grey	36	"	

Only small quantities of oil were noted accompaned by a copious flow of saline water.

Elevation above tide about 697 feet.

No records of other wells in this township have been received, though from information obtained from the drillers it is learned that none of the many borings made were of economic importance.

Well at Kingstone's Mills.

Kingstone's Mills.

In the township of Warwick, which lies east of Plympton, many wells were sunk, notably that at the Elarton salt works, which reached a depth of 1,400 feet, terminating in a hard rock, of unknown character. Salt was found, it is said, at 1,200 feet, continuing, interstratified with shale, for 130 feet or to a total depth of 1,330 feet, beneath which there was a hard rock (probably dolomite) seventy feet thick.

Another well, of which the following is, according to Dr. Sterry Hunt, the record, was also sunk at or near this place :—

Clay	14	feet.	
Black shale	50	"	Portage.
Shales, soft and limestone	396	"	Hamilton.
Limestone, hard	44	"	Corniferous.

Dr. Hunt speaks of this well* as being important in showing the thickness, in Ontario, of the middle and upper Devonian. To the 396 feet of soft shales and limestone of the Hamilton formation shown above, he adds 213 feet of rocks of the Portage formation, known to exist through a boring made at Corunna, on the St. Clair River, making a total of 609 feet.

Wells in Township of Bosanquet.

Bosanquet, Port Franks.

The deepest well in this township is that at Port Franks which was sunk by Mr. Joseph Williams who for many years has used the brine

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 247.

obtained therefrom in the manufacture of salt. The boring is particularly remarkable owing to the great thickness of drift deposits traversed before reaching bed rock. The record, according to Mr. Williams, is as follows :—

Fine sand	60	260 feet.
Gravel	16	
Clay and gravel	178	
Gravel	6	
Limestone	940	"
Shale	45	"
Salt and shale	110	"

The limestone will probably include the lower part of the Hamilton the whole of the Corniferous and that part of the Onondaga overlying the salt beds. This supposition is borne out by the fact that, at 365 feet from the surface, or 105 feet in the rock, the driller reports having passed through four or five feet of soft marl-like beds ("soapstone"?) which would be utterly unlike the hard grey limestone so characteristic of the Corniferous, and at a point too high to allow of their belonging to the Onondaga formation. Elevation of well above tide, 590 feet.

Widder. Of other wells in this township Dr. Sterry Hunt, writes*:— "Another at Widder station, in Bosanquet, gave: clay, 34; soft shale, etc., 196; limestone, 120 = 350 feet. At 196 feet from the surface, some gallons of oil were obtained. A well, on the southern line of the township, on the third lot, not far from Arkona. Arkona, was sunk in a valley, which showed, above the boring, the strata of the Hamilton shales, nearly as follows, in descending order: hard limestone, 8; shale, 40; limestone, 3; shale, 9; from which point a boring was carried 224; hard white limestone, yielding some oil, 18 = 242 feet, in August last. This shows 284 feet of the Hamilton formation at this point. To the west of this, at what is called the Grand Trunk Well. Trunk Well, on the twelfth lot of the tenth range of Bosanquet, after clay 90, hard black shale 95, 350 feet of soft shales were said to have been found = 535 feet, and the boring from this depth was in a very soft grey calcareous marl resembling the strata of the Hamilton: neither this nor the well near Arkona, however, represents the entire thickness, in the vicinity of the soft grey shales and so called soapstones of the Hamilton formation, which at Kingstone's Mills, in Warwick, measure, as we have seen, 396 feet, while in the valley of the Thames, as shown above, these strata do not measure over 250 or 290 feet, showing a rapid thickening to the northward."

*Geol. Surv. of Can., Rept. of Progr., 1866, p. 248.

Wells in Township of Brooke.

Brooke.

Operations were also carried on in this township, unfortunately, however, without finding oil in economic quantities. No records have been kept of the work.

Wells in Township of Euphemia.

Euphemia.

In late years some forty wells have been sunk in this township and small quantities of oil shipped. The field is small and the largest flow from an individual well (the Wilson and Bennett) has been but one barrel per day. The record of this well is as follows :—

Surface	53 feet.	
Shales, etc	224 "	Hamilton.
Limestone	93 "	Corniferous.

Another, the Parson's well, gave the following section :—

Surface	58 feet.	
Shales, etc	265 "	Hamilton.
Limestone	37 "	Corniferous.

No oil was found, the only product being salt water, which was struck in a heavy flow at 360 feet.

All the oil from this field is shipped by Grand Trunk Railway from Newbury station, the greater part being consigned to London, Ontario, where it is refined.

Wells in Township of Dawn.

Dawn.

Explorations for oil have been carried southward from Oil Springs into this township, though with poor results. Of the many wells sunk, one record alone is available, namely, that on lot 32, concession 10, which reached a depth of 700 feet, and for which I am indebted to the driller, Mr. W. Harris, of Petrolea, who reports as follows :—

Surface	50 feet.
Shale, black	70 "
Limestone	70 "
Shale and limestone	285 "
Limestone	225 "

The "middle lime," which is not shown in the record, consisted, according to the driller, of about two feet of soft limestone, though at what depth I was unable to ascertain. The driller also states that throughout the 285 feet of shales he noted several "streaks" of limestone from two to four feet thick.

No oil was obtained in this boring, and salt water was struck at 625 feet.

Mr. Lionel Smith states* that he was informed that Mr. Peter McEwen, when boring for oil in this township, had struck rock salt at 1,100 feet. I have been unable to discover where this well is or any further data regarding it.

Wells in the Township of Sombra.

No records are at hand of wells bored in this township, though it is supposed that considerable exploratory work has been done. Dr. Sterry Hunt writes† of the work done in this township :— Sombra.

"Several wells sunk along the Sydenham river, in the townships of Sombra and Camden, present a considerable thickness of black shales overlying the soapstone, or grey Hamilton shales. One, on the north branch of the Sydenham, on the twelfth lot of the seventh range of Sombra, not more than ten feet above the river level, was sunk through 112 feet of quaternary clays, and then through 100 feet of black shale; after which it had, at the time of my visit in August last, been carried a little over 100 feet in the soapstone. Similar results were obtained in a well on an adjoining lot, while another on lot twelve, of the tenth range, gave, below 120 feet of clay, twenty feet of black shales, followed by sixty feet of soap stone at the time of my visit."

A salt block has been erected at Port Lambton on a well the depth of and information regarding which I have been unable to obtain. Port Lambton

Wells in Township of Moore.

As in the case of the other townships surrounding Enniskillen, boring operations have been carried into this township in anticipation of an extension of the Petrolea and Oil Springs pools, unfortunately, however, with but slight success. Of the many wells sunk the records of but two are available, viz., a well on lot twenty-eight of the first range, at the village of Corunna, and that of the Courtright Salt Company. Moore.

Of the former the following has been preserved :— Corunna.

Clay	54	120 feet.	Surface deposits.
Shingle of black shale	56		
Clay	10		
Shale, black	8 "		Portage and Chemung.
Sandstone, greenish	20 "		
Shale black, with pyrites	185 "		
Grey shale and lime	17 "		Hamilton.

* Geo. Surv. of Can., Rept. of Progr., 1874-75, p. 288.

† Ibid., 1866, p. 244.

What the results of the boring were is not stated, though it is presumed oil was not found.

Courtright.

Courtright.—At the works of the Courtright Salt Co. a well was sunk in June, 1884, to a depth of 1,665 feet. The following record of it has been kindly furnished by the driller, Mr. E. Rawlings, of Petrolea :—

Surface (sand, etc.).... 132 Hard-pan..... 28	160 feet.		
Shale, black.....	32	"	Portage.
Limestone.....	40	"	Hamilton.
Shale and limestone	310	"	
Limestone, white.....	50	"	
" grey.....	100	"	Corniferous.
" white, hard.....	370	"	Onondaga, including lower part of Corniferous.
Sandstone*	32	"	
Limestone	400	"	
" and gypsum.....	136	"	
Salt.....	22	"	
Gypsum	13	"	

**Probably dolomite.*

Elevation above tide, 588 feet.

Salt water was met with at 680 feet, which was effectually cased off, by casing to a depth of 740 feet. A considerable quantity of gas was met with in a few feet of quicksand immediately underlying the "hard-pan." This was thought to be of such importance that a drive pipe was afterwards sunk near the salt well, and the gas utilized until cut off shortly after, when nearly exhausted, by the filling of the casing with sand and water.

Wells in Township of Sarnia.

Sarnia.

The productive oil territory of the Petrolea pool extends into the south-eastern corner of this township, in which part many successful wells have been and are being sunk. The records of none of these are available, though it is supposed that they would not differ much from those of wells nearer to Petrolea, and that typical of the Petrolea pool.

In the south-western part of the township several wells have been sunk, from which considerable flows of gas are recorded. Of one of these, on J. D. Simpson's farm, lot 15, block A, Indian reserve, the following has been obtained :—

Simpson's Farm.

Surface.....	124	feet	
Shale, with hard streaks...	32	"	Portage.
Shale and limestone.....	324	"	Hamilton.
Limestone	15	"	

At 480 feet gas was found accompanied by oil and salt water; the flow of gas being estimated at about 20,000 cubic feet per diem.

Wells in Town of Sarnia.

Sarnia. King's grist-mill.

In the town of Sarnia are several wells, prominent among which is that at King's Grist-mill, drilled in 1875 by Mr. E. Rawlings, of Petrolea, to whom I am indebted for the following record :—

Surface sand	9	120 feet	
Blue clay	109		
"Hard-pan"	2		
Shale, black	36	"	Portage.
Limestone	30	"	Hamilton.
Shale	263	"	
Limestone	5	"	
Shale	40	"	
Limestone	60	"	
" grey	100	"	Corniferous.
" hard	546	"	Onondaga, including lower part of Corniferous.
" hard and flinty	200	"	
" with gypsum	105	"	

Elevation above tide, 589 feet.

Fresh water was encountered at 120 feet beneath the "hard-pan" and a copious flow of salt water at 654 feet; the casing, however, was carried to only 495 feet or just into the lower limestone of the Hamilton. Oil was not observed, but gas in small quantities was found at 400 feet and cased off.

Peterson's well.

Peterson's well.—During 1887, Messrs. N. C. Peterson and Sons drilled at their works in the town for the purpose of obtaining a supply of gas for their boilers. The drilling was carried to a depth of 685 feet, in which two small flows of gas were obtained at 330 and 515 feet, the latter affording the greater supply. According to the driller, Mr. H. Mitchell, the log is as follows :—

Surface	200	feet.	
Shale, black	15	"	Portage.
Limestone	150	"	Hamilton, including upper part of Corniferous.
Shale	85	"	
Limestone	5	"	
Shale	60	"	
Limestone	170	"	

In the last few feet bored there was a heavy flow of salt water which rose to a considerable height, flooding the gas-rock. The well was not packed, and after supplying fuel for some time to the boiler at the works, was finally abandoned.

Agricultural works well.

Agricultural Works Well.—This well, also drilled by Mr. Mitchell, gave the following record :—

Surface	130	feet.	
Shale, black	80	"	Portage.
Limestone	80	"	
Shale	160	"	
Limestone	5	"	
Shale	60	"	
Limestone	150	"	
Depth	665	"	

Gas in small quantities was found at 515 feet, and salt water at 645 feet. The casing was carried to a depth of 140 feet, and the hole plugged at 640 feet, but owing to the water being ineffectually shut off the gas was never available and the well was finally abandoned.

Dickens we

Dickens Well.—Possibly the most important of the wells in Sarnia is the Dickens Well, sunk in the southern part of the town, near the corner of Rose and Tecumseh streets. It also was sunk by Mr. Mitchell, who furnishes the following record :—

Surface	130	200 feet.	Surface deposit.	
Hard-pan	55			
Gravel	15			
Limestone	90	"	Hamilton.	
Shale	100	"		
Limestone	5	"		
Shale	68	"		
Limestone	77	"		

Gas was found in the lower shale at 473 feet, affording about 20,000 cubic feet per diem. This was used in the lighting of several private dwellings and street lamps in the immediate neighbourhood. The boring may be considered dry, no casing below the conductor being necessary.

Wells in Kent County.

Many wells have been drilled throughout this county in search of both gas and oil, principally during the years following immediately upon those marking the discovery of oil in large quantities in the Petrolea and Oil Springs pools. From none of these borings, however, has much oil been obtained, though found in many of them. Again, in later years, considerable energy has been evinced in sinking wells for gas, so far unsuccessfully, as only small quantities have been found, nowhere sufficient to warrant further trial.

Boring was first begun along the banks of the Sydenham river, and operations were carried on actively on lines gradually receding north and south from the river banks, till about 1867, when operations ceased. Since the finding of gas in large quantities near Kingsville, Essex county, drilling for gas has been indiscriminately carried on throughout the county. Unfortunately data regarding all these are not at hand, and it has therefore been found impossible to correlate the records received, with the rocks shown to exist by more correct logs.

Wells at Bothwell.

Bothwell.

Of the many wells sunk in and around the village of Bothwell in the township of Zone, only few records are available; among others that of the Clinton Oil Well. This, drilled in 1865 or 1866, reached a depth of only 370 feet, at which point a small show of oil is reported. The record is as follows :—

Surface	155 feet.
Soapstone	31 "
Shale, black	4 "
Soapstone	32 "
Limestone	148 "

Elevation above tide about 691 feet.

Of another well near Bothwell, Dr. Sterry Hunt gives the following record* :—

Sand	25	90 feet.
Blue clay	45	
Boulder clay	20	
Shale, black	77	"
Soapstone, etc.	193	"
Limestone	120	"

Again, in the same report, Dr. Hunt describes other borings as follows : † " At Bothwell, one boring gave clay 90, shale, etc., 270, after which the well was sunk 120 feet in solid limestone, without yielding either oil or gas. Another, the Empire well, was sunk through clay 120 feet, shale 160 feet, after which oil was reached at a distance of 140 feet in the limestone. In another, the Pepper well, after about the same depth of clay, oil was found in great abundance at 210 feet in the rock, while the Chambers well gave a copious supply of oil at a depth of 385 feet from the surface. The Thames well was sunk to 618 feet, but met with a copious supply of salt and sulphuric water, and some oil, at 475 feet."

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 245.

† Ibid., p. 247.

Wells in Camden and Chatham Townships.

Camden and Chatham.

Dr. Hunt writes as follows of several wells sunk in the townships of Camden and Chatham :* "A well on lot eight of the second range of Camden offered clay 53, black shale 200, and soapstone, etc., 167 = 420 feet. Another, on the seventh range of Chatham, on the line of Camden, gave clay 48, black shale 100, soapstone, etc., 252, limestone 195 = 595 feet. One on lot six of the fourth range of Camden gave clay 33, black shale 98, soapstone, etc., 229, limestone 55 = 415 feet. Another, on lot two of range five of the same township, clay 50, black shale 146, soapstone, etc., 202, limestone 161, sandstone 10 = 569 feet."

Another well, drilled more recently, on lot 3, concession 2, Camden, gave, according to the driller, Major Savage, of Petrolea:—

Sand	13	
Clay	40	60 feet.
"Hard-pan"	7	
Shale, black	20	"
Limestone	30	"
Soapstone	204	"
Limestone	117	"
Sandstone	46	"
Hard rock (limestone)	23	"
Depth	500	"

Salt water in considerable quantity was noted at 431 feet; neither oil nor gas was found.

Wells at Thamesville.

Thamesville.

Of the wells in the neighbourhood of Thamesville, Dr. Hunt writes as follows† :—"At Thamesville, about a mile north from the railway station, a well was sunk through clay 60, grey shale, etc., 240′, grey limestone 32′ = 332 feet. At a depth of sixteen feet in the limestone oil was met with, and the well, at the time of my visit—in October, 1866—had yielded some thirty barrels, which had been dipped out, the well not having yet been pumped. Another well adjoining the railway station was sunk 615 feet without yielding oil. It gave clay 76′, grey shales, etc., 207′, the remainder being harder strata, of which the first 186 feet were described as hard limestone."

*Geol. Surv. of Can., Rept. of Progr., 1866, p. 244.

†Ibid., p. 247.

Well at Dresden.

During 1888, a well was sunk in the village of Dresden by Major Savage, of Petrolea, who has kindly furnished the following record :— Dresden.

Surface	43	feet.
Shale, black	180	"
Limestone	12	"
Soapstone	172	"
Limestone	75	"
Sandstone	44	"
Limestone, hard	79	"

What the economic results were was not stated.

Wells at Chatham.

Reference is again made to Dr. Hunt's report for information regarding a boring at Chatham. This reached a depth of 1,000 feet, of which the first seventy feet consisted of clay, followed by soft shaly rocks for 294 feet, including near the base, or at about 360 feet from the surface, six feet of black shale. According to Dr. Hunt* : " After this hard limestone was encountered in which, at a depth of 58 feet, a vein of salt water, with some oil, was found. Still lower, at about 600 feet from the surface, a copious source of sulphurous water was struck, which continued to flow for some months, filling a pipe of $3\frac{1}{2}$ inches until stopped by a plug driven into the bore." Chatham.

Another well was drilled, during recent years, about one mile north-west of the Grand Trunk Railway station at Chatham, which reached a depth of 1,000 feet, as follows :—

Surface clay	60	feet.	
Shale, black	118	"	Portage.
Soapstone	200	"	
Limestone	18	"	
Soapstone	37	"	
Limestone	567	"	

Casing was only carried to a depth of 260 feet, and a heavy flow of salt water was struck at about 700 feet. A small "show" of oil was noted at 475 feet. Elevation above tide, 583 feet.

Well at Charing Cross.

It is reported that a well was drilled here to a depth of 700 feet, in which a small " show " of gas was noted, though at what depth was not stated. Charing Cross

*Geol. Surv. of Can., Rept. of Progr., 1866, p. 247.

Wells in Harwich Township.

Harwich. On lot 9, concession 4, township of Harwich, a well was drilled, prior to 1866, of which the following record is given :—

Clay	163	feet.	
Shale	17	"	Portage.
Shale, black	58	"	
Soapstone	192	"	Hamilton.
Limestone	70	"	

What the results of the boring were is not stated.

Elevation, above tide, 634 feet.

Rondeau. *Rondeau.*—A well at Rondeau, in the township of Harwich, is thus described by Dr. Hunt* :—" At Stoddard's Mills, at the Rondeau, and near the level of the lake, the clay was 104, followed by about 60 feet of black shale, and 200 feet or more of soapstone with layers of black shale, below which the well was sunk in limestone to a total depth of 520 feet. No correct record of the boring of this well had been kept, but this approximate statement was obtained from what seemed a trustworthy source."

Harwich. *Near Harwich.*—I am indebted to Mr. Richard Ransford, of Clinton, for the following record of a well drilled for oil on the line between Howard and Harwich townships, and near the village of Harwich. No oil was found :—

Surface	78	feet.
Shale, black	60	"
" white	23	"
Soapstone	10	"
Limestone, white	15	"
Shale	70	"
Limestone, grey	20	"
Shale, white	100	"
Soapstone	20	"
Limestone, white	24	"
Shale, white	20	"
Limestone, white	5	"
" grey	110	"
" blue	15	"

Well at Blenheim.

Blenheim. During 1890 a well was drilled at this place by a company composed chiefly of citizens of the place under the title of "The Citizens Gas

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 245.

Company." The depth reached was 900 feet, where the tools stuck and the hole was abandoned. Gas in small quantities is said to have been found at 700 and 800 feet.

Gas is said to have been found in a shallow well on the farm of Wm. Mead, in concession 7 of Harwich, and about three miles and a-half from Blenheim. Sufficient is said to be obtained for heating and lighting that gentleman's house.

Wells in Howard Township.

Howard.

A well in concession 4 of Howard on the line of Orford township is described in the Geological Survey Report,* and the following record given :—

Clay	95 feet
Soapstone and light shales, with a black band near the base	255 feet
Limestone, bluish	160 "
Limestone, grey, sandy	197 "
Depth	707 "

Wells in Orford Township.

Orford, Ravey well.

Ravey Well.—This was drilled during 1890 by Messrs. Hiram Walker and Sons, of Walkerville, to whose driller, Mr. J. S. Hyland, I am indebted for the logs of both this and the Grant well. The drilling was made on lot 10, concession 11, Orford township, on the Ravey farm, and reached a depth of 1,000 feet as follows :—

Surface	160 feet
Broken limestone	81 "
Shale, white	70 "
Limestone, grey	90 "
Limestone, pink	154 "
" Sandstone," fine white	30 "
" Sandstone," grey	45 "
Limestone, grey	285 "
" Sandstone," fine	85 "

The well was, in the upper part, comparatively free from water, only small seams being found to a depth of 630 feet where a strong flow of sulphur water was struck, and cased off, the casing afterwards being carried to a depth of 915 feet. At 965 feet a heavy flow of salt water was struck which rose to 100 feet from the

* Geol. Surv. of Can., Rept. of Progr., 1866, p. 245.

surface, where it now stands. Gas was not noted, but a "show" of oil was reported at 470 feet.

Elevation, above tide, 740 feet.

Grant well.

Grant Well.—This was drilled by the same firm as the preceding, on the Grant farm, lot 23, concession 14, Orford township, and reached a depth of 500 feet, of which the following record was obtained:—

Surface	240 feet
Broken limestone	10 "
Limestone, pink and grey	140 "
Limestone, white	20 "
" Sandstone," fine grey	30 "
" Sandstone," and limestone, grey and white	60 "

No gas was found; oil accompanied by water was struck in small quantities at 318 and 410 feet. Sulphur water was encountered in considerable quantities at several points, the greatest flow being from the lower sixty feet.

Elevation above tide, 691 feet.

It is to be regretted that specimens of drillings were not obtained from these two wells as the records furnished to this office afford little information regarding the rocks traversed.

Wells in Essex County.

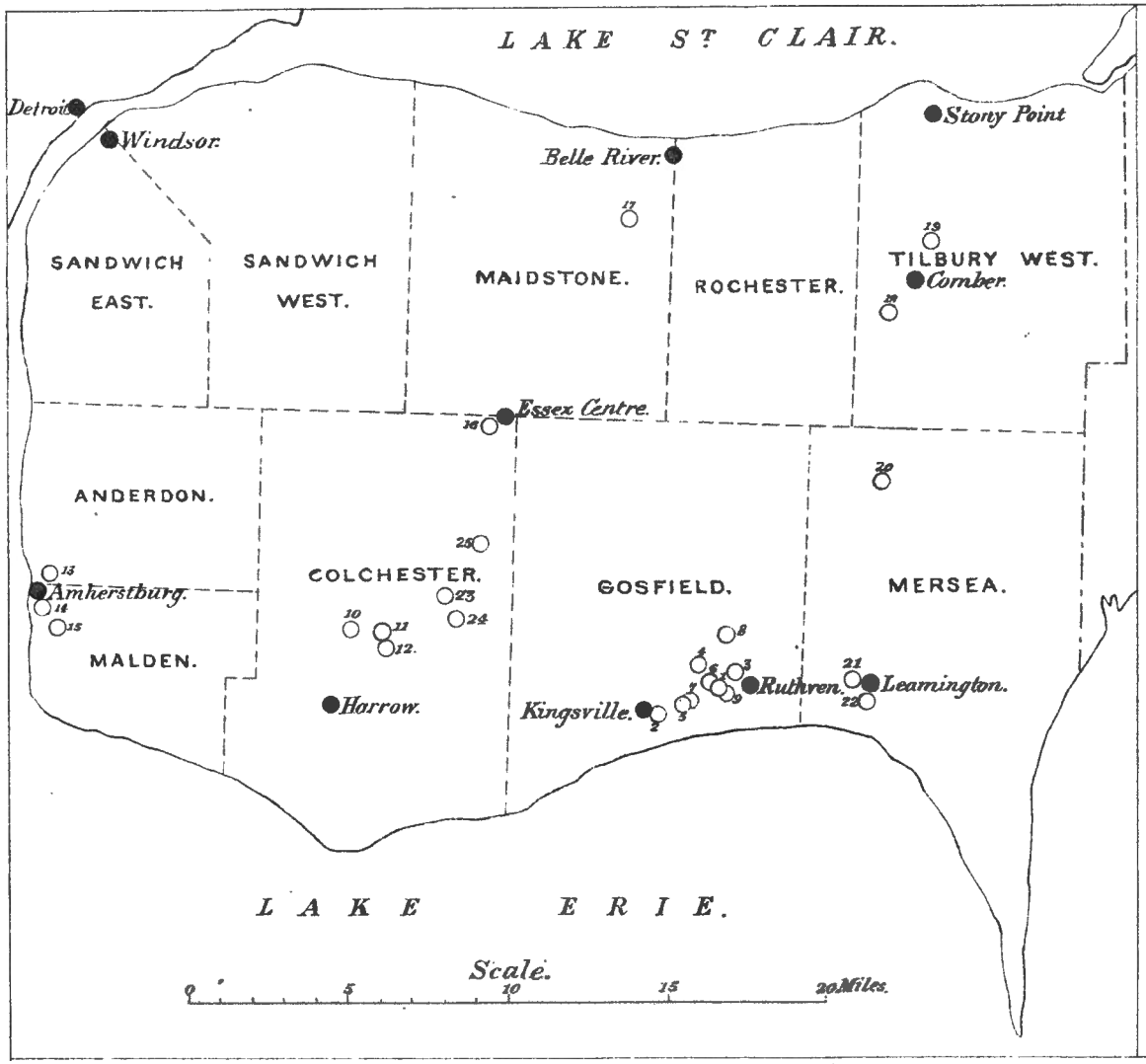
The history of gas explorations throughout this county is somewhat recent, and may be considered as beginning during December, 1888, with the Coste Well No. 1, which had a measured flow of 10,000,000 cubic feet per day. Since that date about twenty-five wells have been sunk in search of gas, but in only one instance with success, namely, in the case of the boring made by the Kingsville Natural Gas and Oil Association, known as Citizens' No. 2, which has a daily flow of 7,000,000 cubic feet. The drilling of this latter well was the cause of considerable litigation between its owners and the Ontario Natural Gas and Fuel Company, the owners of the Coste No. 1. The right to bore on the road allowances of the municipality was granted by the county council to the Kingsville Citizens Company, who at once commenced drilling on the high road some fifty-five yards west of the Coste No. 1; an injunction was taken out by the proprietors of the latter, who were, however, eventually unable to restrain the operations. Except in these two wells all efforts to find gas in paying quantities have been unsuccessful, and many thousands of dollars have been spent, and the gas obtained has hitherto only been used to light the streets of the village of Kingsville.

While drilling for gas on what is known as Walker's Marsh, oil, in what was at first thought to be paying quantities, was found, and

Geological Survey Department.
Canada.

ALFRED R.C.SELWYN, C.M.G, LL.D. F.R.S &c. DIRECTOR.

Plate II.



SKETCH PLAN OF

ESSEX COUNTY.

Shewing location and depth of wells.

1. *Coste No. 1. —— 1031 feet.*
2. *" " 2. —— 1038 "*
3. *" " 3. —— 1017 "*
4. *Darius Wigle —— 1095 "*
5. *Kingsville Citizens No. 1 —— 1126 fe.*
6. *" " " 2 —— 1020 "*
7. *" " " 3 —— 1085 "*
8. *H. Walker & Sons — Bruner — 1184*
9. *" " " " — Lypps. — Unfinisl.*
10. *" " " " — Marsh No. 1 —— 90 feet.*
11. *" " " " " " 2 —— 16 "*
12. *" " " " " " 3 —— finished.*
13. *Fraser Well. —— 530 feet.*
14. *Amherstburg — Colwell Grove —— 1418 ft.*
15. *" — Parks —— 1004*
16. *Essex Centre —— 1200 feet.*
17. *Belle River —— 1465 "*
18. *Comber — Woodward No. 2. —— 1280 fe*
19. *" " " 3. —— 1306 "*
20. *Blytheswood Well. —— 1200 feet.*
21. *Leamington Citizens —— 1030 "*
22. *" " (Report 1866) —— 10 feet.*
23. *Union Gas Co. No. 1. —— 1175 feet.*
24. *" " " 2. —— 1154 "*
25. *Premier Oil Co. —— 1135 feet.*

Drawn for photo-lithography by L.N. Richard B.A.Sc.

To illustrate report on Gas and Oil opions in Ontario by H.P Brunell.

Vol. V, Part Q.

several wells were drilled both by Messrs. Walker and Sons, of Walkerville, and the Union Gas Company. It was found, however, that the quantity of oil available in any one well nowhere exceeded three barrels per day, and was accompanied by so much salt water that operations were discontinued.

I am unable to give the records of most of the wells in this county, for although specimens are at hand from several, they have not yet been closely examined; suffice it to say that the oil and gas horizon is near the summit of the Clinton or base of the Niagara formation.

Wells in Tilbury Township.

Three wells have been sunk in this township, near Comber, and are known as numbers 1, 2 and 3 respectively. Of No. 1 no data are available, and it is understood that through some defect it was not accepted from the contracting driller. Tilbury.

No. 2.—Is on lot 7, concession 5, Tilbury West. It was drilled for Mr. M. J. Woodward, of Petrolea, to a depth of 1,280 feet. At 1,213 feet a small quantity of oil was found, several barrels of which were shipped to the proprietors' refinery at Petrolea. Comber, No. 2

The record of drilling as supplied by the driller is as follows :—

Surface	120 feet.
"Hard rock" (limestone?)	53 "
Limestone, white	110 "
Sandstone	20 "
Limestone	200 "
Sandstone	10 "
Limestone, soft	76 "
" hard	23 "
Sandstone	35 "
Limestone, soft	27 "
" hard	12 "
" soft	34 "
" hard	22 "
Shale	100 "
Limestone, soft	12 "
" hard	125 "
" white, with shale	50 "
Limestone, blue	10 "
" hard, with shale	55 "
"Very hard rock," with pyrites	20 "
Limestone, hard	156 "
"	10 "

Casing was carried to a depth of 683 feet effectually shutting off all water. Elevation above tide 604 feet.

Comber, No. 3

No. 3.—This well is about half-a-mile west and one mile south of the Michigan Central Railway Station at Comber, and is 1,306 feet deep. It was drilled, for the same gentleman as the preceding, by Mr. J. R. Minhinnick, of London, Ont., to whom I am indebted for the following :—

Surface (clay)	124 feet.
Limestone	136 "
" white	100 "
Sandstone	10 "
Limestone, in alternate soft and hard layers	370 "
Shale, with streaks of hard lime	100 "
Limestone	135 "
" white, with shale	50 "
" with shale	53 "
" hard	128 "
" very hard	100 "

Unlike the last, no oil was found, and gas in small quantities was found at 260 and 1,078 feet.

Fresh water was found at 150 feet or twenty-six feet in the first limestone, sulphurous water at 260 feet, and a strong flow of saline water at 1,127. Casing was carried to a depth of 700 feet.

Elevation above tide 600 feet.

Wells in Maidstone Township.

Maidstone, Belle River.

Belle River.—Two wells were sunk near this village, both of which are on lot 12, concession 6, township of Maidstone, at an elevation of about eighteen feet above Lake St. Clair, or about 600 feet above tide. The deepest was 1,465 feet, of which the following record is available :—

Surface, blue clay	92 feet.
" hard-pan	3 "
Limestone, blue	90 "
Shale, dark	90 "
Sandstone, white	25 "
Limestone	925 "
Sandstone (?) grey	25 "
?	215 "

Water was first found at 275 feet or at the base of the dark shales ; and again, at 1,300 feet, a strong flow of salt water was

found, though no salt beds were pierced. Gas in small quantities was noted, though at what depth was not stated.

Though no name is given to the strata penetrated below the twenty-five feet of sandstone, there is every reason to believe that they consisted of shale, etc., of Medina age, and that the boring ceased in that formation.

The other well was drilled close to the foregoing and reached a depth of 1,010 feet, the record of rocks pierced being practically the same. Water was found under similar conditions and at the same depths; gas was not noted.

Well in Anderdon Township.

Only one well was sunk in this township, viz., "The Fraser Well," drilled about one-half mile east of the Detroit river and near the town line. The well is only 530 feet deep, seventy feet of which consisted of surface deposits. Fresh water was found at 130 feet, but neither gas nor oil was noted. Anderdon, Fraser well.

Wells in Malden Township.

During 1889 a company was formed in Amherstburg under the title of the "Great South-western Gas and Oil Company, of Amherstburg." This company drilled two wells near the town, viz., "The Colwell Grove Well," on lot 2, concession 1, and the "Parks Well," on lot 4, concession 2, of Malden township, in neither of which was any economic result attained. Malden.

I am indebted to Major John Savage, of Petrolea, for records of these two wells, as follows:—

Colwell Grove Well—Depth, 1,418 feet. Colwell Grove well.

Surface (clay)	8	feet.
Limestone	252	"
Sandstone (?)	60	"
Limestone	180	"
Shale and gypsum	16	"
Limestone, hard	320	"
" soft	297	"
"	265	"
Grey shale	20	"

Casing was carried to a depth of 508 feet, or eight feet into the first shale, effectually shutting off all water down to that depth. A heavy flow of salt water was found at 1,115 feet, to shut off which no effort was made. Neither gas nor oil was noted.

Parks well.

Parks Well.—Depth, 1,004 feet.

Surface (sand and gravel)	30 feet.
Limestone	228 "
Sandstone (?)	84 "
Limestone	182 "
Gypsum	12 "
Limestone	468 "

The well was cased to a depth of 820 feet; at 987 feet, a heavy flow of salt water was found accompanied by small quantities of gas.

Wells in Colchester Township.

Colchester.

In and about "Walker's Marsh," in this township, several wells were sunk from which small flows of oil were obtained, the greater quantity being found in Messrs. Walker and Son's wells, Nos. 1 and 2. The supply proving to be small, the field has been abandoned.

Walker's No. 1.

Walker's No. 1.—This well on lot 8, concession 6, Colchester township, is 1,300 feet deep, terminating in a fine grained brown sandy shale. A small show of oil was noted at 1,000 feet accompanied by a very small quantity of gas. Water was found at 180 feet and again at 1,100 feet; the latter not being cased off as the casing was only carried to a depth of 600 feet.

The following record has kindly been furnished by the driller, Mr. Hyland:—

Surface, clay	35	87 feet.
" sand	52	
Limestone, grey	113	"
" white	70	"
" grey	70	"
" grey and white	10	"
" brown	10	"
" brown and grey	5	"
" fine grey	5	"
" dark brown	270	"
" brown and white	20	"
" "	10	"
Shale, dark grey, and limestone	10	"
Limestone, light pink	40	"
" dark pink	35	"
" grey	75	"
Shale, dark grey and limestone	100	"
Limestone, grey and white	10	"
" brown and white	130	"
" fine white	10	"
" and sandstone, brown	200	"

Walker's No. 2.—This well is on lot 11, concession 6, Colchester; and reached a depth of 1,016 feet; the record to this depth is very similar to that obtained of the foregoing. Casing was carried to a depth of 600 feet and sulphurous water accompanied by oil was found at 1,000 feet; this well is said to have pumped five barrels of oil per diem. Walker's No. 2.

Walker's No. 3.—This well, on lot 11, concession 5, Colchester, was not, at the time of my visit, completed, though it has been since reported that small quantities of oil and gas were obtained. Walker's No. 3.

Union Gas Co.

Well No. 1.—A syndicate composed of Messrs. P. McLaren, of Perth; N. A. Coste, of Amherstburg; E. Coste, of Buffalo; D. McGillivray, of Port Colborne, and others, under the provisional title of the Union Gas Co., sank two wells between the Walker's marsh series of wells and Essex Centre, unfortunately, however, without success. The first, or No. 1, was drilled on lot 17, concession 7, Colchester, to a depth of 1,175 feet, near the base of the Niagara formation, according to the following record, kindly furnished by Mr. E. Coste :— Union Gas Co. No. 1.

Surface	66	feet.	
Limestone, white and grey	169	"	Corniferous.
Dolomite and gypsum, with blue black shales towards bottom	740	"	Onondaga.
Dolomites	200	"	Guelph and Niagara.

Sulphurous water was found at 582 and 613 feet, which was shut off by casing to a depth of 630 feet. A strong flow of salt water was, however, found at 1,175 feet, on finding which the casing was drawn and the well abandoned.

Well No. 2.—This well on lot 16, concession 6, Colchester, reached a depth of 1,154 feet, and though twenty-one feet less than the foregoing, was nineteen feet lower in the geological scale, terminating two feet below the summit of the Clinton. No. 2.

The record furnished by Mr. E. Coste shows :—

Surface	93	feet.	
Limestone, white and grey	92	"	Corniferous.
Dolomites and gypsum with blue-black shales towards bottom	740	"	Onondaga.
Dolomites	217	"	Guelph and Niagara.
Limestone	2	"	Clinton.

Casing was carried to a depth of 680 feet which was, however, withdrawn on the subsequent abandonment of the well.

Essex Centre.

Wells at Essex Centre.—A well was drilled during 1889 on lot 283, South Talbot Road, Essex Centre, Colchester, by the Central Gas and Oil Company, of Essex county, of which Mr. John Milne, of Essex, Centre, is president. It reached a depth of 1,200 feet without either gas or oil being noted. Specimens of the drilling were obtained and are now in the Geological Survey office. Considerable flows of water interfered greatly with the operations and necessitated a string of casing 950 feet in length. The first flow of water was found at 130 feet or nineteen feet below the surface of the rock; this was followed by fresh water seams at 155 and 190 feet, by sulphur water at 310 and 565 feet and salt water at 800 and 1,130 feet.

A well was drilled at Decew's mill for water which was found at 180 feet, or fifty feet below the base of the surface deposits. The depth reached was 209 feet, neither gas nor oil being noted.

Sweetman's Mills.

Premier Oil Company's Well.—This well was drilled by Mr. R. E. Menzies for the above company on lot 19, concession 9, Colchester North, at Sweetman's mills to the depth of 1,135 feet where salt water was struck; neither gas nor oil was found.

Wells of the Ontario Natural Gas Co. in Gosfield Township.

Ont. Nat. Gas Co., Coste No. 1.

Coste No. 1.—This, the first well drilled for gas in the county, afforded about 10,000,000 cubic feet a day. It is on the north-west corner of lot 7, concession 1, and about midway between the villages of Kingsville and Ruthven. Gas was struck at 1,017 feet in a vesicular dolomite, probably of Clinton age. The boring was then continued to 1,021 feet, when the great pressure made it no longer possible to operate the tools. The supply has, unfortunately, never been drawn upon owing to dissensions among the shareholders of the company. Frequent borings have since been made in the vicinity, but nothing of any value has been found, except in the well bored by the Citizens Company of Kingsville, described below as Citizens' No. 2.

Coste No. 2.

Coste No. 2.—This boring, made by the same company as the preceding, is on the south-west corner of the south half of lot 1, concession 1, township of Gosfield, close to the Lake Erie, Essex and Detroit River Railway Company's station at Kingsville. Beyond the fact that the depth reached was 1,038 feet, no information is at hand, though it is presumed that the rocks pierced are very similar to those in Coste No. 1.

Coste No. 3.

Coste No. 3.—Was also bored by the same company and is on lot 8, concession 2, Gosfield. No particulars are at hand regarding it except

that the depth reached was 1,017 feet, and that up to that point the well was barren of gas or oil, and that salt water was struck in heavy flows near the bottom of the well.

Isaac Wigle Well.—This was drilled by a syndicate composed of some of the shareholders of the above-mentioned company, and is on lot 5, concession 2, Gosfield. It proved, however, to be practically barren of gas, only small quantities being noted at 1,090 feet, at which depth the drill was about fifteen feet above the beds in which Coste No. 1 finished. The total depth was 1,095 feet, where a heavy flow of salt water was struck. The surface deposits showed a total thickness of 117 feet and the casing was carried 468 feet deeper. Isaac Wigle well.

Wells of the Citizens' Gas, Oil and Piping Co. of Kingsville.

Three wells in all were drilled by this company, which was incorporated in 1889, with S. A. King as president and J. H. Smart as secretary. Citizens' Gas, Oil and Piping Co.

Citizens' No. 1.—This, the first well drilled by the above company, is on lot 3, con. 1, East Division Gosfield South, and is 1,126 feet deep. The boring was begun on the 18th May, 1889, and was not finished, owing to several unavoidable delays, till the 19th of August of the same year. The first water was struck at sixty-eight feet, and was shut off by casing to a depth of 604 feet. Gas in small quantities was obtained at 750 feet, which was, however, interrupted by a heavy flow of salt water between 1,100 and 1,121 feet. Citizens' No. 1

Citizens' No. 2.—This well was drilled on the road allowance of the second concession about 55 yards west of Coste No. 1, and reached a depth of 1,020 feet. No particulars of the boring are at hand beyond the fact that in the vesicular dolomite at that depth a daily flow of gas equal to 7,014,000 cubic feet was obtained. The gas has been piped to Kingsville, a distance of about three miles, where it is being utilized in a small measure by the people of that place. The drilling of this well was the cause of considerable litigation between its owners and those of Coste No. 1, who were, however, finally unable to restrict operations. Citizens' No. 2

That the precedent so established, of allowing mining of any kind to be carried on upon the road allowances of a municipality is bad, cannot be denied. More especially is this so in regard to operations in search of gas or oil, as these minerals are peculiar in their mode of occurrence, and, have not like solids, a fixed position.

Citizens' No. 3

Citizens' No. 3.—This, the last well sunk by the above company, is on lot 4, con. 1, Gosfield South, it reached a depth of 1,085 feet without affording gas in quantity, a small flow only being noted at 980 feet. Salt water was struck at 1,085 feet, and the well was abandoned.

Bruner Well.

Bruner Well.—This well was drilled by Messrs. Walker and Sons, of Walkerville, on lot 18, con. 3, to 1,184 feet, a greater depth than was reached in any other boring made in the township. A small show of gas was noted at 1,020 feet, which was, however, cut off by a heavy flow of salt water, struck at a lower point. Casing was carried to a depth of 580 feet.

Wells in Mersea Township.

Leamington.

Well one Mile South of Leamington.—Regarding a well sunk some years ago near the village of Leamington, Dr. T. S. Hunt writes as follows :— *

"On the seventh lot of the first range of Mersea and a mile south of the village of Leamington, a well was sunk through clay 100, limestone 310 = 410 feet without finding either oil or saline water. The rock at 380 feet from the surface was a somewhat magnesian limestone. Indications of oil in the shape of gum-beds or superficial layers of thickened petroleum are said to have been found in this vicinity."

Leamington Citizens Well.

Well at Leamington.—During 1889 a syndicate of citizens of this place under the title of the Leamington Citizens Natural Gas Company, undertook to bore for natural gas in the vicinity of the village and commenced operations on the 10th of May of the same year. The well known as "The Leamington Citizens Well" is on the south half of lot 5 concession 2, Mersea, a short distance west of the village and alongside the L. E. E. & D. R. Ry. Co.'s tracks. Operations were suspended at 1,030 feet owing to heavy flows of salt water which were never cased off. The surface deposits measured 128 feet in thickness, beyond which the casing was carried only twelve feet or 140 feet from the surface. Water was struck at 135, 410, 425 and 500 feet, and gas in small quantity at 965 feet. At the time of my visit the well was full of water and although there was a strong odor of gas at the casing the quantity was not sufficient to indicate any pressure on a Pitot's tube over an aperture bushed to one inch.

Blytheswood.

Well at Blytheswood.—A well was during 1889 drilled near this place on the north-west corner of lot 7, concession 9, Mersea, presumably by

* Geol. Surv. of Can. Rept. of Progr., 1866, p. 249.

the Standard Oil Company to the depth of about 1,200 feet. From facts gleaned from operators in the district, I understand that a small flow of gas was obtained at 1,050 feet, followed at 1,150 feet by a heavy flow of salt water which was not cased off, the casing being carried to a depth of but 800 feet. Oil was not found.

APPENDIX A.

TABLE of Beaumé's Hydrometer with Corresponding Specific Gravities. Table of Gravities.

Temp. 60° Fahr.

Beaumé.	Specific Gravity.	Beaumé.	Specific Gravity.	Beaumé.	Specific Gravity.	Beaumé.	Specific Gravity.
10	1·0000	30	0·8750	50	0·7777	70	0·7000
11	0·9929	31	0·8695	51	0·7734	71	0·6965
12	0·9859	32	0·8641	52	0·7692	72	0·6930
13	0·9790	33	0·8588	53	0·7650	73	0·6896
14	0·9722	34	0·8536	54	0·7608	74	0·6863
15	0·9655	35	0·8484	55	0·7567	75	0·6829
16	0·9589	36	0·8433	56	0·7526	76	0·6796
17	0·9523	37	0 8383	57	0·7486	77	0·6763
18	0·9459	38	0·8333	58	0·7446	78	0 6730
19	0·9395	39	0 8284	59	0·7407	79	0·6698
20	0·9333	40	0·8235	60	0·7368	80	0·6666
21	0·9271	41	0·8187	61	0·7329	81	0·6635
22	0·9210	42	0·8139	62	0·7290	82	0·6604
23	0·9150	43	0·8092	63	0·7253	83	0·6573
24	0·9090	44	0·8045	64	0·7216	84	0·6542
25	0·9032	45	0·8000	65	0·7179	85	0·6511
26	0·8974	46	0·7954	66	0·7142	86	0·6481
27	0·8917	47	0·7909	67	0·7106	87	0·6451
28	0·8860	48	0·7865	68	0·7070	88	0·6422
29	0·8805	49	0·7821	69	0·7035	89	0·6392
. .. ..	....	... .	.....	.....	. .. ...	90	0·6363

APPENDIX B.

COST OF "DRILLING RIG" COMPLETE AT PETROLEA, ONT. F. O. B. Cost of drilling rig.

One 20 h. p. boiler and 20 h. p. engine (10 ins. diameter and 14 ins. stroke)	$ 800
One 3½-in. steel counter shaft, 5 ft. long, 4 flanges, crank waist pin, nodale pin, saddle, 2 pair brasses and pitman straps, 2 stirrup and plates, 2 14-in. sheaves for derrick	90
Wooden wheels and rig spring pole and wrench block	97
One 12-in. leather belt, 28 ft. long	25
One 12-in. 5-ply rubber belt, 40 ft. long	25
1,000 ft. ash poles	23
One horn socket with clevis	7
One 2-legged socket with dog	14
One 3½-in. drill sinker, 30 feet long	55
One 3-in. do do	42
One 2½ in. do do	35
One pair 1¼-in. jars	26
One pair 1⅛-in. jars	23
One pair 1-in. jars, for fishing	15
Two Dutchman's subs	18
Three 6-in. drill bits	54
Three 4¾ in. do	42
One 12-in. mud bit	15
One 8-in. reamer	16
One 6-in. do	14
One 5-in. do	13
Two tool wrenches	10
Two pole wrenches	4
Twenty pairs pole joints and centre straps	70
One drill swivel and drill chain	14
One draw swivel	8
One cast-iron spring pole jacket	6
One slipper-out with cast wheel	15
One pole holder	2
One weight and two clevises for rope	4
One 4-in. sand pump, 36 feet long	27

One sand pump hanger and chain	$ 4
Two chain rings and hooks for tools	3
One lever and two chains for wrenches	3
One $\frac{5}{8}$-in. chain ring and hook for casing	8
One stirrup bolt, king bolt and plate	4
Two $1\frac{1}{4}$-in. clamp bolts	4
One chain and swivel for spool	3
One 12-inch auger	18
One 8-in. mud pump	14
100 feet boring stems and connections	45
Total	$ 1,715

APPENDIX C.

Bibliography.

Bibliography.

The following list of works referring to the hydrocarbons in Canada is taken from the Report on Petroleum by S. F. Peckham, vol. X., 10th Census, U. S. For those interested in the study of hydrocarbons there is no better list. Some additions have been made to the list by the writer, of works referring to boring operations, or otherwise intimately connected with the subject.

Abbreviations.

Abbreviations

A.J.S.—American Journal of Science and Arts (Silliman's Journal).
A.J.G.L.—American Journal of Gas-lighting.
An. M.—Annales des Mines.
A.S.J.—Art Society Journal.
B.B.S.N.S.—Bulletin of the Buffalo Society of Natural Sciences.
B.S.G.F.—Bulletin de la Société Géologique de France.
C.J.—Canadian Journal.
C.R.—Comptes-Rendus des séances de l'Académie Française.
C.N.—London Chemical News.
C. Nat.—Canadian Naturalist.
G.S. Report.—Report of the Geological Survey of Canada.
J.F.I.—Journal of the Franklyn Institute.
J.S.A.—Journal of the Society of Arts.
J.R.G.S.—Journal of the Royal Geographical Society.
J.S.C.I.—Journal of the Society of Chemical Industry.
P.A.A.A.S.—Proceedings of the American Association for the Advancement of Science.
P.A.P.S.—Proceedings of the American Philosophical Society, Philadelphia.
P.B.S.N.H.—Proceedings of the Boston Society of Natural History.
P.C.I.—Proceedings of the Canadian Institute.
Ph. J.—Pharmaceutical Journal, London.
T.A.I.M.E.—Transactions American Institute of Mining Engineers.
T.R.S.—Transactions of the Royal Society.
T.R.S.C.—Transactions of the Royal Society of Canada.

BIBLIOGRAPHY.

Date.	Author.	Subject or Title.	Reference.
1820	Harman, D. W.....	Journal of voyages and travels in the interior of North America (notes on Athabasca bitumen).....	Andover, Flagg & Gould, 1820.
1833	Back, Capt. R. W..	Account of route to be pursued by the Arctic land expedition in search of Capt. Ross (notes on Athabasca bitumen)	J. R. G. S., iii, 65.
1850	Hunt, T. Sterry.....	On soils, peat, asphaltum, mineral springs, etc	G. S. Report, 1849-50.
1850	Jackson, C. T.....	On the asphaltic coal of New Brunswick.	P.B.S.N.H., 1850, p. 279;
1851	do J. G. Percival and others	Reports on the Albert coal mine.....	A. J. S. (2) xi, 292. New York, 1851. A. J. S.
1851	Richardson, Sir J...	Narrative of an expedition in search of Sir John Franklin (notes on Athabasca bitumen).....	(2) xiii, 276.
1852	Taylor, R. C.....	On a vein of asphaltum at Hillsboro', Albert Co., N.B.	P. A. P. S., v, 241.
1853	Ure, A..... ..	Various articles in Dictionary of Arts, etc.	
1854	Encyclopædia Britannica	do under the different headings.....	8th edition, 1854-60.
1855	Taylor, R. C.....	Statistics of coal....	Philadelphia, J. W. Moore, 1855.
1861	Andrews, E. B	Rock oil, its geological relations and distribution....	A. J. S. (2) xxxii, 85. Ph. J. (2) iv, 73.
1861	Hunt, T. Sterry.....	On the history of petroleum or rock oil.	C. Nat. (1) vi, 245.
1861	Macrae, Alexander..	Oil springs of America and Canada.....	J. S. A., x, 89.
1862	Geological Survey Corps.	Descriptive catalogue of a collection of economic minerals of Canada..	Montreal, 1862.
1862	Robb, Chas.	On the petroleum springs of western Canada.....	Ph. J. (2) iv, 67.
1862	.. ..	Petroleum gas	Jour. of the Board of Arts and Mfrs. for Upper Canada.
1863	Boileau, Gauldrée...	Exploitation de l'huile minérale dans l'Amérique du Nord..	Paris, 1863.
1863	Fleming, Sandford..	The oil wells of Canada.	J. S. A., xi, 652.
1863	do ..	Notes on the present condition of the oil wells of Enniskillen.	C. J., viii.
1863	Geological Survey Corps	Various articles on bitumens, etc.....	G. S. report, 1863.
1863	Hunt, T. Sterry.....	Contributions to the chemical and geological history of bitumens and pyroschists or bituminous shales. . .	A. J. S. (2) xxxv, 157, reprinted in Chemical and Geological essays, Boston, 1875. J. R. Osgoode & Co.
1863	Pelouzé, J., et Aug. Cahours..... . .	Recherches sur les pétroles d'Amerique....	Articles in comptes rendus etc.
1864	Archer, Prof	Oil wells of Pennsylvania and Canada.	A. S. J., August, 1864.
1864	Bailey, L. W.....	Report on the mines and minerals of New Brunswick	Fredericton, 1864.
1864	Marcet, William....	On petroleum, its economic value, and a visit to the petroleum wells of Canada..	J. S. A., xii, 230.
1865	Bailey, L. W., and others..	Observations on the geology of southern New Brunswick	Fredericton, 1865.
1865	Hind, H. Y	Preliminary report on the geology of New Brunswick.	do 1865.
1865	Hitchcock, C. H....	Albertite of New Brunswick.....	A. J. S. (2) xxxix, 267.]
1865	Hunt, T. Sterry.....	Petroleum, its geological relations considered with special reference to its occurrence in Gaspé.	Quebec, G. E. Desbarats, 1865.
1865	Rand, Theo. D.....	On the occurrence of petroleum in Canada..... ...	J. F. I., lxxx, 220.
1865	Schorlemmer, C....	Presence of benzole series in Canadian petroleum....	T. R. S., xiv, 168; C. N. xi, 255.
1865	. ...	The oil district of Canada..... ...	New York, Am. News Co., 1865.
1866	Andrews, E. B.....	Petroleum in its geological relations.....	A. J. S. (2) xlii, 33.
1866	Hunt, T. Sterry.....	On petroleum.....	C. Nat. xi, 121. P. A. A. A. S., 1866.
1866	do	do and its geology.	G. S. report, 1863-66.

BIBLIOGRAPHY—*Continued.*

Date.	Author.	Subject or Title.	Reference.
1866	Winchell, A.	Geology of petroleum in Canada West	A. J. S., xli, 176-178.
1867	Fouqué, M.	Étude chimique des cinq gaz des sources de pétrole de l'Amérique du Nord	C. R., lxvii, 1045.
1867	Hunt, T. Sterry	Pétroles de l'Amérique du Nord	B.S.G.F., xxiv, 570-573.
1867	do	Un catalogue descriptif de la collection des minereaux économique du Canada	Paris, 1867.
1868	Boileau, Gauldrée	Mémoire sur les pétroles du Canada	An. M. (6) iv, 105.
1868	Dawson, Sir J. W	Bituminous shales, stellarite and petroleum	Acadian Geol., 2nd ed., 1868.
1868	Hunt, T. Sterry	Notes on geology of south-western Ontario	A. J. S. (2) xlvii, 355.
1869	Hartley, E.	Report on part of the Pictou coal field	G. S. Report. 1869.
1869	Hunt, T. Sterry	On the Goderich salt region	do 1869.
1869	Peckham, S. F.	On the probable origin of albertite and allied minerals	A. J. S., xlviii, 362; A. J. G. L., xi, 164.
1870	Winchell, A.	Sketches of creation	New York, Harper Bros., 1870.
1871	Hunt, T. Sterry	Laurentian limestones of North America (Anthracite?)	Albany, 1871.
1871	Honeyman, D	Notes on limestone containing petroleum in Nova Scotia	A. J. S. (3) i, 386.
1872	Bailey, L. W., and G. F. Matthew	Preliminary report on geology of southern New Brunswick	G. S. Report, 1870-71.
1872	McLeod, M. (editor)	Canoe voyage from Hudson Bay to Pacific by the late Sir George Simpson in 1828	Ottawa, J. Durie & Son, 1872.
1873	Henry, J. G	The early and later history of petroleum	Philadelphia, Jas. B. Rodgers & Co., 1873.
1875	Hunt, T. Sterry	Chemical and geological essays	Boston, J.R. Osgood&Co., 1875.
1875	Poole, H. S.	Report, Dept. of Mines of Nova Scotia for the year 1874	Halifax, 1875.
1876	Bailey, L. W	Woods and minerals of New Brunswick	Fredericton, 1876.
1876	Geological Survey Corps	Descriptive catalogue of a collection of economic minerals of Canada	Montreal, 1876.
1876	Smith, J. Lionel	Observations on the history and statistics of the trade and manufacture of Canadian salt (borings)	G. S. Report, 1874-75.
1878	Bailey, L. W., and R. W. Ells	Albert shales and albertite	do 1876-77.
1878	Harrington, B. J.	Notes on mineral resins	do 1876-77.
1878	do	Catalogue des minéreaux économiques du Canada	London, 1878.
1878	Hunt, T. Sterry	On the Goderich salt region and Mr. Attrill's explorations (borings)	G. S. Report, 1876-77.
1878	Poole, H. S.	Report, Dept. of Mines of Nova Scotia for the year 1877	Halifax, 1878.
1880	Bailey, L. W., R. W. Ells and G. F. Matthew	Notes on albertite	G. S. Report, 1878-79.
1881	Gilpin, E., jr.	Report, Dept. of Mines of Nova Scotia, 1880	Halifax, 1881.
1882	Macoun, John	Manitoba and the Great North-west (Athabasca bitumen)	Guelph, "World" Pub. Co., 1882.
1883	Ells, R. W.	Report on geology of Gaspé peninsula	G.S. Report, 1880-82.
1883	Hoffmann, G. C.	Notes on bituminous sand-rock and mineral tar or maltha	do 1880-82.
1885	Bell, Robt	Athabasca bitumen	do 1882-84.
1885	Fletcher, Hugh.	Geology of northern Cape Breton (petroleum of Lake Ainslie)	do 1882-84.
1885	Peckham, S. F.	Report on petroleum, Vol. X., Tenth Census, U.S.	Washington, 1885.
1886	Ells, R. W.	Geology of Albert and Westmoreland counties, New Brunswick	G. S. Report, 1885.
1886	Geological Survey Corps	Descriptive catalogue of a collection of economic minerals of Canada	London, 1886.

BIBLIOGRAPHY—*Concluded.*

Date.	Author.	Subject or Title.	Reference.
1886	Pohlmann, Julius. .	Thickness of the Onondaga salt group at Buffalo, N.Y.	B. B. S. N. S., 1886.
1887	Coste, E.	Petroleum production for the year 1886 and previous years	G.S. Report, 1886, Part S.
1887	Dawson, G. M . .	On certain borings in Manitoba and North-west Territories	T. R. S. C., iv, sec. iv.
1887	do . .	Notes on northern geology	G. S. Report, 1886.
1887	Obalski, J.	Report on natural combustible gas.	Report Crown Lands Dept., Quebec, 1886-87.
1887	Redwood, Boverton.	Notes of a recent visit to some of the petroleum-producing territories of the United States and Canada	Journ. of the Soc. of Chemical Industry, June, 1887.
1887	do	Petroleum, its production and use.	New York, D. Van Nostrand, 1887.
1888	Ashburner, C. A.	Geology of Buffalo as related to natural gas explorations along Niagara River	T. A. I. M. E., xvii.
1888	Bell, Robt.	The petroleum field of Ontario	T. R. S. C., v, sec. iv.
1888	Coste, E.	Petroleum production for the year 1887.	G. S. Report, 1887-88, Part S.
1888	Kerr, James. .	The oil belt	Toronto "Mail," Dec. 1, 1888.
1888	Laflamme, L'abbé.	Le gaz naturel dans la province de Québec.	T. R. S. C., vi, sec. iv.
1889	Ashburner, C. A.	Natural gas explorations in the eastern Ontario peninsula.	T. A. I. M. E., xviii.
1889	Brumell, H. P.	Petroleum production for the year 1888	G. S. Report, 1889. Part S.
1889	Ingall, E. D	Mines and mining on Lake Superior (Gas at Silver Islet)	do 1887-88. Pt. H.
1889	McRae, John C.	Geological formation at Port Colborne, as shown by drilling for natural gas	P. C. I., 1889.
1889	Marvin, Chas.	Coming oil age.	London, R. Anderson & Co., 1889.
1890	Blake, Wm. P. .	Uintahite, albertite, grahamite and asphaltum described and compared, with observations on bitumen and its compounds	T. A. I. M. E., xviii.
1890	Brumell, H. P	Natural gas	G. S. Report, 1888-89, Part S.
1890	do	Petroleum.	do 1888-89 do
1890	Obalski, J.	Report on mining service for 1889 and for 1890.	Reps., Comm'er Crown Lands, Quebec.
1890	do	Mines et minéraux de la province de Québec.	Quebec, 1890.
1890		Report of the Royal Commission on the mineral resources of Ontario	Toronto, Warwick & Sons, 1890.

GEOLOGICAL SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA

FROM THE

LABORATORY OF THE SURVEY

BY

G. CHRISTIAN HOFFMANN, F. Inst. Chem., F.R.S.C.,
Chemist and Mineralogist to the Survey.

ASSISTANTS

F. G. WAIT, M.A., F.C.S.,
R. A. A. JOHNSTON.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1892

To Alfred R. C. Selwyn, C.M.G., LL.D., F.R.S.,

Deputy Head and Director of the Geological Survey of Canada.

Sir,—I have the honour of herewith laying before you my report upon the work carried out in the Laboratory of this Survey during the year 1890, and in so doing desire to point out that owing to exceptional circumstances it has, on this occasion, been found impracticable either to incorporate the whole of the work conducted in that year or to avoid the introduction of certain other of more recent date. The principal work held over, and which related to building stones, was well advanced, but not sufficiently so for publication, when it was found necessary to temporarily lay the same aside in order to carry out the analysis of a series of nickel and cobalt ores, a work more urgently called for by reason of the interest and economic importance now attaching to these latter. The analyses of a few of the most important of these although made out of the proscribed limit of time have nevertheless been included in this report in order to make the work in this connection as complete as possible and avoid delay in their publication. Again, although the examination of the series of salt waters was all but finished at the close of the year in question, a little of the work in connection with the same extended into the following year and this could not have been excluded from the present report without leaving the matter in an incomplete form or deferring the publication of the work already accomplished in connection with it.

Of the work herein recorded—the analyses of the brines from Manitoba and the district of Saskatchewan were, together with some other analyses, conducted by Mr. F. G. Wait; whilst the analysis of the series of nickel ores, as likewise the gold and silver assays, and many other analyses and examinations the results of which are herein formulated, were conducted by Mr. R. A. A. Johnston. The analyses made by these gentlemen have, in all instances, been duly credited to them—the work not otherwise particularized having been carried out by myself.

I have the honour to be,

Sir,

Your obedient servant,

G. CHRISTIAN HOFFMANN.

Ottawa, 30th November, 1891.

TABLE OF CONTENTS.

PAGE.

MISCELLANEOUS MINERALS.

Ilvaite, from near the head of Barclay Sound, Vancouver Island, B.C. 11
Native iron, from the north shore of St. Joseph Island, Lake Huron, O 12
Harmotome, from the Beaver mine, township of O'Connor, district of Thunder Bay, O 16
Common opal, from Savona Mountain, south of Savona station on the line of the C.P.R., B.C. 16
Danaite, from the north half of lot 6, range 3, of the township of Graham, district of Algoma, O 19
Tripolite, from the head of Loon Lake, Interior plateau, B.C. 20
Scheelite, from lot 1, range 7, of the township of Marlow, Beauce county, Q. 21
Chromiferous muscovite, from the township of Matawatchan, Renfrew county, O 21
Gersdorffite, from lot 12, range 3, of the township of Denison, district of Algoma, O 22

NATURAL WATERS.

Water from a boring on Kanak Creek, near Port Haney, district of New Westminster, B.C 22
——— from hot spring on the west side of Kootanie Lake, eight miles north of the West Arm, B.C 24
——— from hot spring on the east side of Upper Arrow Lake, B.C. 24
——— from a well six miles south of Calgary, district of Alberta, N.W.T. 25
——— from a spring on lot 4, range 4, of the township of Kenyon, Glengarry county, O 25
——— from springs on the shore of Lake St. John, at Chambord, first range of the township of Metabetchouan, Chicoutimi county, Q 26
——— from spring on hillside, near the shore of Dawson Bay, two miles east of the mouth of Steep Rock River, Lake Winnipegosis, Man 26

PAGE.

NATURAL WATERS—*Continued.*

Water from spring near the west shore of Dawson Bay, three-quarters of a mile north of the mouth of Steep Rock River, Lake Winnipegosis, Man... 27
——— from a spring at Salt Point, on the south-west shore of Dawson Bay, Lake Winnipegosis, Man. 28
——— from spring on west side of Dawson Bay, three miles and a-half north of the mouth of Bell River, and a mile back from the shore of the Lake, Lake Winnipegosis, Man..... 28
——— from brook flowing into the west side of Dawson Bay, Lake Winnipegosis, Man..... 29
——— from spring on the shore of Pelican Bay, just east of the mouth of Pelican Creek, Lake Winnipegosis, Man..... 30
——— from spring on the west side of the mouth of Pine Creek, near its discharge into Lake Winnipegosis, Man..... 30
——— from Monkman's salt spring on the west shore of Lake Winnipegosis, Man..... 31
——— from well, at same locality as the last..... 32
——— from spring half a mile back from the west shore of Swan Lake, between it and the lower portion of Swan River, Man..... 32
——— from lower salt spring on the north side of Red Deer River, a mile and three-quarters from its entry into Lake Winnipegosis, district of Saskatchewan, N.W.T..... 33
——— from spring on the south bank of Red Deer River, four miles from its entry into Lake Winnipegosis, district of Saskatchewan, N.W.T.... 34
Tabulated statement of results of analyses of waters of salt springs occurring in the province of Manitoba, and district of Saskatchewan, N.W.T..... 35
Brief outline of the methods pursued in the manufacture of salt..... 36

IRON ORES.

Magnetite, from Pine Creek, Waterton River, fifteen miles from forks of North Fork and Waterton River, B.C.. 38
——— from location 400 R., Atic-okan River, Rainy River district, O..... 38

PAGE.

IRON ORES—*Continued.*

Magnetite from location 402 R., Atic-okan River, Rainy River district, O..... 38
——— from location 403 R., Atic-okan River, Rainy River district, O..... 38
——— from two miles and a-half west of Sabawy Lake, Atic-okan River, Rainy River district, O..... 38
——— from line between locations 10 E. and 11 E., Atic-okan River, Rainy River district, O..... 38
Hematite, from south-east end of Black Sturgeon Lake, district of Thunder Bay, O..... 39
——— from the vicinity of Sunnybrae, a mile and a-quarter north of the East River, Pictou county, N.S..... 39
——— from the township of Bastard, Leeds county, O... 39

NICKEL AND COBALT ORES.

Pyrrhotite, from the property of R. J. Nicholson, Barrachois Harbour, Cape Breton county, N.S..... 39
——— from three miles north of St. Stephen, Charlotte county, N. B..... 39
——— from L'Etete, Charlotte county, N.B 40
——— from vicinity of Lake Mistassini, Q..... 40
——— from the Lake Memphremagog mine, lot 24, range 18, of the township of Potton, Brome county, Q. 40
——— from lot 24, range 7, of the township of Clarendon, Pontiac county, Q..... 40
——— from location W. 7, east side of Waddell's Lake, district of Nipissing, O..... 41
——— from Boucher's mine, north-east side of Lake Wahnapitae, district of Nipissing, O..... 41
——— from McCormick's mine, north-west corner of lot 12, range 3, of the township of Neelon, district of Nipissing, O..... 41
——— from two miles north of the township of Lumsden, on the boundary line between the districts of Nipissing and Algoma, O..... 41
——— from O'Connor's claim on lot 11, range 5, of the township of Lorne, district of Algoma, O..... 42
——— from the same locality as the last..... 42
——— from O'Connor's claim on lots 1 and 2, range 3, of the township of Nairn, district of Algoma, O. 42

PAGE.

NICKEL AND COBALT ORES—*Continued.*

Pyrrhotite from Loughran and Dwyer's claim, lot 3, range 3, of the township of Drury, district of Algoma, O. 42
——— from the south half of lot 6, range 2, of the township of Denison, district of Algoma, O..... 42
——— from lot 7, range 2, of the township of Levack, district of Algoma, O..... 43
——— from same locality as the last mentioned..... 43
——— from lot 3, range 4, of the township of Levack, district of Algoma, O..... 43
——— from the Ross mining location, three miles north of the northern township line of the township of Morgan, district of Algoma, O..... 43
——— from lot 10, range 4, of the township of Creighton, district of Algoma, O..... 44
Nickeliferous ore from the Vermilion mine, lots 5 and 6, range 4, of the township of Denison, district of Algoma, O..... 44
Nickel ore from the Vermilion mine—same locality as that of the preceding specimen..... 44
Cobaltiferous arsenopyrite, from the north half of lot 6, range 3, of the township of Graham, district of Algoma, O..... 45
Niccolite and Gersdorffite, from O'Connor's claim on lot 12, range 3, of the township of Denison, district of Algoma, O..... 45
Pyrrhotite, from the township of Clarendon, Frontenac county, O..... 45
——— from two miles west of Schreiber on the line of the C. P. R., district of Thunder Bay, O..... 46
——— from the same locality as the last mentioned..... 46
——— from Darlington Bay, Lake of the Woods, district of Rainy River, O..... 46
——— from near the head of Barclay Sound, Vancouver Island, B.C..... 46
——— from the Monashee mine, Monashee Mountain, near the head of Cherry Creek, B.C..... 47
Notes on the occurrence of nickel and cobalt ores in other parts of Canada..... 47

PAGE.

GOLD AND SILVER ASSAYS.

Of specimens from the—

Province of Nova Scotia..... 48
" New Brunswick..... 49
" Quebec..... 50
" Ontario..... 51
" British Columbia..... 55

MINERALOGICAL NOTES.

Voigtite, from North-east Harbour Shelburne county, N.S.. 65
Jamesonite, from Vermont Creek, Middle Fork of the Spilimichene River, B.C..... 65
Freibergite, from branch entering Eagle River from the north-west, near Sicamous, Shuswap Lake, B.C..... 65
Native platinum, from the North Saskatchewan, in the neighbourhood of Edmonton, district of Alberta, N.W.T..... 65
Native mercury, from eastern entrance to Seshart Channel, Barclay Sound, Vancouver Island, B.C..... 65
Cinnabar, from last mentioned locality..... 66
Lazulite, from Lake Mistassini region, Q..... 66
Metacinnabarite, from west side of Read Island, off the north-east coast of Vancouver Island, B.C..... 66
Sphalerite, from north side of Burrard Inlet, opposite Vancouver, B.C..... 66
Graphite, from lot 34, range 8, of the township of Denbigh, Addington county, O..... 67
Talc, from lot 34, range 2, of the township of Clarendon, Frontenac county, O..... 67
Pyrite, from head of Eckstall Inlet, south of Port Essington, Skeena River, B.C..... 67
Cookeite, from the Wait-a-bit Creek, a tributary of the Columbia River, B.C..... 67
Fibrolite, from lot 9, range 3, of the township of Dryden, district of Nipissing, O..... 68
Mineral associations of apatite..... 68
Mineral inclusions in mica..... 69

MISCELLANEOUS EXAMINATIONS.

Semi-anthracite, from the main Red Deer River, about one hundred miles north of Anthracite, B.C..... 70

PAGE..

MISCELLANEOUS EXAMINATIONS—*Continued.*

Phosphatic rock, from the mouth of Macintosh Brook, north shore East Bay, Cape Breton county, N.S..... 70

Quartz sand, from a boring at the mouth of Coal River, lower Missinaibi River, O..... 70

Volcanic tufa, from Lawn Hill, near the entrance to Skidegate Inlet, Queen Charlotte Islands, B.C..... 71

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA

FROM THE

LABORATORY OF THE SURVEY.

MISCELLANEOUS MINERALS.

Miscellaneous minerals.

1. Ilvaite.

Several specimens of what proved to be this rare mineral were received for identification from a gentleman, who described it as occurring in large irregular masses in a vein about twenty feet wide, near the head of Barclay Sound, Vancouver Island, British Columbia.

Ilvaite from near the head of Barclay Sound, Vancouver Island, British Columbia.

Portions of the material were fairly free from foreign admixture, containing only small quantities of white, translucent, cleavable calcite; this, however, was in some fragments supplemented by inclusions of altered tremolite, and in others by a brownish-yellow andradite. It had a more or less closely compacted crystalline structure. The lateral faces of crystals were not infrequently striated longitudinally, and sometimes exhibited a slight iridescent tarnish. Colour, iron-black; streak, greenish-black; lustre, sub-metallic; brittle; fracture, uneven. Before the blow-pipe fuses quietly at about 2·5 to a black magnetic globule. Hardness, 5·5; specific gravity, 3·859. Readily decomposed by hydrochloric acid, forming a yellow jelly.

An analysis conducted upon very carefully selected and prepared material, dried at 100° C., afforded me the following results:

Silica	29·81
Alumina	0·16
Ferric oxide	18·89
Ferrous oxide	32·50
Manganous oxide	2·22
Lime	13·82
Magnesia	0·30
Water	1·62
	99·32

Miscellaneous minerals—*Con.*

2. Native iron.[1]

Native iron from St. Joseph Island, Lake Huron, Ontario.

In the course of examining some surface specimens of quartzite[2] from the north shore—fifth concession, back of Campement d'Ours—of St. Joseph Island, Lake Huron, Ontario, it was observed that certain faces, apparently fissure surfaces, of the same were coated with a thin deposit of dark reddish-brown limonite through which was disseminated numerous metallic looking spherules, thereby imparting to it an oolitic structure. In the specimen which best showed its mode of occurrence, this deposit formed a layer on one face of from one to one and a-half millimetre in thickness, and this, judging from the appearance of the exposed surface of the same, which showed indications of having been a contact surface, may perhaps be fairly assumed to represent the diameter of the original fissure. Running parallel to and in direct communication with the latter was a gouge-shaped groove measuring where it opened into the fissure, its widest part, five millimetres across, and having a varying depth of from five to six millimetres. This groove, retaining these dimensions, extended right across the face of the specimen, which face, in this direction, measured four centimetres. There was nothing to indicate what the probable length of this groove may have been, as it occurred in the rock, *in situ*, or whether it occupied a vertical, horizontal, or intermediate position, although conjecture might perhaps, in this particular instance, favour the former view. It was closely packed with material of precisely the same character as that contained in the fissure, the material of the one forming an uninterrupted connection with and, as it were, extension of, that of the other, so that we may indifferently regard the material in the fissure as an overflow from the groove, or that in the latter, more especially if this merely represented an elongated cavity, as a filling in from the former.

No metallic grains or matter likely to have resulted from the alteration of the same, or mineral from which the iron could possibly have been derived, was observable in any other part of the specimens examined.

---

[1] The material in question formed the subject of a paper by me, entitled "On a peculiar form of Metallic Iron found in Huronian quartzite, on the north shore of St. Joseph Island, Lake Huron, Ontario," which appeared in the Transactions of the Royal Society of Canada, vol. VIII. (1890), sec. iii. p. 39. The coloured plate illustrating that paper is here unavoidably omitted.

[2] A greyish, in parts greenish and brownish coloured quartzite, with here and there an inclusion of white vitreous quartz, and red and blackish or brownish-black jasper.

Miscellaneous minerals–*Con.*

The material which, as already remarked, had an oolitic structure, was dense in texture and firmly adherent to the face of the quartz. It was found to be made up of:

Native iron from St. Joseph Island, Lake Huron, Ontario–*Con.*

Metallic grains	58·85
Limonite	39·73
Siliceous matter	1·42
	100·00

The siliceous matter consisted of angular particles of quartz which had evidently been chipped off with, and remained attached to, the material when removing it from the rock.

The metallic grains varied greatly in size, the largest not exceeding thirty-seven hundredths of a millimetre in diameter, whilst many, perhaps the greater number, were of far smaller dimensions, and others were of microscopic minuteness. Although diverse in form yet all were rounded and, for the most part, more or less spherical in shape. They were strongly attracted by the magnet and after separation by its aid from the associated non-metallic matter, aggregated themselves into loose bunchy masses or formed trains. Brittle—in the process of pulverization emitted a faint yet distinct phosphoretted odour. Colour of freshly fractured surface of metal, steel-grey. When immersed in a solution of cupric sulphate the grains became immediately coated with a film of metallic copper. They were readily attacked by hydrochloric acid with evolution of hydrogen possessing a marked odour of phosphine, the latter, however, gradually passed off as digestion proceeded, when a peculiar fetid smell similar to that which characterizes hydrogen evolved from wrought iron or impure zinc, was observable. Hydrochloric acid did not effect complete solution—the undissolved material still presenting a metallic aspect; a further treatment with nitric acid, however, removed the remaining metallic matter, leaving a granular, nucleiform, non-metallic, insoluble residue.

The metallic spherules were found to have a specific gravity, at 15·5°C., of 6·8612, and a composition, as follows:

Iron	88·00
Manganese	0·51
Nickel	0·10
Cobalt	0·21
Copper	0·09
Sulphur	0·12
Phosphorus	0·96
Carbon	
Organic matter	undet.
Insoluble, non-metallic, residue	9·76
	99·75

Miscellaneous minerals–*Con.*

Native iron from St. Joseph Island, Lake Huron, Ontario–*Con.*

The insoluble residue consisted of spherical, ovoid, &c., shaped grains which were more or less coated with a yellowish-brown, apparently humus-like, substance. When broken, these spherules were seen to have a concentric structure, apparently of a concretionary character. On ignition the organic matter readily burnt off, leaving them snow-white. The ignited spherules were found to be exceedingly hygroscopic, so much so, that in the short space of time occupied in their transference from one container to another, they absorbed not less than 0·775 per cent of water.

An analysis of this residue gave the following results:

Silica	9·17
Alumina	0·11
Ferric oxide	0·10
Lime	0·06
Magnesia	0·03
Loss? [3]	0·29
	9·76

Hence, the centesimal composition of the metallic portion of the spherules, would be:

Iron	97·79
Manganese	0·57
Nickel	0·11
Cobalt	0·23
Copper	0·10
Sulphur	0·13
Phosphorus	1·07
Carbon	?
	100·00

and that of the insoluble, non-metallic, residue:

Silica	93·95
Alumina	1·13
Ferric oxide	1·02
Lime	0·62
Magnesia	0·31
Loss? [3]	2·97
	100·00

The limonite did not contain any, so to say, denuded nuclei, so that supposing it to have resulted from the weathering of the metallic spherules, the change had, in no instance, proceeded so far as to effect

[3] The analysis was conducted upon a very small amount of material—the silica may, not improbably, be a little too low.

the removal of the whole of the metallic covering. Some of the nuclei were of microscopic minuteness, hence it may be inferred that even the smallest of the metallic spherules contained a siliceous nucleus. The limonite gave no reaction for chlorine. Miscellaneous minerals—*Con.*

From what has preceded it will be seen that the metallic looking spherules which were disseminated through the limonite, consisted of nuclei of silica coated with a humus-like substance which in turn was overlain by a metallic layer—the latter containing all the elements most frequently met with in meteoric iron. The amount of phosphorus is relatively large, that of the nickel, however, very small, consequently if it be regarded as present in the form of any of the varieties of nickel-iron or schreibersite, it would represent but comparatively trifling amounts of either of these bodies. Native iron from St. Joseph' Island, Lake Huron, Ontario—*Con.*

Owing to the fact that all meteoric iron contains nickel, the presence of that element in a native iron has generally been regarded as evidence of its extra-terrestrial origin and for this reason the irons of Chotzen and Petropaulwosk although sometimes mentioned in connection with those of accepted telluric origin [4] are, in consideration of their having been shown to be nickeliferous, referred to by some authorities as most probably of meteoric origin. It will be remembered, however, that the native iron of Ovifak, Disco Bay, Greenland, which was at first regarded by the discoverer, Nordenskiöld, and others as meteoric iron, also contains a certain amount of nickel, yet the observations of Steenstrup, Törnebohm and Smith, make it very certain that the iron is not meteoric but of terrestial origin, in which case the presence of nickel in an iron would not have the same significance as it was formerly supposed to have.

Assuming, therefore, that the trifling amount of nickel present in this iron would not necessarily imply a cosmic origin, the relatively large amount of phosphorus accompanying the nickel, the presence of organic matter [5] and the fact of the spherules containing nuclei, apparently of a concretionary character, would suggest the possibility of this iron having a terrestrial source, upon the assumption that it has result-

[4] Such as the iron found by Andrews in basaltic rocks from the Giants Causeway, and that found by Mossier in lava from Graveneire in Auvergne.

[5] The presence of organic matter of the nature (humus-like) of that here referred to would not appear to be inconsistent with an extra-terrestrial origin. The meteorite of Alais contained a carbonaceous matter which Berzelius considered might not improbably be humus. Wöhler found the carbonaceous matter of the Kold-Bokeveldt and Kaba meteorites to consist of a mixture of amorphous carbon and bituminous matters, described as not unlike Scheererite or Ozocerite. Cloez again, found the carbonaceous matter of the Orgueil meteorite to resemble, both in appearance and composition, certain humus substances.

Miscellaneous minerals—*Con.*

ed from the reduction of an iron-salt by organic matter, in which case it would have a community of origin with the sideroferrite [6] of Bahr.

3. Harmotome.

Harmotome from O'Connor, district of Thunder Bay, Ontario.

From the Beaver mine, township of O'Connor, district of Thunder Bay, province of Ontario; collected by Dr. A. C. Lawson.

It occurs, in small crystals implanted on prisms of calcite resting on a layer of crystalline quartz, coating the surface of a dark grey shale, traversed by seams of similar quartz and purple fluorite. Numerous isolated crystals of pyrite, or small aggregations of the same, occur disseminated through the shale as well as attached to the layer of quartz upon which the calcite crystals rest.

Specific gravity (employing 0·0848 gram of the mineral), at 15·5° C., 2·39. An analysis conducted upon 0·0798 gram material (employing the ammonium chromate method for separation of baryta from lime), afforded me the following results:

Silica	46·36
Alumina	17·16
Baryta	21·18
Lime	2·25
Potassa	?
Soda	?
Water	14·54
	101·49

4. Common Opal.

Common opal from Savona Mountain, British Columbia.

Very characteristic specimens of this mineral were found by Dr. G. M. Dawson (Survey) in the Tertiary basaltic breccia or agglomerate rocks of Savona Mountain, south of Savona station on the line of the Canadian Pacific Railway, British Columbia. Their examination afforded me the following results:

Colour, white, pale greenish-white, and apple-green. Translucent. Lustre, subvitreous. Fracture, conchoidal. Does not adhere to the tongue. On ignition turns porcelain-white and becomes opaque. Specific gravity, 2·012—of the same material, after ignition, 2·083. It is readily attacked, and almost completely soluble, in a boiling solution of caustic potash; the undried material leaving, when submitted to

[6] A native iron found by Bahr, in the form of grains, thin laminae and powder, in a fragment of mineralized wood—resembling bog-iron ore in appearance—from a floating island in the Ranälnger Lake in Smäland, Sweden.

the action of this reagent, an insoluble residue amounting to only 1·92 per cent. An analysis of this gave silica 0·76, alumina 0·23, ferric oxide 0·26, lime 0·35, magnesia 0·23, alkalies ? 0·09 = 1·92. Miscellaneous minerals -*Con.*

The material rapidly gains or loses water, according to the hygrometric condition of the atmosphere, as is exemplified by the following experiments : Common opal from Savona Mountain, British Columbia–*Con.*

Portions of the finely pulverized mineral were placed in a perfectly dry atmosphere, that is to say, over strong sulphuric acid under a bell jar, and left, weighing at intervals, under these conditions until the last weighing indicated no further diminution in weight. It was found that—

						I.		II.	
After the first exposure of			24	hours,	the loss amounted to	2·477	p.c.	2·550	p.c.
"	second	"	24	"	"	0·313	"	0·356	"
"	third	"	24	"	"	0·261	"	0·207	"
"	fourth	"	24	"	"	0·130	"	0·119	"
"	fifth	"	24	"	"	0·078	"	0·015	"
"	sixth	"	24	"	"	nil.		nil.	
Total loss.....						3·259		3·247	

or a mean loss of 3·25 per cent for the total period of 120 hours. The percentage of water in the original mineral, as determined by ignition over a Bunsen blast-lamp, amounted to—

I.	II.	Mean.
7·040	6·968	7·00

deducting from this the loss incurred by the mineral when exposed to a dry atmosphere, it will be seen that it persistently retains, at the ordinary temperature, 3·75 per cent of this water under the conditions stated.

The above portions of material, dried in the manner indicated, were now placed in an atmosphere saturated with moisture. This was accomplished by substituting for the glass dish containing sulphuric acid, in above experiment, one containing a shallow stratum of water, over which was heaped shreds of filtering paper, the bell jar inclosing the experiments being in turn covered by one of larger dimensions, to prevent deposition of dew. The exposure was continued, weighing at intervals, until the last weighing indicated no further increase in weight. It was found that—

							I.		II.	
Miscellaneous minerals–*Con.*	After a first exposure of	48	hours,	the	gain	amounted to	6·206	p.c.	6·272	p.c
	" second "	72	"	"			0·235	"	0·178	"
	" third "	72	"	"			0·182	"	0·119	"
Common opal from Savona Mountain, British Columbia–*Con.*	" fourth "	72	"	"			0·052	"	0·089	"
	" fifth "	72	"	"			0·052	"	0·059	"
	" sixth "	72	"	"			0·026	"	0·029	"
	" seventh "	72	"	"			nil.		nil.	
						Total gain.....	6·753		6·746	

or a mean gain, by absorption of water, of 6·75 per cent for the total period of 408 hours exposure. Hence, not only had the mineral regained the whole of the water previously lost by exposure to a dry atmosphere, but in addition absorbed 3·50 per cent more than it originally contained.

Some further experiments, bearing upon the absorption of water by the original mineral, were made in which the latter was employed in the form of fragments. These were of fairly large dimensions, five to eight millimetres diameter, and apparently free from fissures. One portion of this material was placed in an atmosphere saturated with moisture and, as in previous instances, left there, weighing at intervals, until no further increase in weight was perceptible. It was observed that in the course of—

The first	exposure of	72	hours,	the	mineral absorbed	3·181 p.c. water.
" second	"	72	"	"		0·030 "
" third	"	72	"	"		0·040 "
" fourth	"	72	"	"		0·030 "
" fifth	"	72	"	"		nil.
					Total gain.....	3·281

This material was next immersed in water for 48 hours, then withdrawn, the superfluous moisture removed by a soft absorbent cloth, and reweighed. The weight coincided with that previous to immersion, consequently no further absorption had taken place. The percentage of water absorbed by the mineral, in addition to that which it originally contained, amounted therefore to 3·28 per cent.

The remaining portion of the material was immersed in water for about forty hours, after which the water was poured off, the superfluous moisture removed, and the mineral weighed. The weight indicated an increase by absorption of water of 3·29 per cent. This agrees very closely with the result obtained in the last experiment, but is, as perhaps might have been anticipated, somewhat lower than in the experiments in which the material was employed in a finely powdered condition.

Miscellaneous minerals–*Con.*

A portion of the material, in the form of fragments, was ignited over a Bunsen blast-lamp, and placed in an atmosphere saturated with moisture. The increase in weight, even after an exposure of 264 hours, was so slight that it was deemed unworthy of recording.

Common opal from Savona Mountain, British Columbia–*Con.*

Briefly stated—the mineral contained, at the time of its examination, 7·00 per cent of water ; of this it lost 3·25 per cent, persistently retaining the balance of 3·75 per cent when exposed to a perfectly dry atmosphere at the ordinary temperature. On exposure to a moist atmosphere, of a similar temperature, it rapidly regained the water thus lost, and, in addition, absorbed 3·50 per cent more than it originally contained. The mineral after strong ignition, when placed under similar conditions, experienced such a slight increase in weight that it may be said to be non-absorbent.

5. Danaite.

Danaite from Graham, district of Algoma, Ontario–*Con.*

This mineral, not previously identified as occurring in Canada, was met with, in diorite, in the course of developing a deposit of nickeliferous pyrrhotite on the north half of lot six, in the third range of the township of Graham, district of Algoma, Ontario. Examined for Mr. D. L. McLean.

The results of the examination are as follows :—

Massive, structure, more or less crystalline granular. Colour, steel-grey. Intermixed with it were small quantities of white translucent quartz, some pyrrhotite, a little galenite, and a trifling amount of chalcopyrite, and attached to one of the faces of the specimen was a layer of greyish-green serpentine. Specific gravity (after correction for a little included quartz), at 15·5° C., 5·988.

An analysis, by Mr. R. A. A. Johnston, of carefully selected material, showed the same to have the composition given under I. If the gangue (silica) be deducted and the remainder of the analysis recalculated for one hundred parts, we obtain the figures given under II.

	I.	II.
Arsenic	40·16	42·22
Sulphur	17·92	18·84
Iron	31·69	33·32
Cobalt	3·89	4·09
Nickel	0·88	0·93
Antimony	0·57	0·60
Gold	trace.	trace.
Gangue (quartz)	4·77	.....
	99·88	100·00

6. Tripolite or Infusorial Earth.

Miscellaneous minerals—*Con.*

From the head of Loon Lake, Interior plateau, British Columbia. Geological position, Tertiary. Received, for identification, from Mr. F. W. Foster—who stated that it was said to constitute an extensive deposit at the aforementioned locality.

Tripolite from the head of Loon Lake, British Columbia.

It is very fine-grained, closely compacted and tough, with a coarse, dull, earthy fracture : is meagre and rough to the feel : adheres strongly to the tongue ; colour, light reddish.

Some slides of this material were prepared by Mr. T. C. Weston, and these showed it to be almost entirely made up of frustules of Diatomaceæ—some siliceous spicules of fresh water sponges being also present.

Professor A. H. MacKay, who has kindly undertaken a critical examination of this earth, informs me that although the work is not yet completed the conclusions he has arrived at in regard to it, thus far, show that of the Diatomaceæ, *Melosira granulata*, Ehr., constitutes the most abundant species. *Melosira crenulata*, *Var.* (?), *Pinnularia major*, Rab., *Pinnularia viridis*, Rab., *Pinnularia divergens*, W. Sm., *Navicula legumen*, Ehr., *Navicula mesolepta*, *var. nodosa*, Ehr., *Cymbella Ehrenbergii*, Kütz., *Asterionella formosa*, Hass., and *Fragillaria mutabilis*, Gun. (?), being also represented—and that among the sponge spicules were, *Spongilla fragilis*, Leidy and varieties, *Spongilla lacustris*, Linn. (?), and *Meyenia fluviatilis*, Carter.

This material has been used by the Indians in the vicinity of Cache Creek for making tobacco-pipes—a not inappropriate application in view of the facility with which it may be carved, its lightness and absorbent power. The opening up of the locality may lead to its employment for many purposes for which it can now be scarcely regarded as available by reason of the present difficulties and cost attendant upon its transport.

The occurrence of a diatomaceous earth, also of lacustrine origin, in the tertiary beds on Blackwater River, just above the bridge, is referred to by Dr. G. M. Dawson in his "Report on explorations in British Columbia," Rep. Geol. Surv. Can., 1875-76, p. 256, in the following words :—"The rocks are light coloured, chiefly pale greenish and greyish-white, and generally quite fine grained, constituting fireclays, which are sometimes massive but often thin bedded. Soft sandstones, and occasional beds with small pebbles, also occur. Some layers are highly diatomaceous, a species of *Melosira*, like *M. varians*, being most abundantly represented."

7. Scheelite.

Miscellaneous minerals-*Con.*

This mineral, a specimen of which was found and recognized by Mr. W. F. Ferrier (Survey), amongst a series of rock specimens collected by Mr. A. Webster in 1881, occurs on lot one of the seventh range of the township of Marlow, Beauce county, province of Quebec.

Scheelite from Marlow, Beauce county, province of Quebec.

In this specimen the scheelite occurred in crystals of a pale wine-yellow colour, together with some specular iron, pyrrhotite and pyrite, in a white sub-translucent quartz. Mr. R. A. A. Johnston found it to have a specific gravity, at 15·5°C., of 6·059, and—agreeably with the results of his analysis—the following composition :

Tungstic acid	79·90
Lime	19·37
Ferric oxide	0·70
Silica	0·29
	100·26

The mineral wolframite, a tungstate of iron and manganese, had already been met with by Professor Chapman, in a large boulder of gneiss, on the north shore of Chief's Island, in Lake Couchiching, province of Ontario.

8. Chromiferous Muscovite.

Chromiferous muscovite from Matawatchan, Renfrew county, Ontario.

A very handsome, scaly, massive, bright emerald green muscovite, with some intermixed scales of a dark brown mica, a little quartz and a few grains of pyrite, occurs in the township of Matawatchan, Renfrew county, Ontario.

Mr. F. G. Wait found it to have a specific gravity at 15·5°C., of 2·93, and—agreeably with the results of his analysis—the following composition :

Silica	43·72
Alumina	35·51
Ferric oxide	2·94
Chromic oxide	1·26
Manganous oxide	0·26
Lime	4·46
Magnesia	1.36
Potassa	8·88
Soda	0·39
Water (direct estimation)	3·68
	102·46

9. GERSDORFFITE.

Miscellaneous minerals—*Con.*

Gersdorffite from Denison, district of Algoma, Ontario.

Has been met with at the O'Connor claim on lot twelve of the third range of the township of Denison, district of Algoma, Ontario, where it occurs with niccolite, chalcopyrite and pyrrhotite, in a gangue consisting of an association of a light to dark green, fine grained, diabase with small quantities of a dark green chloritic schist, a little greyish-white to white translucent quartz and a trifling amount of calcite.

Structure, for the most part lamellar, but occasionally granular; a few minute, fairly well developed crystals exhibiting the forms of the octahedron and cubo-octahedron, with the faces of the octahedron predominating, were also observed. Colour, steel-grey—here and there tarnished blackish. Specific gravity (after correction for a little included quartz), at 15·5°C., 6·231.

The material upon which the analysis was conducted, although selected with all possible care and, so far as could be seen, apparently pure, nevertheless contained, it was subsequently found, a very appreciable amount of quartz. Its analysis afforded Mr. R. A. A. Johnston the results given under I. Deducting the gangue (silica), and recalculating the remaining constituents for one hundred parts we obtain the figures given under II.

	I.	II.
Arsenic	40·31	46·96
Sulphur	14·34	16·71
Nickel	22·59	26·32
Iron	6·78	7·90
Cobalt	1·73	2·01
Copper	0·09	0·10
Gangue (quartz)	13·55	....
	99·39	100·00

This mineral had not previously been identified as occurring in Canada.

Natural waters.

NATURAL WATERS.

Water from boring on Kanak Creek, near Port Haney, British Columbia.

1.—Water from a boring on Kanak Creek, near Port Haney, district of New Westminster, British Columbia. Examined for Mr. H. Abbott.

Dr. G. M. Dawson informs me that this water rises from nearly horizontal beds of tertiary strata, consisting of sandstones, clay-shales, and conglomerates, resting upon granitic rocks.

Natural waters—*Con.*

It was bitter and saline to the taste. Specific gravity, at 15·5° C., 1·039. An analysis by Mr. F. G. Wait showed it to contain—in 1000 parts by weight—

Water from boring on Kanak Creek, near Port Haney, British Columbia—*Con.*

Potassium	0·202
Sodium	2·554
Calcium	14·980
Magnesium	0·015
Chlorine	30·740
	48·491
Chlorine required, in addition to that found to satisfy bases	0·018
	48·509

The foregoing constituents may reasonably be assumed to be present in the water in the following state of combination:

Chloride of potassium	0·385
" sodium	6·496
" calcium	41·569
" magnesium	0·059
	48·509
Total dissolved solid matter, by direct experiment	48·723

It contained no trace of sulphates. Barium and strontium were not sought for. Lithium was sought for, and not detected. Iodine was found to be present in notable amount, but no evidence of the presence of bromine was obtained.

The above water is remarkable for the very large amount of chloride of calcium which it contains and the great preponderance of this over the other constituents, amounting, as it does, to rather more than eighty-five per cent of the solid contents. The only other water of which, so far as I am aware, there is any recorded analysis, that can be compared with it, is one from a well on Manitoulin Island (Lake Huron, province of Ontario), examined by Dr. T. Sterry Hunt, the results of whose analysis, as calculated for 1000 parts, are as follows:—

Chloride of potassium	0·792
" sodium	4·800
" calcium	12·420
" magnesium	3·650
	22·662

It contained no trace of sulphates, barium or strontium. It was not examined for iodine or bromine, but these, it is remarked, were probably present.

Natural waters—*Con.*

The foregoing two waters, whilst resembling each other, in that they contain the same constituents, yet differ considerably as regards amounts and relative proportions of the same.

Water from hot spring on Kootanie Lake, British Columbia.

2.—Water from hot spring on the west side of Kootanie Lake, eight miles north of the West Arm, British Columbia. Collected by Dr. G. M. Dawson (Survey).

There are several outflows—the principal orifice, that from which this sample was collected, was roughly estimated to discharge about sixty gallons per minute. The temperature of the water at the time of collection, June 25, 1889, was found to be 101·5°F.

The water, which was odourless and devoid of any marked taste, contained 1·123 parts of dissolved solid matter, dried at 15·5°C., in 1000. A qualitative analysis afforded Mr. R. A. A. Johnston the following results:—

Soda	small quantity.
Lime	large quantity.
Magnesia	very small quantity.
Alumina	trace.
Ferrous oxide	trace.
Sulphuric acid	very small quantity.
Carbonic acid	large quantity.
Silica	very small quantity.
Chlorine	large quantity.
Organic matter	trace.

No evidence was obtained of the presence of potassa.

Water from hot spring on Upper Arrow Lake, British Columbia.

3.—Water from hot spring on the east side of Upper Arrow Lake (twelve miles from its head, and one hundred and fifty yards from the lake), British Columbia. Collected by Dr. G. M. Dawson (Survey).

Temperature of the water at the time of collection, June 13, 1889, 123·5°F. It contained 0·777 parts of dissolved solid matter, dried at 180°C., in 1000 parts, by weight, of the water. Agreeably with the results of a qualitative analysis, conducted by Mr. R. A. A. Johnston, it contained:

Soda	very small quantity.
Lime	small quantity.
Magnesia	very small quantity.
Alumina	trace.
Ferrous oxide	trace.
Sulphuric acid	fairly large quantity.
Carbonic acid	trace.
Silica	very small quantity.
Chlorine	trace.
Organic matter	small quantity.

Potassa was sought for, and not detected. On boiling, the water which was previously colourless, assumed a pale brownish tint. Natural waters—*Con.*

A deposit which forms round the mouth of this spring was found by Mr. Johnston to consist of, approximately, 78 per cent silica, and 15 per cent alumina, together with small quantities of lime and magnesia.

4.—Water from a well six miles south of Calgary, district of Alberta, North-west Territory. Examined for Mr. J. Bannerman. Water from a well near Calgary, district of Alberta, North-west Territory.

The water was colourless, odourless, and devoid of any marked taste. It contained 0·843 parts of dissolved solid matter, dried at 180°C., in 1000 parts, by weight, of the water. A qualitative analysis by Mr. R. A. A. Johnston, showed it to contain:

Soda	large quantity.
Lime	large quantity.
Magnesia	small quantity.
Ferrous oxide	trace.
Sulphuric acid	large quantity.
Carbonic acid	large quantity.
Chlorine	small quantity.
Organic matter	small quantity.

Potassa was absent. Boiling produced a precipitate which consisted for the most part of carbonate of lime, with some carbonate of magnesia.

5.—Water from a spring on lot four, range four, of the township of Kenyon, Glengarry county, Ontario. Examined for Mr. A. McDowell. Water from a spring in Kenyon, Glengarry county, Ontario.

The water was perfectly colourless, clear and bright; devoid of odour and any marked taste. It contained 0·300 parts of dissolved solid matter, dried at 180°C., in 1000 parts, by weight, of the water. Mr. R. A. A. Johnston made a qualitative analysis of this water, and found it to contain :

Soda	small quantity.
Lime	small quantity.
Magnesia	very small quantity.
Ferrous oxide	trace.
Sulphuric acid	small quantity.
Phosphoric acid	trace.
Carbonic acid	small quantity.
Chlorine	small quantity.
Organic matter	very small quantity.

Potassa was found to be absent.

Natural waters-*Con.*

Water from springs on shore of Lake St. John, Chicoutimi county, province of Quebec.

6.—This water, which rises from the Trenton formation, is found issuing along the shore of Lake St. John, at Chambord—first range of the township of Metabetchouan, Chicoutimi county, province of Quebec—for a distance of about eight hundred yards, and about five feet below high water mark. Examined for Mr. J. G. Scott.

When received it contained a trifling amount of suspended matter. This was removed by filtration. The filtered water, which had a very bitter saline taste, was colourless and odourless. It was found to have a specific gravity, at 15·5°C., of 1·0345, and to contain 45·719 parts of dissolved solid matter (anhydrous) in 1000 parts, by weight, of the water. A qualitative analysis, conducted by Mr. F. G. Wait, showed it to contain :

Soda	large quantity.
Lime	very large quantity.
Magnesia	small quantity.
Sulphuric acid	small quantity.
Chlorine	very large quantity.
Bromine	distinct trace.
Iodine	distinct trace.

This water would appear to have much the same general composition as those of Ancaster and Hallowell. These contain chloride of sodium with large proportions of chlorides of calcium and magnesium, some sulphates, as likewise bromides and iodides.

The following series of brines represent all the principal salt springs on Swan and Winnipegosis Lakes, province of Manitoba, and on the Red Deer River, district of Saskatchewan, North-west Territory. They were collected by Mr. J. B. Tyrrell, and are referred to by him in his report on the Geology of North-western Manitoba—this volume, Part E. The analyses were all conducted by Mr. F. G. Wait.

Water from spring near shore of Dawson Bay, east of mouth of Steep Rock River, Lake Winnipegosis, Manitoba.

7.—From spring on hillside, near the shore of Dawson Bay, two miles east of the mouth of Steep Rock River, Lake Winnipegosis. Collected August 8, 1889.

It had a specific gravity, at 15·5°C., of 1·041, and contained in 1000 parts, by weight, as follows :

Potassium	1·296
Sodium	20·054
Calcium	1·231
Magnesium	0·315
Sulphuric acid (SO_4)	3·025
Chlorine	32·732
	58·653
Chlorine required, in addition to that found, to satisfy bases	0·275
	58·928

Hypothetical combination:

Chloride of potassium	2·473
" sodium	51·005
" magnesium	1·176
Sulphate of lime	4·185
" magnesia	0·089
	58·928

Total dissolved solid matter, by direct experiment, dried at 180°C., 59·219.

It contained a trace of lithium. Barium, strontium, bromine and iodine, were not sought for.

8.—From spring near the west shore of Dawson Bay, three-quarters of a mile north of the mouth of Steep Rock River, Lake Winnipegosis. Collected August 6, 1889.

Specific gravity, at 15·5°C., 1·039. It contained in 1000 parts, by weight:

Potassium	1·509
Sodium	18·393
Calcium	1·198
Magnesium	0·357
Sulphuric acid (SO_4)	2·889
Chlorine	30·647
	54·993
Chlorine required, in addition to that found to satisfy bases	0·156
	55·149

Hypothetical combination:

Chloride of potassium	2·879
" sodium	46·781
" magnesium	1·399
Sulphate of lime	4·073
" magnesia	0·017
	55·149

Total dissolved solid matter, by direct experiment, dried at 180°C., 54·579.

It contained a trace of lithium. Barium, strontium, bromine and iodine were not sought for.

Natural waters–*Con.*

9.—From Salt Point, on the south-west shore of Dawson Bay, Lake Winnipegosis. Collected August 3, 1889.

Water from Salt Point, south-west shore of Dawson Bay, Lake Winnipegosis, Manitoba.

Specific gravity, at 15·5°C., 1·044. It contained in 1000 parts, by weight :

Potassium	0·989
Sodium	20·899
Calcium	1·098
Magnesium	0·328
Sulphuric acid (SO_4)	3·154
Chlorine	33·939
	60·407
Chlorine in excess of that required to satisfy bases	0·199
	60·208

Hypothetical combination :

Chloride of potassium	1·887
" sodium	53·155
" magnesium	0·649
Sulphate of lime	3·733
" magnesia	0·784
	60·208

Total dissolved solid matter, by direct experiment, dried at 180°C., 61·06.

It contained a trace of lithium, also a trace of iodine, but no bromine, nor were barium and strontium detected.

Water from spring on west side of Dawson Bay, north of mouth of Bell River, Lake Winnipegosis, Manitoba.

10.—From spring on west side of Dawson Bay, three miles and a-half north of the mouth of Bell River, and a mile back from the lake shore, Lake Winnipegosis. Collected August 2, 1889.

Specific gravity, at 15·5°C., 1·041. It contained in 1000 parts, by weight :

Potassium	1·044
Sodium	19·819
Calcium	1·251
Magnesium	0·328
Sulphuric acid (SO_4)	2·909
Chlorine	32·357
	57·708
Chlorine required, in addition to that found, to satisfy bases	0·220
	57·928

Hypothetical combination :

Chloride of potassium	1·992
" sodium	50·408
" calcium	0·108
" magnesium	1·299
Sulphate of lime	4·121
	57·928

Total dissolved solid matter, by direct experiment, dried at 180°C., 57·992.

It contained a very distinct trace of lithium and faint traces of strontium and iodine. Barium and bromine were absent.

Water from spring on west side of Dawson Bay, north of mouth of Bell River, Lake Winnipegosis, Manitoba-*Con.*

11.—From brook flowing into the west side of Dawson Bay, Lake Winnipegosis. Collected August 1, 1889.

Water from brook on west side of Dawson Bay, Lake Winnipegosis, Manitoba.

Specific gravity, at 15·5°C., 1·063. It contained in 1000 parts, by weight :

Potassium	0·607
Sodium	32·415
Calcium	1·681
Magnesium	0·478
Sulphuric acid (SO_4)	4·243
Chlorine	50·118
	89·542
Chlorine required, in addition to that found, to satisfy bases	0·248
	89·790

Hypothetical combination :

Chloride of potassium	1·158
" sodium	80·970
" magnesium	1·686
Sulphate of lime	5·715
" magnesia	0·261
	89·790

Total dissolved solid matter, by direct experiment, dried at 180°C., 88·946.

It contained traces of lithium, but neither barium nor strontium. Bromine and iodine were not sought for.

Natural waters–*Con.*

12.—From spring on the shore of Pelican Bay, just east of the mouth of Pelican Creek, Lake Winnipegosis. Collected July 21, 1889.

Water from spring on shore on Pelican Bay, Lake Winnipegosis, Manitoba.

Specific gravity, at 15·5°C., 1·039. It contained in 1000 parts, by weight:

Potassium	1·296
Sodium	20·054
Calcium	1·247
Magnesium	0·313
Sulphuric acid (SO_4)	3·114
Chlorine	32·888
	58·912
Chlorine required, in addition to that found, to satisfy bases	0·077
	58·989

Hypothetical combination:

Chloride of potassium	2·473
" sodium	51·005
" magnesium	1·120
Sulphate of lime	4·240
" magnesia	0 151
	58·989

Total dissolved matter, by direct experiment, dried at 180°C., 59·080.

It contained a trace of lithium, faint traces of bromine and a trace of iodine. Barium and strontium were absent.

Water from spring on Pine Creek, Lake Winnipegosis, Manitoba.

13.—From spring on the west side of the mouth of Pine Creek, near its discharge into Lake Winnipegosis. Collected July 6, 1889.

Specific gravity, at 15·5°C., 1·022. It contained in 1000 parts, by weight:

Potassium	1·100
Sodium	10·298
Calcium	0·924
Magnesium	0·282
Sulphuric acid (SO_4)	2·028
Chlorine	17·955
	32·587
Chlorine in excess of that required to satisfy bases.	0·088
	32·499

Natural waters–*Con.*

Water from spring on Pine Creek, Lake Winnipegosis, Manitoba–*Con.*

Hypothetical combination:

Chloride of potassium	2·099
" sodium	26·192
" calcium	0·219
" magnesium	1·116
Sulphate of lime	2·873
	32·499

Total dissolved solid matter, by direct experiment, dried at 180°C., 32·633.

It contained a trace of lithium, but neither barium, strontium, bromine nor iodine.

14.—From Monkman's salt spring on the west shore of Lake Winnipegosis. Collected July 1, 1889.

Water from Monkman's salt spring on west shore on Lake Winnipegosis, Manitoba.

Specific gravity, at 15·5°C., 1·016. It contained in 1000 parts, by weight:

Potassium	0·359
Sodium	7·447
Calcium	0·847
Magnesium	0·239
Sulphuric acid (SO_4)	2·156
Chlorine	12·326
	23·374
Chlorine required, in addition to that found, to satisfy bases	0·109
	23·483

Hypothetical combination:

Chloride of potassium	0·685
" sodium	18·941
" magnesium	0·823
Sulphate of lime	2·880
" magnesia	0·154
	23·483

Total dissolved solid matter, by direct experiment, dried at 180°C., 23·304.

It contained a very distinct trace of lithium, as likewise of iodine. Barium, strontium, and bromine were also sought for and found to be absent.

Natural waters–*Con.*

15.—From well at same locality as the last. Collected July 1, 1889. Specific gravity, at 15·5°C., 1·035. It contained in 1000 parts, by weight:

Water from well on west shore of Lake Winnipegosis, Manitoba.

Potassium	0·167
Sodium	16·820
Calcium	1·245
Magnesium	0·496
Sulphuric acid (SO_4)	2·462
Chlorine	27·739
	48·929
Chlorine required, in addition to that found, to satisfy bases	0·229
	49·158

Hypothetical combination:

Chloride of potassium	0·319
" sodium	42·780
" calcium	0·608
" magnesium	1·963
Sulphate of lime	3·488
	49·158

Total dissolved solid matter, by direct experiment, dried at 180°C., 49·356.

It contained a trace of lithium and strontium, but no barium, bromine or iodine.

Water from spring on west shore of Swan Lake, Manitoba.

16.—From spring half a mile back from the west shore of Swan Lake, between it and the lower portion of Swan River. Collected August 31, 1889.

Specific gravity, at 15·5°C., 1·035. It contained in 1000 parts, by weight:

Potassium	1·004
Sodium	17·546
Calcium	1·196
Magnesium	0·272
Sulphuric acid (SO_4)	2·747
Chlorine	28·904
	51·669
Chlorine in excess of that required to satisfy bases	0·015
	51·654

Natural waters—*Con.*

Water from spring on west shore of Swan Lake, Manitoba—*Con.*

Hypothetical combination :

Chloride of potassium	1·916
" sodium	44·626
" calcium	0·144
" magnesium	1·077
Sulphate of lime	3·891
	51·654

Total dissolved solid matter, by direct experiment, dried at 180°C., 51·559.

It contained a trace of lithium, but no barium or strontium. Bromine and iodine were not sought for.

17.—From lower salt spring on the north side of Red Deer River, a mile and three-quarters from its entry into Lake Winnipegosis. Collected August 13, 1889.

Water from lower salt spring on north side of Red Deer River, district of Saskatchewan, Northwest Territory.

Specific gravity at 15·5°C., 1·031. It contained in 1000 parts by weight :—

Potassium	0·832
Sodium	15·124
Calcium	1·094
Magnesium	0·354
Sulphuric acid (SO_4)	2·285
Chlorine	25·494
	45·183
Chlorine in excess of that required to satisfy bases.	0·098
	45·085

Hypothetical combination :

Chloride of potassium	1·587
" sodium	38·466
" calcium	0·394
" magnesium	1·401
Sulphate of line	3·237
	45·085

Total dissolved solid matter, by direct experiment, dried at 180°C., 45·027.

It contained a trace of lithium, and faint traces of iodine, but no bromine. Barium and strontium were also absent.

Natural waters–*Con.*

18.—From spring, on the south bank of Red Deer River, four miles from its entry into Lake Winnipegosis. Collected September 9, 1889.

Water from spring on south bank of Red Deer River, district of Saskatchewan, North-west Territory.

Secific gravity, at 15·5°C., 1·039. It contained in 1000 parts, by weight:

Potassium	1·181
Sodium	18·524
Calcium	1·156
Magnesium	0·277
Sulphuric acid (SO_4)	2·812
Chlorine	29·805
	53·755
Chlorine required, in addition to that found, to satisfy bases	0·650
	54·405

Hypothetical combination:

Chloride of potassium	2·253
" sodium	47·114
" magnesium	1·061
Sulphate of lime	3·930
" magnesia	0·047
	54·405

Total dissolved solid matter, by direct experiment, dried at 180°C., 53·243.

It contained a trace of lithium. Barium, strontium, bromine and iodine were not sought for.

Remarks on composition of brines from Manitoba, and district of Saskatchewan, North-west Territory.

On referring to the several analyses it will be seen that all these brines contained a trace of lithium; also, that in the nine instances in which barium and strontium were sought for, the former was found to be absent in all, the latter present in two of them; and further, that of the seven examined for iodine and bromine, four contained a trace of the first mentioned, but no evidence of the presence of the latter was, in any instance, obtained.

The results of the analyses of the foregoing brines have, with the object of affording easy reference and facilitating a comparison the one with the other, been embodied in the following tables. In the first of these the amounts of the several constituents of the solid contents are expressed as parts by weight in one thousand parts by weight of the water, whilst the second shows the amounts, expressed as grains, of the various saline constituents contained in an imperial gallon of the water. The numbers heading the columns correspond with those assigned to the several analyses of these waters as given on the preceding pages, and under each of which will be found mentioned the locality of occurrence of the various springs whence they were obtained.

Analyses of Waters of Salt-springs occurring in the province of Manitoba, and district of Saskatchewan, N.-W. Territory.

Constituents in 1000 Parts, by Weight, of Water

Constituents.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Chloride of potassium	2·473	2·879	1·887	1·992	1·158	2·473	2·099	0·685	0·319	1·916	1·587	2·253
" sodium	51·005	46·781	53·155	50·408	80·970	51·005	26·192	18·941	42·780	44·626	38·466	47·114
" calcium	.....	.....	.....	0·108	.....	.....	0·219	.....	0·608	0·144	0·394	.....
" magnesium	1·176	1·399	0·649	1·299	1·686	1·120	1·116	0·823	1·963	1·077	1·401	1·061
Sulphate of lime	4·185	4·073	3·733	4·121	5·715	4·240	2·873	2·880	3·488	3·891	3·237	3·930
" magnesia	0·089	0·017	0·784	.....	0·261	0·151	.....	0·154	.....	.....	.....	0·047
Total	58·928	55·149	60·208	57·928	89·790	58·989	32·499	23·483	49·158	51.654	45·085	54·405
Specific gravity	1·041	1·039	1·044	1·041	1·063	1·039	1·022	1·016	1·035	1·035	1·031	1·039

Grains of Saline Constituents in One Imperial Gallon of Water.

Chloride of potassium	180·21	209·39	137·90	145·16	86·17	179·86	150·16	48·72	23·11	138·81	114·59	163·86
" sodium	3716·73	3402·38	3884·57	3673·23	6024·98	3709·59	1873·78	1347·08	3099·41	3233·15	2777·44	3426·61
" calcium	.....	.....	.....	7·87	.....	.....	15·67	.....	44·05	10·43	28·45	.....
" magnesium	85·69	101·75	47·43	94·66	125·46	81·46	79·84	58·53	142·22	78·03	101·16	77·17
Sulphate of lime	304·96	296·23	272·81	300·30	425·25	308·38	205·53	204·83	252·71	281·90	233·73	285·83
" magnesia	6·49	1·24	57·30	.....	19·42	10·98	.....	10·95	.....	.....	.....	3·42
Total	4294·08	4010·99	4400·01	4221·22	6681·28	4290·27	2324·98	1670·11	3561·50	3742·32	3255·37	3956·89

Natural waters-*Con.*

The proportion of foreign saline matters in these brines is not excessive, and if certain purifying processes are had recourse to, there is no reason—local conditions being favourable—why they should not be utilized in the manufacture of salt.

Outline of methods pursued in the preparation of salt from its solutions.

The following brief outline of the methods pursued in the preparation of salt from its solutions, will serve to convey some idea of the expedients resorted to for the economical treatment of the weaker salt waters. The processes may be arranged under the following headings: 1. Those in which the evaporation is entirely effected by artificial heat; 2. Those dependent upon natural evaporation—either wholly or in part; 3. That in which concentration is effected by congelation—with subsequent recourse to artificial heat.

By artificial evaporation.

1. By artificial evaporation.

The manufacture of salt from its solutions by evaporation with artificial heat, is conducted either in large shallow iron pans—as in Cheshire, Worcestershire and Staffordshire,—or in kettles—as at the Onondaga salines, and elsewhere. The heating in both instances being effected by fires placed beneath.

By natural evaporation.

2. By natural evaporation—either wholly or in part.

(*a.*) By the influence of the sun, aided by that of the air—solar evaporation. This method is resorted to in the preparation of salt from sea water, on the shores of the Mediterranean, some parts of the English and Scottish coasts, and in some localities on the Atlantic and Pacific coasts of the United States. The evaporation is carried on in a series of shallow ponds or basins in which the water is spread over a very large surface. These reservoirs, which are excavated on the sea shore, are generally puddled with clay, but on the Bay of San Francisco the better grade of salt is prepared in ponds which are provided with wooden floors or wholly inclosed with boards, and when a specially pure salt is required, the cleanest of the brine is transferred to, and the evaporation completed in, wooden tanks. When solar evaporation is pursued in the manufacture of salt from natural brines, the process is conducted in a series of shallow wooden vats, arranged in tiers, provided with movable covers running upon rollers for use during rainy weather. The brine is let into the upper tier of vats and from thence is allowed, at different stages of alteration, to pass on until it ultimately arrives—having in the interval deposited suspended and nearly all the less soluble impurities, and lost a large proportion of its water by evaporation—as a clear saturated brine, in the lower tier of vats where the formation of salt goes on.

(*b.*) By exposure to a current of air—the "graduation" process. A method employed, among other places, at Moutiers in France, and at

Nauheim, Dürrenberg, Rodenberg, and Schönebeck, in Germany, in the preparation of salt from weak brines. The process is carried on in what are termed "graduation-houses." These are large wooden structures covered over at the top to exclude rain, but left open at the sides to allow of free circulation of air through the building. The interior arrangements may, in a general way, be described as consisting of a large shallow wooden cistern, for the reception of the brine, over which are arranged bundles of brushwood or thorns built up in the form of a wall between wooden supports, and over this a reservoir for the weak brine. The saline water is pumped into the upper reservoir and thence allowed to trickle down over the surface or through the interstices of the thorns, thereby exposing it, diffused over a very large surface, to the influence of the air and effecting its concentration. The operation is repeated as often as may be found necessary for the conversion of the weak into a strong brine.

Natural waters–*Con.*

Outline of methods pursued in the preparation of salt from its solutions–*Con.*

By natural evaporation *Con.*

The success of these two processes, solar evaporation and "graduation," being altogether dependent upon the state of the atmosphere, their use is consequently limited to the more favourable time of the year.

3. By congelation.

By congelation.

In some parts of northern Europe the separation of salt from sea water is, in part, effected by the agency of frost—salt water when partially frozen separating into ice, retaining very little salt, and a proportionately strong saline liquor. So that by submitting sea water, contained in reservoirs, to repeated partial congelations and removing the ice as it forms, each successive mother liquor becomes more and more impregnated with salt, until at length the solution attains the strength of a saturated brine.

The process dependent upon evaporation with artificial heat is usually only resorted to in the treatment of strong brines, but where cheap fuel can be obtained the same plan is pursued with the waters of the weaker springs and sometimes, though rarely, even with sea water. When fuel is scarce the more dilute saline waters cannot be profitably worked in this way, and these can, therefore, only be utilized by resorting to one of the processes of natural evaporation—solar evaporation or that by "graduation." The salt may, by either of these methods, be prepared without the aid of artificial heat, as is customary in the preparation of "bay-salt" and "solar-salt," and is also the practice at the "graduation works" at Moutiers, in France, or the weak brine may be brought to the point of saturation and further evaporation effected with artificial heat. The concentrated liquor obtained by the repeated partial freezing of a weak salt water is treated as a strong brine, the salt being obtained from it by artificial evaporation.

Iron ores.

IRON ORES.

Magnetite from Pine Creek, Waterton River, British Columbia.

1.—Magnetite. From Pine Creek, Waterton River, fifteen miles from forks of North Fork and Waterton River, British Columbia. Examined for Mr. John Herron.

Massive, very fine crystalline; colour, greyish-black. Mr. Wait found it to contain:

Metallic iron	55·62 per cent.
Insoluble matter	9·36 "
Titanic acid	trace.

Magnetite from location 400 R., Atic-okan River, Ontario.

2.—Magnetite. From location 400 R., Atic-okan River, Rainy River district, province of Ontario. This, and the five following specimens were collected by Dr. A. C. Lawson (Survey).

A massive magnetite. Determinations by Mr. Johnston gave:

Metallic iron	68·03 per cent.
Titanic acid	none.

Magnetite from location 402 R., Atic-okan River, Ontario.

3.—Magnetite. From location 402 R., Atic-okan River, Rainy River district, province of Ontario.

Massive, fine-granular. Mr. Johnston found it to contain:

Metallic iron	68·58 per cent.
Titanic acid	none.

Magnetite from location 403 R., Atic-okan River, Ontario.

4.—Magnetite. From location 403 R., Atic-okan River, Rainy River district, province of Ontario.

A fine-granular magnetite. Examined by Mr. Johnston it was found to contain:

Metallic iron	64·55 per cent.
Titanic acid	none.

Magnetite from Sabawy Lake, Atic-okan River, Ontario.

5.—Magnetite. From two miles and a-half west of Sabawy Lake, Atic-okan River, Rainy River district, province of Ontario.

A massive magnetite. It was found by Mr. Johnston to contain:

Metallic iron	67·42 per cent.
Titanic acid	trace.

Magnetite from line between locations 10 and 11 E., Atic-okan River, Ontario.

6.—Magnetite. From line between locations 10 E. and 11 E., Atic-okan River, Rainy River district, Province of Ontario.

Massive, fine-granular. Determinations by Mr. Johnston gave:

Metallic iron	65·71 per cent.
Titanic acid	none.

Iron ores—*Con.*

Hematite from Black Sturgeon Lake, Ontario.

7.—Hematite. An iron-black hematite from the south-east end of Black Sturgeon Lake, district of Thunder Bay, province of Ontario.

Agreeably with the results of an examination by Mr. Johnston, it contained :

Metallic iron	47·17 per cent.
Titanic acid	none.

Hematite from Sunnybrae, Pictou county, Nova Scotia.

8.—Hematite. A sample of hematite from the vicinity of Sunnybrae, a mile and a-quarter north of the East River, Pictou county, Nova Scotia, examined by Mr. Johnston, was found to contain :

Metallic iron	50·63 per cent.
Phosphorus	0·26 "

Hematite from Bastard, Leeds county, Ontario.

9.—Hematite. From the township of Bastard, Leeds county, province of Ontario. The specimen, which was examined for Mr. Smith Curtis, was found, by Mr. Johnston, to contain :

Metallic iron	65·98 per cent.

NICKEL AND COBALT ORES.

Nickel and cobalt ores.

Pyrrhotite from Barrachois Harbour, Cape Breton county, Nova Scotia.

1.—Pyrrhotite. From the property of R. J. Nicholson, at Barrachois Harbour, Cape Breton county, Nova Scotia. Examined for Mr. Alex. McLeod.

The pyrrhotite, which was free from gangue, was examined by Mr. Johnston and found to contain :

Nickel	trace.
Cobalt	none.

Pyrrhotite from near St Stephen, Charlotte county, New Brunswick.

2.—Pyrrhotite. From what is stated to be an extensive deposit, three miles north of St. Stephen, Charlotte county, New Brunswick.

The material consisted of pyrrhotite, through which was disseminated a little copper-pyrites and a very small amount of quartzose gangue. A partial analysis, by Mr. Johnston, gave as follows :—

Nickel	1·72 per cent.
Cobalt	0·16 "
Copper	0·31 "

or—calculated upon the material free from all gangue :

Nickel	1·82 per cent.
Cobalt	0·17 "
Copper	0·33 "

Nickel and cobalt ores—*Con.*

Another sample of ore from this locality consisted of pyrrhotite, in a gangue composed of diorite and white sub-translucent quartz.

Pyrrhotite from L'Etete, Charlotte county, New Brunswick.

3.—Pyrrhotite. From L'Etete, Charlotte county, New Brunswick.

The sample consisted of pyrrhotite, with a little copper-pyrites, in a gangue of diorite. The pyrrhotite was found, by Mr. Johnston, to contain both nickel and cobalt. The material would appear to be precisely similar to that from the vicinity of St. Stephen. Both closely resemble much of the ore found in the Sudbury district, province of Ontario.

Pyrrhotite from Lake Mistassini, province of Quebec.

4.—Pyrrhotite. From the vicinity of Lake Mistassini, province of Quebec. Collected by Mr. Walter McOuat (Survey) in 1872.

The pyrrhotite, which was in a gangue of hornblendic schist, constituted seventy-three per cent, by weight, of the whole. Mr. Johnston found it to contain :

Nickel	distinct trace.
Cobalt	distinct trace.

Pyrrhotite from Potton, Brome county, province of Quebec.

5.—Pyrrhotite. From Lake Memphremagog mine, lot twenty-four, range eighteen, of the township of Potton, Brome county, province of Quebec. Collected by Dr. R. W. Ells (Survey).

There were two samples—the one consisted of an association of pyrrhotite, copper-pyrites, and iron-pyrites, through which was disseminated a small amount of gangue. The pyrrhotite constituted, approximately, seventy-seven, and the copper and iron-pyrites, about twenty per cent, by weight, of the whole. The other sample consisted almost exclusively of pyrrhotite ; copper and iron-pyrites were present but only in very small quantities. The pyrrhotite of both samples was examined by Mr. Johnston, and found to contain—the former, a very small amount, the latter, a trace, of nickel.

Pyrrhotite from Clarendon, Pontiac county, province of Quebec.

6.—Pyrrhotite. From lot twenty-four, range seven, of the township of Clarendon, Pontiac county, province of Quebec. Examined for Mr. W. A. Allan. The material does not, so far as is known, occur in quantity.

The pyrrhotite, which was free from gangue, was found by Mr. Johnston to contain :

Nickel	1·50 per cent.
Cobalt	trace.

7.—Pyrrhotite. From location W. 7, east side of Waddell's Lake, district of Nipissing, Ontario. This, and the following specimen, was collected by Dr. R. Bell (Survey). Nickel and cobalt ores *Con.*

An association of a somewhat coarse granular pyrrhotite with a small quantity of copper-pyrites, in a gangue of greyish-green diorite. An analysis, by Mr. Johnston, showed it to contain: Pyrrhotite from Waddell's Lake, Ontario.

Nickel	2·00 per cent.
Cobalt	none.

The gangue constituted, approximately, forty per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, about 3·3 per cent nickel.

8.—Pyrrhotite. From Boucher's mine, north-east side of Lake Wahnapitae, district of Nipissing, Ontario. Pyrrhotite from Lake Wahnapitae, Ontario.

An intimate association of copper-pyrites and pyrrhotite, in a gangue of greyish-green diorite. Determinations by Mr. Johnston gave:

Nickel	1·57 per cent.
Cobalt	none.

The gangue constituted, approximately, twenty-five per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, about 2·1 per cent nickel.

9. Pyrrhotite. From McCormick's mine, north-west corner of lot twelve, range three, of the township of Neelon, district of Nipissing, Ontario. Collected by Mr. A. E. Barlow (Survey). Pyrrhotite from Neelon, Ontario.

A somewhat coarse granular pyrrhotite, associated with small quantities of copper-pyrites. Agreeably with the results of determinations made by Mr. Johnston, it contained:

Nickel	3·10 per cent.
Cobalt	trace.

10.—Pyrrhotite. From two miles north of the township of Lumsden, on the boundary line between the district of Nipissing and Algoma, Ontario. Examined for Mr. Christie Crites. Pyrrhotite from Lumsden, Ontario

The material consisted of pyrrhotite in association with small quantities of dark green diorite. The pyrrhotite, free from gangue, was found, by Mr. Wait, to contain, approximately:

Nickel	2·7 per cent.
Cobalt	none.

Nickel and cobalt ores—*Con.*

11.—Pyrrhotite. From O'Connor's claim, lot eleven, range five, of the township of Lorne, district of Algoma, Ontario. Collected by Mr. A. E. Barlow (Survey).

Pyrrhotite from Lorne, Ontario.

It consisted of pyrrhotite, together with a trifling amount of copper-pyrites, in association with a greyish-green diorite. The latter constituted but a small proportion, by weight, of the whole. Determinations by Mr. Johnston gave :

Nickel	1·95 per cent.
Cobalt	none.

Pyrrhotite from Lorne, Ontario.

12.—Pyrrhotite. Another sample of material from the township of Lorne, consisting of pyrrhotite, together with a little copper-pyrites, in a gangue of greyish-green diorite, was found by Mr. Johnston to contain :

Nickel	1·57 per cent.
Cobalt	none.

The gangue constituted thirty-three per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, about 2·3 per cent nickel.

Pyrrhotite from Nairn, Ontario.

13.—Pyrrhotite. From O'Connor's claim, lots one and two, range three, of the township of Nairn, district of Algoma, Ontario. This, and the following specimen, was collected by Mr. A. E. Barlow (Survey).

The material consisted of pyrrhotite in association with a greyish-green diorite. The latter constituted but a small proportion, by weight, of the whole. An analysis, by Mr. Johnston, showed it to contain :

Nickel	1·95 per cent.
Cobalt	trace.

Pyrrhotite from Drury, Ontario.

14.—Pyrrhotite. From Messrs. Loughran and Dwyer's claim, lot three, range three, of the township of Drury, district of Algoma, Ontario.

An association of pyrrhotite with a little copper-pyrites, through which was disseminated a trifling amount of a quartzose gangue. Agreeably with determinations conducted by Mr. Johnston, it contained :

Nickel	2·01 per cent.
Cobalt	trace.

Pyrrhotite from Denison, Ontario.

15.—Pyrrhotite. From the south half of lot six, range two, of the township of Denison, district of Algoma, Ontario. This, and the five following specimens, were collected by Dr. R. Bell (Survey).

A somewhat coarse granular pyrrhotite, through which was disseminated a small amount of quartzose gangue. Determinations by Mr. Johnston gave : Nickel and cobalt ores—*Con.*

Nickel	1·55 per cent.
Cobalt	none.

Pyrrhotite from Denison, Ontario—*Con.*

The gangue constituted twelve and a-half per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, about 1·8 per cent nickel.

16.—Pyrrhotite. From lot seven, range two, of the township of Levack, district of Algoma, Ontario. Pyrrhotite from Levack, Ontario.

A somewhat coarse granular pyrrhotite, through which was disseminated a quartzose gangue. Mr. Johnston found it to contain :

Nickel	2·36 per cent.
Cobalt	trace.

The gangue amounted to twenty-two per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, about 3·0 per cent nickel.

17.—Pyrrhotite. Also from lot seven, range two, of the township of Levack, district of Algoma, Ontario. Pyrrhotite from Levack, Ontario.

A very coarse granular pyrrhotite, free from gangue, was found by Mr. Johnston to contain :

Nickel	4·13 per cent.
Cobalt	none.

18.—Pyrrhotite. From lot three, range four, of the township of Levack, district of Algoma, Ontario. Pyrrhotite from Levack, Ontario.

A somewhat coarse granular pyrrhotite, together with a very small amount of copper-pyrites, in association with a greyish-green diorite. Determinations, conducted by Mr. Johnston, gave :

Nickel	1·96 per cent.
Cobalt	trace.

The gangue constituted eighteen and a-half per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, about 2·4 per cent nickel.

19.—Pyrrhotite. From the Ross mining location, three miles north of the northern township-line of the township of Morgan, district of Algoma, Ontario. Pyrrhotite from Morgan, Ontario.

A coarse granular pyrrhotite, with which was associated a small amount of copper-pyrites. The gangue was not readily discernible.

Nickel and cobalt ores—*Con.*

Agreeably with the results of determinations made by Mr. Johnston, it contained:

Pyrrhotite from Morgan, Ontario—

Nickel	2·75 per cent.
Cobalt	none.

The gangue constituted sixteen and a-half per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, about 3·3 per cent nickel.

Pyrrhotite from Creighton, Ontario.

20.—Pyrrhotite. From the property of Mr. James Stobie, on lot ten, range four, of the township of Creighton, district of Algoma, Ontario.

The material consisted of coarse granular pyrrhotite, in association with some zinc-blende, through which was disseminated a somewhat small amount of a dark grey schistose rock and white quartz. It was examined by Mr. Johnston and found to contain neither nickel nor cobalt. The gangue constituted sixteen per cent, by weight, of the whole.

Nickeliferous ore from Vermilion mine, Denison, Ontario.

21.—Nickeliferous ore from the Vermilion mine, lots five and six, range four, of the township of Denison, district of Algoma, Ontario. This, and the following specimen, was presented to Mr. A. E. Barlow by Mr. F. L. Sperry. The material was, in both instances, merely intended to represent certain portions of the ore occurring at this mine.

It consisted of an association of chalcocite and chalcopyrite, through which was disseminated some polydymite. Some of the fragments were coated and seamed with green carbonate of copper.

Agreeably with the results of determinations by Mr. Johnston, it contained:

Nickel	9·40 per cent.
Cobalt	none.

Nickel ore from Vermilion mine, Denison, Ontario.

22.—Nickel ore from the Vermilion mine—same locality as the preceding specimen (*see* remarks made in connection therewith).

The material consisted of polydymite, together with a little chalcopyrite, in a gangue composed of diorite and small quantities of a white translucent quartz. Carefully selected material—which, however, it was ultimately found still contained a little intermixed gangue and chalcopyrite—was found by Mr. Johnston, to contain:

Nickel	40·80 per cent.
Cobalt	none.

Conformably with the results of an examination by F. W. Clarke and C. Catlett, who were the first to point out its occurrence in the ore of this mine, the mineral here met with is a ferriferous variety of the polydymite of Laspeyres and has, when free from all foreign admixture, the following composition—nickel 43·18, iron 15·47, sulphur 41·35 = 100·00. Nickel and cobalt ores—*Con.*

23.—Cobaltiferous arsenopyrite. A cobaltiferous mispickel containing 4·09 per cent of cobalt and 0·93 per cent of nickel, has been found in the workings of a nickeliferous pyrrhotite deposit on the north half of lot six, in the third range of the township of Graham, district of Algoma, Ontario. The complete analysis of this mineral is given under "Miscellaneous minerals" (No. 5, Danaite), *ante*. Cobaltiferous arsenopyrite from Graham, Ontario.

It cannot, at present, be conjectured as to whether much of this ore is likely to be met with or not—should it occur in quantity it could be made available as a source of cobalt.

24.—Niccolite and Gersdorffite. From O'Connor's claim on lot twelve of the third range of the township of Denison, district of Algoma, Ontario. Collected by Mr. A. E. Barlow (Survey). Niccolite and Gersdorffite from Denison, Ontario.

The material was not intended to represent an average of any portion of the ore of this claim—on the contrary, it was so selected as to ensure the obtaining of the best procurable specimens of the minerals in question. The sample, which was made up of some sixteen fragments and weighed, in the aggregate, twelve pounds and a quarter, may be described, as a whole, as consisting of an association of a light to dark green, fine grained, diabase with small quantities of a dark green chloritic, and a little light greenish-grey micaceous, schist, small quantities of a greyish-white to white translucent quartz and a trifling amount of calcite—containing, in parts, chalcopyrite, a little pyrrhotite, niccolite and, more or less intimately associated with the latter, Gersdorffite. No analysis was made of the niccolite. This, when pure, contains in one hundred parts 44·1 of nickel and 55·9 of arsenic; part of the arsenic being sometimes replaced by antimony. The Gersdorffite, however, was, in view of the fact that this mineral often varies greatly in its composition, submitted to analysis and found to contain 26·32 per cent of nickel and 2·01 per cent of cobalt. The complete analysis is given under "Miscellaneous minerals" (No. 9), *ante*.

25.—Pyrrhotite. From the township of Clarendon, Frontenac county, Ontario. Pyrrhotite from Clarendon, Ontario.

Nickel and cobalt ores—*Con.*

A greyish-white gneissoid rock through which was disseminated a somewhat large amount of pyrrhotite. Agreeably with the results of determinations by Mr. Johnston, it contained:

Pyrrhotite from Clarendon, Ontario—*Con.*

Nickel	trace.
Cobalt	0·20 per cent.

The gangue amounted to sixty per cent, by weight, of the whole. The metallic portion of the ore contained therefore, about 0·5 per cent of cobalt.

Pyrrhotite from near Schreiber, Ontario.

26.—Pyrrhotite. From an extensive deposit two miles west of Schreiber, on the line of the Canadian Pacific Railway, district of Thunder Bay, Ontario. Examined for Mr. Thomas Mark.

A massive pyrrhotite, free from gangue. On examination, by Mr. Johnston, it was found to contain:

Nickel	0·03 per cent.
Cobalt	trace.

Pyrrhotite from near Schreiber, Ontario.

27.—Pyrrhotite. From the same locality as the preceding specimen. A fair average sample, collected by Dr. A. R. C. Selwyn. The material consisted of a fine granular, massive pyrrhotite, through which was disseminated a little quartzose gangue. The latter constituted, approximately, ten per cent, by weight, of the whole. Mr. Johnston found it to contain:

Nickel	trace.
Cobalt	trace.

Pyrrhotite from Darlington Bay, Lake of the Woods, Ontario.

28.—Pyrrhotite from Darlington Bay, Lake of the Woods, district of Rainy River, Ontario. Examined for Mr. Mather.

Consisted of pyrrhotite in association with a dark grey gneissoid rock. The latter constituted, approximately, twenty per cent, by weight, of the whole. It was found on examination by Mr. Johnston, to contain:

Nickel	trace.
Cobalt	trace.

Pyrrhotite from Barclay Sound, Vancouver Island, British Columbia.

29.—Pyrrhotite. From near the head of Barclay Sound, Vancouver Island, British Columbia. Examined for Capt. J. Jaques.

A massive pyrrhotite from this locality has been examined by Mr. Johnston, and found to contain:

Nickel	trace.
Cobalt	trace.

30.—Pyrrhotite. From Monashee mine, Monashee Mountain, near the head of Cherry Creek, British Columbia. Collected by Dr. G. M. Dawson (Survey). Nickel and cobalt ores—*Con.*

An association of white sub-translucent quartz and dark green diorite, carrying large quantities of pyrrhotite and a little copper-pyrites. On examination, by Mr. Johnston, it was found to contain: Pyrrhotite from Monashee Mountain, British Columbia.

Nickel	none.
Cobalt	trifling amount.

It may not be amiss to draw attention here to certain other nickel and cobalt ores, or minerals containing a noteworthy amount of one or the other of these metals, which have from time to time been met with in Canada in the course of this Survey's work. Occurrence of nickel and cobalt ores in other parts of Canada.

One of these, described as a steel-grey pyritous ore, from the Wallace mine on Lake Huron, was found by Dr. T. S. Hunt to contain 13·93 per cent of nickel. Of two others found on Michipicoten Island, Lake Superior, the one was shown by Dr. Hunt to be an intimate mixture of the arseniurets of copper and nickel; different portions of the same mass affording him from 17·03 to 36·39 per cent of nickel, whilst the other, also examined by Dr. Hunt, proved to be a hydrated silicate of nickel which, after drying at 100°C., was found by him to contain 30·40 per cent oxide of nickel (equivalent to 23·91 per cent nickel). The arsenide of nickel, which for present purposes may be regarded as consisting of 44·1 of nickel and 55·9 of arsenic, has also been found at the 3A mine, on lot 3A of the township of McGregor, district of Thunder Bay, where it occurs in somewhat large nodular grains and nugetty bunches, together with native silver, of a similar form, freely disseminated through a gangue of calcspar with some quartz. The foregoing are all rich ores of nickel, and should the deposits on further exploration be found to yield a sufficiency of the material these would, as available sources of this metal, prove of economic importance,

Less important, by reason of their occurring only in limited quantity or as containing but a relatively small amount of nickel or cobalt, are the following:—Millerite or nickel sulphide, a rich and valuable ore of nickel, occurs in small grains and prismatic crystals disseminated through a mixture of chrome-garnet and calcspar in a vein on the east side of Brompton Lake, in the township of Orford, province of Quebec. It is also reported to have been observed, in the form of prismatic crystals, disseminated through certain portions of the nickeliferous ore of the Copper Cliff mine, in the township of McKim, district

Nickel and cobalt ores–*Con.*

Occurrence of nickel and cobalt ores in other parts of Canada–*Con.*

of Nipissing, Ontario. Erythrite or hydrous cobalt arsenate, a valuable ore of cobalt when met with in quantity, is mentioned by Dr. Hunt as occurring in rose-red incrustations on calcareous spar at Prince's mine on Lake Superior. Smaltite, a cobalt arsenide, was oberved by Mr. E. B. Kenrick in the form of minute crystals in a sample of copper pyrites (brought to the Survey for examination) from the township of McKim, district of Nipissing, Ontario. A sample of iron-pyrites from the seigniory of Daillebout, Joliette county, province of Quebec, was found by Dr. Hunt to contain 0·55 per cent of oxide of nickel (equivalent to 0·43 nickel) mixed with cobalt, and a brilliant compact variety of iron-pyrites from Elizabethtown, Leeds county, Ontario, yielded him from 0·5 to 0·6 per cent oxide of cobalt (equivalent to 0·39 to 0·47 cobalt), whilst a sample of iron-pyrites from Londonderry, Nova Scotia, was found by me (Rep. Geol. Surv. Can., 1874–75, p. 316) to contain 0·81 per cent of cobalt and 0·14 per cent of nickel.

Gold and silver assays.

GOLD AND SILVER ASSAYS.

These were, with but one exception (No. 36), all conducted by Mr. R. A. A. Johnston.

Province of Nova Scotia.

Province of Nova Scotia

1.—From the Caledonia gold-field, Queen's county.

The material, which consisted of finely crushed tailings, was found, on assay, to contain :

Gold.....	0·073	of an ounce to the ton of 2,000 lbs.
Silver.....	0·131	" " "

2.—From the farm of Donald McDonald, North River, St. Ann's, Victoria county. Examined for Mr. B. E. Tremaine.

White sub-translucent quartz carrying a somewhat large amount of zinc-blende, and small quantities of galena, copper-pyrites and iron-pyrites. The sample, which consisted of four pieces, weighed twelve ounces. Assays gave :

Gold.....	trace.
Silver.....	0·467 of an ounce to the ton of 2,000 lbs.

3.—From the farm of John McDonald. Same locality as the preceding specimen. Examined for Mr. B. E. Tremaine.

Consisted of an association of white sub-translucent quartz and iron-pyrites. Weight of sample, one pound three ounces. It contained : Gold and silver assays—*Con.*

Gold..... trace.
Silver..... 0·583 of an ounce to the ton of 2,000 lbs.

Province of Nova Scotia—*Con.*

4.—From railway cutting at mouth of Bear River, Digby county. Examined for Mr. H. F. Sims.

A quartzo-felspathic rock carrying zinc-blende and copper-pyrites. The sample, which consisted of numerous fragments, weighed thirteen ounces.

It contained neither gold nor silver.

5.—From the same locality as the last mentioned, and examined for the same person.

A white to greyish-white sub-translucent quartz carrying large quantities of zinc-blende and copper-pyrites. It was found to contain :

Gold..... trace.
Silver..... trace.

6.—This, and the following specimen, is from the Brookfield gold-field, Colchester county.

Specimen from near barytes pit, Brookfield. A somewhat ferruginous quartz conglomerate. Weight of sample, two pounds two ounces.

It contained neither gold nor silver.

7.—Specimen from three hundred yards above old mill, Pembroke. A coarse quartz conglomerate. Weight of sample, two pounds twelve ounces.

It contained neither gold nor silver.

Province of New Brunswick.

Province of New Brunswick.

8.—From a vein on Millstream, about two miles from the iron ore deposit, fifteen miles from Bathurst, and about seven miles in a direct line from the line of the Intercolonial Railway, Gloucester county. Examined for Mr. W. R. Payne.

It consisted of iron-pyrites, together with small quantities of galena, and, apparently, trifling amounts of mispickel, in a gangue composed of white to grey, sub-translucent quartz, and a little

Gold and silver assays *Con.*

dark grey shale. A fair average of this particular specimen—which weighed eleven pounds—was found, on assay, to contain :

Gold..... 0·175 of an ounce to the ton of 2,000 lbs.
Silver..... 9·450 ounces " "

Province of Quebec.

PROVINCE OF QUEBEC.

9.—From lot twenty-five, range three, of the township of Ascot, Sherbrooke county. Examined for Mr. J. A. Chicoyne.

An association of a greenish-grey chloritic schist and dolomite, carrying a very large quantity of iron-pyrites.

It contained neither gold nor silver.

10.—From the Garthby mine, township of Garthby, Wolfe county.

A fine grained iron-pyrites through which was disseminated a small quantity of copper-pyrites. Weight of sample, two pounds. It was found to contain :

Gold..... very distinct trace.
Silver..... trace.

11.—From lot nine, range nine, of the township of Wakefield, Ottawa county. Examined for the Rev. C. Gay.

A bluish-white to white, opalescent quartz, through which was disseminated a few grains of iron-pyrites and a few scales of yellowish-white mica. The specimen was more or less seamed with hydrated peroxide of iron. Assays gave :

Gold..... trace.
Silver..... none.

12.—From lot twenty-seven, Kennebec road, of the township of Linière, Beauce county. Examined for Mr. L. G. Gendreau.

A white sub-translucent quartz, carrying appreciable quantities of iron-pyrites, and small quantities of copper-pyrites and galena. Weight of sample, one pound four ounces. Assays showed it to contain :

Gold..... none.
Silver..... 34·767 ounces to the ton of 2,000 lbs.

13.—From a seam traversing a vein of green apatite on lot eleven, range five, of the township of Templeton, Ottawa county. Examined for Mr. Hector McRae.

The iron-pyrites, which composes the seam in question, freed from gangue, was found, on assay, to contain : Gold and silver assays *Con.*

Gold..... trace.
Silver..... none.

Province of Ontario.

Province of Ontario.

14.—From Hybla, Hastings county. Examined for Mr. G. Bartlett.

An association of iron-pyrites and magnetic-pyrites, in a gangue composed of calcite and white sub-translucent quartz. The gangue constituted but a small proportion, by weight, of the whole. Weight of sample, two pounds ten ounces.

It contained neither gold nor silver.

15.—From lot nineteen, range three, of the township of Darling, Lanark county. Examined for Mr. R. McGregor.

White sub-translucent quartz carrying small quantities of iron-pyrites. The quartz was more or less honeycombed ; the cavities containing hydrated peroxide of iron. The sample, consisting of two pieces, weighed seven ounces.

It contained neither gold nor silver.

16.—From the property of the Anglo-Canadian Phosphate Company, north-east corner of lot three, range eight, of the township of North Burgess, Lanark county. Examined for Capt. R. C. Adams.

A white pegmatite, composed of felspar and quartz, containing a few grains of iron-pyrites. The sample, consisting of one piece, weighed, two pounds ten ounces.

It contained neither gold nor silver.

17.—From lot twenty-five, range five, of the township of Darling, Lanark county. Examined for Mr. R. McGregor.

A white sub-translucent to dark grey quartz, with which was associated a small quantity of magnetite. It carried large quantities of iron-pyrites and small quantities of magnetic-pyrites, copper-pyrites and bornite. The sample, consisting of eight fragments, weighed seventeen ounces. Assays gave :

Gold..... distinct trace.
Silver..... none.

Gold and silver assays–*Con.*

Province of Ontario–*Con.*

18.—From the west half of lot twenty-two, range four, of the township of Darling, Lanark county. Examined for Mr. J. Craig.

An association of white sub-translucent quartz with a white fine grained dolomite, carrying small quantities of bournonite and copper-pyrites. The sample, composed of three pieces, weighed seven ounces and a-half. It was found to contain :

Gold..... 0·116 of an ounce to the ton of 2.000 lbs.
Silver..... 5·176 ounces " "

19.—From lot seven, range four—near east line, half a mile from south-east corner post—of the township of Drury, district of Algoma.

A greyish-white quartz, more or less stained with hydrated peroxide of iron, carrying a somewhat large amount of copper-pyrites. The sample, which consisted of eight fragments, weighed fourteen ounces and a-half. It was found to contain :

Gold ..... trace.
Silver..... .... 0·583 of an ounce to the ton of 2,000 lbs.

20.—This, and the seven following specimens are from lot thirty-two, range two, of the township of Chandos, Peterborough county. They were examined for Mr. C. P. Cameron.

Copper-pyrites in a gangue of coarsely crystalline limestone. It contained :

Gold ..... distinct trace.
Silver.... .... 0·233 of an ounce to the ton of 2,000 lbs.

21.—Copper-pyrites together with a little iron-pyrites, in a gangue of coarsely crystalline limestone. Assays gave :

Gold..... distinct trace.
Silver.... ..... 0·933 of an ounce to the ton of 2,000 lbs.

22.—Grey felstone carrying small quantities of copper-pyrites. It was found to contain :

Gold..... trace.
Silver..... .... 0·116 of an ounce to the ton of 2,000 lbs.

23.—A more or less weathered felstone, carrying small quantities of iron-pyrites. Assays showed it to contain :

Gold..... trace.
Silver..... none.

24.—An association of limestone and felstone, carrying small quantities of copper-pyrites. Assays gave:

Gold ..... distinct trace.
Silver..... 0·291 of an ounce to the ton of 2,000 lbs.

25.—Iron-pyrites in a gangue composed of white, coarse crystalline calcite and grey felstone. It contained:

Gold..... trace.
Silver..... none.

26.—An association of white limestone and grey felstone together with a little mica, through which was disseminated small quantities of iron-pyrites. It was found to contain;

Gold..... trace.
Silver..... 0·116 of an ounce to the ton of 2,000 lbs.

27.—A slightly calcareous gneissoid rock, through which was disseminated a few scales of graphite.

It contained neither gold nor silver.

28.—From the vicinity of Algoma Mills, township of Long, district of Algoma. Examined for Mr. W. A. Allan.

An association of white sub-translucent quartz with small quantities of greyish-green chloritic schist, more or less stained and coated with hydrated peroxide of iron, carrying small quantities of iron-pyrites, copper-pyrites and bornite. It was found on assay to contain:

Gold..... trace.
Silver..... 0·233 of an ounce to the ton of 2,000 lbs.

29.—From ten miles north of Schreiber, on the line of the Canadian Pacific Railway, district of Thunder Bay, Lake Superior. This, and the following specimen, was examined for Sir James Grant.

Consisted of an association of dark green chloritic schist, with white sub-translucent quartz and a little felspar, carrying small quantities of zinc-blende and galena, and a little copper-pyrites. Weight of sample, which consisted of six pieces, fourteen ounces. Assays showed it to contain:

Gold..... none.
Silver..... 0·117 of an ounce to the ton of 2,000 lbs.

Gold and silver assays—*Con.*

Province of Ontario—*Con.*

30.—From the same locality as the last.

A greyish-white dolomitic limestone, through which was disseminated small quantities of iron-pyrites. The sample, consisting of eight fragments, weighed one pound thirteen ounces. It was found to contain:

Gold... ..... 0·117 of an ounce to the ton of 2,000 lbs.
Silver..... 0·583 " " "

31.—From the north-east quarter of lot three, range three, of the township of McGregor, district of Thunder Bay, Lake Superior. This, and the three following specimens, were examined for Mr. A. L. Bain.

A greyish-white quartz, through which was disseminated a somewhat large amount of iron-pyrites. The quartz was, in parts, cavernous, the cavities holding a yellowish and reddish-brown coloured ochre. Weight of sample, one pound three ounces. It contained:

Gold..... trace.
Silver..... 0·406 of an ounce to the ton of 2,000 lbs.

32.—From lot six, Donelly's survey, of the township of McTavish, district of Thunder Bay, Lake Superior.

An association of white, greyish and amethystine quartz with a small quantity of a reddish coloured barite, carrying small quantities of copper-pyrites and a little galena. Weight of sample, one pound nine ounces. Assays gave:

Gold..... trace.
Silver..... 0·173 of an ounce to the ton of 2,000 lbs.

33.—From the same locality as the last, but from a different vein.

A fine crystalline galena in a gangue composed of white sub-translucent quartz and reddish coloured felspar. Weight of sample, one pound fourteen ounces. It was found to contain:

Gold..... none.
Silver..... 0·729 of an ounce to the ton of 2,000 lbs.

34.—From the same locality, but from a different vein, to the two preceding.

An association of calcite and white sub-translucent, together with a little amethystine quartz, carrying small quantities of zinc-blende. Weight of sample, six ounces. Assays showed it to contain:

Gold..... trace.
Silver..... trace.

Province of British Columbia.

Gold and silver assays—*Con.*

Of the following—

Specimens Nos. 35–47 are from the East Kootanie district.
" *48–52* " *West* "
" *53–81* " *Interior plateau region*
" *82–88* " *Coast Ranges and coast region.*

Province of British Columbia.

(Specimens Nos. 48–51 and 59–79 were collected by Dr. G. M. Dawson.)

35.—From Wild Horse Creek, Upper Kootanie River, East Kootanie district.

It consisted essentially of tetrahedrite in a siliceous gangue. The latter constituted, approximately, sixty-four per cent, by weight, of the whole. Weight of sample, which consisted of numerous fragments, three ounces. It contained :

Gold..... 2·392 ounces to the ton of 2,000 lbs.
Silver..... 224·700 " "

The tetrahedrite, free from all gangue would, therefore, contain :

Gold..... 6·644 ounces to the ton of 2,000 lbs.
Silver..... 624·166 " "

36.—From Copper Creek—East Kootanie district.

An association of galena, zinc-blende and iron-pyrites, in a gangue of quartz. It was stained, and, in parts, coated with hydrated peroxide of iron and a little carbonate of lead. The sample, which consisted of ten fragments, weighed four pounds. It was found, by Mr. F. G. Wait, to contain :

Gold..... trace.
Silver..... 33·25 ounces to the ton of 2,000 lbs.

37.—From St. Mary's River, about ten miles from Fort Steele—East Kootanie district.

It consisted of an association of iron and copper-pyrites, in a gangue of white sub-translucent quartz. It was in parts coated with hydrated peroxide of iron and blue and green carbonate of copper. The gangue constituted but a small proportion, by weight, of the whole. Weight of sample, one and a-half ounces. Assays gave :

Gold..... trace.
Silver..... 1·076 ounce to the ton of 2,000 lbs.

Gold and silver assays–*Con.*

38.—This, and the three following specimens, are from Bugaboo Creek which flows into the Spilimichine River, near Golden—East Kootanie district.

Province of British Columbia–*Con.*

From "mother" lode. Consisted of iron-pyrites in a gangue of white sub-translucent quartz. Weight of sample, two pounds eight ounces. It contained :

Gold..... 0·058 of an ounce to the ton of 2,000 lbs.
Silver..... 0·233 " "

39.—From "mother" lode. An association of iron-pyrites and arsenical-pyrites, in a gangue of white sub-translucent quartz. Weight of sample, seven ounces and a-half. Assays showed it to contain :

Gold..... distinct trace.
Silver..... 0·350 of an ounce to the ton of 2,000 lbs.

40.—From "Albion" mine. Magnetic-pyrites in association with a little copper-pyrites. Weight of sample, thirteen ounces. It was found to contain :

Gold..... none.
Silver..... 0·117 of an ounce to the ton of 2,000 lbs.

41.—From "Albion" mine. Consisted of galena in a gangue of white quartz. Weight of sample, one pound four ounces. Assays gave :

Gold..... trace.
Silver..... 45·208 ounces to the ton of 2,000 lbs.

42.—From the "Syenite Bluff" claim, Deception Creek, Spilimichine River, twenty-seven miles from Golden—East Kootanie district. This, and the following specimen, was examined for Mr. J. McFatchie.

A somewhat coarse crystalline galena with which was associated a trifling amount of iron-pyrites. Weight of sample, seven ounces and a-half. Assays showed it to contain :

Gold..... trace.
Silver..... 107·187 ounces to the ton of 2,000 lbs.

43.—From the same claim as the last.

An association of a fibrous galena with zinc-blende, in a gangue of white sub-translucent quartz. Weight of sample, six ounces and a-half. It contained :

Gold..... 0·762 of an ounce to the ton of 2,000 lbs.
Silver..... 2·916 ounces " "

44.—From the "Law's" claim, Horse Thief Creek, Columbia River, ninety miles south of Golden—East Kootanie district. This, and the three following specimens, were examined for Mr. W. A. Baillie Grohman. Gold and silver assays—*Con.*

Consisted of iron-pyrites associated with small quantities of tetrahedrite and white sub-translucent quartz. The specimen was coated with hydrated peroxide of iron, and some blue and green carbonate of copper. Weight of sample, fourteen ounces. It was found to contain: Province of British Columbia—*Con.*

Gold.....	0·233 of an ounce to the ton of 2,000 lbs.
Silver.....	31·792 ounces " "

45.—From Vermont Creek, vicinity of Golden—East Kootanie district.

An exteriorly weathered fragment of tetrahedrite. Weight of sample, one pound eleven ounces. Assays showed it to contain:

Gold.....	very distinct trace.
Silver.....	25·521 ounces to the ton of 2,000 lbs.

46.—From the same locality as the last.

Galena associated with small quantities of tetrahedrite and quartz. Weight of sample, six ounces. It was found, on assay, to contain:

Gold.....	trace.
Silver.....	164·792 ounces to the ton of 2,000 lbs.

47.—From the same locality as the two preceding.

Consisted of galena in association with small quantities of tetrahedrite and a little quartz. Weight of sample, nine ounces. It contained:

Gold.....	trace.
Silver.....	290·208 ounces to the ton of 2,000 lbs.

48.—From north bank of Kootanie River, at Ward's ferry, about half a mile below the lower fall—West Kootanie district.

A very fine crystalline magnetite seamed with quartz, the latter carrying a very appreciable amount of iron-pyrites. Weight of sample, one pound one ounce. An assay of the pyritous quartz, which constituted about one-third, by weight, of the whole, showed that:

It contained neither gold nor silver.

Gold and silver assays—*Con.*

Province of British Columbia—*Con.*

49.—From copper claim opposite 49 Creek, Kootanie River—West Kootanie district.

Consisted of copper-pyrites, in association with a grey, hornblendic rock. The gangue constituted but a small proportion, by weight, of the whole. Weight of sample, twelve ounces. Assays gave :

Gold..... trace.
Silver..... 1·400 ounce to the ton of 2,000 lbs.

50.—From a quartz vein, two feet wide, traversing argillaceous schists, eight miles from the lower end, east side, of Upper Arrow Lake —West Kootanie district.

A white sub-translucent quartz, through which was disseminated a little iron-pyrites.

It contained neither gold nor silver.

51.—From a quartz vein traversing mica schist at mouth of river at north-west angle, north end, of Kootanie Lake—West Kootanie district.

A greyish-white sub-translucent quartz, through which was disseminated a few scales of mica, stained and, in parts, coated with hydrated peroxide of iron. Weight of sample, three pounds.

It contained neither gold nor silver.

52.—From Gold Hill, Illecillewaet—West Kootanie district. Collected by Dr. A. R. C. Selwyn.

A fine crystalline galena. Weight of sample, nine ounces. It was found to contain :

Gold..... trace.
Silver..... 5·866 ounces to the ton of 2,000 lbs.

53.—From Duck Lake (A. Postill), Okanagan—Interior plateau region. This, and the four following specimens, were examined for Mr. J. W. Mackay.

An association of calcite and greyish-green chloritic rock matter. Weight of sample, four ounces. Assays gave :

Gold..... trace.
Silver..... 0·175 of an ounce to the ton of 2,000 lbs.

54.—From Cherry Bluff, Kamloops Lake—Interior plateau region.

Magnetite, with which was associated a small amount of greyish-green hornblende. Weight of sample, eight ounces and a-half. It contained :

Gold..... trace.
Silver..... 0·116 of an ounce to the ton of 2,000 lbs.

55.—From the Lower Nicola, near Coutlees—Interior plateau region.

Consisted of specular iron ore. Weight of sample, three ounces. Assays showed it to contain:

Gold..... trace.
Silver..... 0·175 of an ounce to the ton of 2,000 lbs.

56.—From Foster's Bar, Fraser River—Interior plateau region.

Consisted of native arsenic, seamed with white sub-translucent quartz. Weight of sample, half an ounce. Assays gave:

Gold... . .... none.
Silver..... 0·729 of an ounce to the ton of 2,000 lbs.

57.—From a two-foot lode on Cedar Creek, Indian reserve, west shore of Okanagan Lake, about ten miles south-west from the head of the lake—Interior plateau region.

A white sub-translucent quartz, stained and coated with hydrated peroxide of iron. It contained, in parts, a little iron-pyrites. Weight of sample, one pound three ounces. It was found to contain:

Gold..... none.
Silver..... 0·292 of an ounce to the ton of 2,000 lbs.

58.—Found on branch entering Eagle River from the north-west, near Sicamous, Shuswap Lake—Interior plateau region. Examined for Mr. J. Butler.

It consisted of a white sub-translucent quartz, in parts, stained and coated with hydrated peroxide of iron and blue and green carbonate of copper, carrying small quantities of tetrahedrite. The latter constituted 3·38 per cent of the whole. Weight of sample, two ounces. The tetrahedrite was carefully freed from gangue and on being submitted to assay found to contain:

Gold..... none.
Silver..... 902·446 ounces to the ton of 2,000 lbs.

Had this particular sample of the ore been assayed as received, the results would have been:

Gold..... none.
Silver..... 30·503 ounces to the ton of 2,000 lbs.

59.—From Edward's Creek, North Thompson River—Interior plateau region.

Gold and silver assays—*Con.*

A grey granite, through which was disseminated a few grains of iron-pyrites, in parts stained with hydrated peroxide of iron. Weight of sample, one pound two ounces. It contained:

Province of British Columbia—*Con.*

Gold	trace.
Silver	none.

60.—From an extensive deposit of pyritous schists and quartzites. A quarter of a mile west from waggon road and four and a-half miles south from Cornwall's, Thompson River—Interior plateau region.

Quartzite, with fissures holding hydrated peroxide of iron. Weight of sample, two pounds and a-half. Assays gave:

Gold	none.
Silver	trace.

61.—From the same deposit as the last mentioned. A quarter of a mile east from waggon road and four and a-half miles south from Cornwall's, Thompson River—Interior plateau region.

A quartzose rock thickly coated with hydrated peroxide of iron. Weight of sample, four pounds three ounces. It was found to contain:

Gold	trace.
Silver	none.

62.—From a mile and a-half west of Stump Lake, Nicola valley—Interior plateau region.

A somewhat honeycombed quartzite, in parts coated with hydrated peroxide of iron. It contained:

Gold	trace.
Silver	trace.

63.—From Lillooet Mountain—Interior plateau region.

A slightly honeycombed felsite, carrying small quantities of iron-pyrites, stained and coated, with hydrated peroxide of iron. Weight of sample, three pounds.

It contained neither gold nor silver.

64.—From foot of Nicola Mountain, one mile and a-half east of bridge at lower end of Nicola Lake—Interior plateau region.

A highly weathered rust-stained rock. Weight of sample, one pound one ounce.

It contained neither gold nor silver.

65.—From the east side, and near the north end of Napier Lake—Interior plateau region.

A grey schistose rock through which was disseminated numerous specks of iron-pyrites. Weight of sample, three pounds six ounces.

It contained neither gold nor silver.

66.—From the Fraser River, west side, three miles above Fountain Creek—Interior plateau region.

A ferruginous dolomitic rock with an incrustation of crystalline calcite. Weight of sample, one pound four ounces.

It contained neither gold nor silver.

67.—From Glen Hart, about six miles from Clinton—Interior plateau region.

An association of white dolomite with white sub-translucent quartz, containing, here and there, a little partially weathered iron-pyrites. Weight of sample, one pound nine ounces. Assays gave:

Gold	trace.
Silver	none.

68.—From close to waggon road along Bonaparte River—Interior plateau region.

A highly weathered rust-stained rock. Weight of sample, one pound eight ounces.

It contained neither gold nor silver.

69.—From east side Fraser cliffs, opposite Lillooet bridge, and about a quarter of a mile back from the river—Interior plateau region.

A weathered calcareous conglomerate. Weight of sample, one pound nine ounces.

It contained neither gold nor silver.

70.—From the Thompson River, west side, nearly opposite Nicoamen—Interior plateau region.

A greenish-grey to white sub-translucent quartz, through which was disseminated a few specks of iron-pyrites. The specimen was more or less stained and coated with hydrated peroxide of iron. Weight of sample, one pound five ounces.

It contained neither gold nor silver.

Gold and silver assays—*Con.*

71.—From Clinton Creek, just above Clinton—Interior plateau region.

A dark grey basalt, thickly coated with hydrated peroxide of iron. Weight of sample, one pound one ounce. It contained:

Province of British Columbia—*Con.*

Gold	trace.
Silver	none.

72.—From the same locality as the preceding specimen.

An association of white crystalline quartz and wad. Weight of sample, fifteen ounces.

It contained neither gold nor silver.

73.—Found loose in gravel at Clinton—Interior plateau region.

A reddish-white, and purple mottled quartz, in parts coated with carbonate of lime and hydrated peroxide of iron. Weight of sample, one pound two ounces.

It contained neither gold nor silver.

74.—From one mile along road eastward from Fountain Creek—Interior plateau region.

Greyish-white quartzite, stained and coated with hydrated peroxide of iron, and carrying a few specks of iron-pyrites. Weight of sample, one pound eight ounces.

It contained neither gold nor silver.

75.—From west side of Fraser River, between Bridge River and Chilcotin, near base of coast ranges—Interior plateau region.

An intimate association of white sub-translucent quartz, dolomite and fibrous calcite. It was stained with hydrated peroxide of iron and blue and green carbonate of copper. Weight of sample, one pound.

It contained neither gold nor silver.

76.—From west side of Fraser River, four miles above Leon Creek—Interior plateau region.

White, opaque to sub-translucent quartz, with inclusion of a dark grey quartzite, more or less stained with hydrated peroxide of iron. Weight of sample, one pound ten ounces.

It contained neither gold nor silver.

77.—From seven miles and a-half north of Clinton—Interior plateau region.

Grey to dull red quartzite. Weight of sample, one pound. It was found to contain : Gold and silver assays—*Con.*

Gold	trace.
Silver	none.

Province of British Columbia—*Con.*

78.—From near tunnel "Bonanza" location, Cayoosh Creek, Lillooet, Fraser River—Interior plateau region.

A dark grey schistose rock. Weight of sample, one pound.

It contained neither gold nor silver.

79.—Concentrates from mill at "Big Slide" mine, mouth of Kelly Creek, Fraser River—Interior plateau region.

Consisted of finely crushed iron-pyrites, with a small quantity of copper-pyrites and a little siliceous matter. It was found, on assay, to contain :

Gold	0·408 of an ounce to the ton of 2,000 lbs.
Silver	0·933 " " "

80.—From a vein on Thompson River, one mile west of Thompson siding, between Lytton and Drynoch—Interior plateau region. Examined for Mr. J. Wilson.

Greyish sub-translucent quartz carrying small quantities of iron-pyrites. Weight of sample, three ounces and a quarter.

It contained neither gold nor silver.

81.—From vicinity of Spence's Bridge, Thompson River—Interior plateau region. Examined for Mr. J. Murray.

Consisted of gypsum, through which was disseminated a very appreciable amount of iron-pyrites. Weight of sample, eleven ounces and a-half.

It contained neither gold nor silver.

82.—From the "Silver Point" claim, two miles and a-half up, and on the west bank of Cayoosh Creek—Coast Ranges and coast region. Examined for Mr. J. Butler.

A greyish-white dolomite in association with small quantities of calcite and white opaque quartz. Weight of sample, one pound ten ounces. It contained :

Gold	none.
Silver	trace.

Gold and silver assays—*Con.*

Province of British Columbia—*Con.*

83.—From above Siwash Creek, eight miles east of Yale—Coast Ranges and coast region. Examined for Mr. G. D. Rodney.

An association of quartz and dolomite, through which was disseminated, in fine particles, small quantities of iron-pyrites and magnetic-pyrites. Weight of sample, one pound. Assays gave :

Gold	trace.
Silver	none.

84.—From Cameron's Bar, Fraser River, between Hope and Yale—Coast Ranges and coast region. Examined for Mr. J. W. Mackay.

An intimate association of galena and zinc-blende. Weight of sample, four ounces and a-half. It was found to contain :

Gold	trace.
Silver	6·562 ounces to the ton of 2,000 lbs.

85.—From "Silver" claim, Bowen Island, Howe Sound—Coast Ranges and coast region.

An association of grey opaque quartz with small quantities of a yellowish-white serpentine schist, through which was disseminated a little iron-pyrites. Weight of sample, one pound two ounces. Assays showed it to contain :

Gold	trace.
Silver	0·116 of an ounce to the ton of 2,000 lbs.

86.—Also from Bowen Island.

A dark greenish-grey quartzite carrying small quantities of iron-pyrites, copper-pyrites and galena. Weight of sample, thirteen ounces. It contained :

Gold	none.
Silver	21·583 ounces to the ton of 2,000 lbs.

87.—This, and the following specimen, is from Texada Island—Coast Ranges and coast region. They were examined for Mr. A. Raper.

A greenish-yellow quartzite carrying some magnetic-pyrites and a little copper-pyrites. Weight of sample, six ounces. Assays gave :

Gold	trace.
Silver	0·816 of an ounce to the ton of 2,000 lbs.

88.—From the "Guiding Star" claim.

A dark greenish-grey banded quartzite with interstratified white calcite. Weight of sample, eight ounces and a-half. It contained :

Gold	trace.
Silver	trace.

MINERALOGICAL NOTES.

Mineralogical notes.

1.—VOIGTITE? A hydrous biotite very closely allied, if indeed not directly referable to, this species, occurs, with staurolite and garnet, in mica schist, at North-east Harbour, Shelburne county, Nova Scotia. The garnet which is in the form of more or less minute, and for the most part rounded, crystals is disseminated, indifferently, through the staurolite and mica crystals and schist. Voigtite.

Colour, nearly black—in thin laminæ and by transmitted light, reddish-brown. Lustre of cleavage surface, pearly. Laminæ—inelastic, flexible. Before the blow-pipe, easily fusible to a magnetic globule. Readily decomposed by hydrochloric acid, leaving the silica in colourless scales. A determination of the water—direct estimation—by Mr. Johnston, gave 6·04 per cent.

2.—JAMESONITE. A fibrous massive form of this mineral has been found on Vermont Creek, as also on Deception Creek (at the "Seyenite Bluff" claim), Middle Fork of the Spilimichene River, East Kootanie, British Columbia. A specimen from the former locality has been examined by Mr. Johnston, and found to contain a trace of gold and 0·02 per cent of silver. Jamesonite.

3.—FREIBERGITE. An argentiferous tetrahedrite, which was found by Mr. Johnston to contain 3·09 per cent of silver, occurs, in quartz, on the branch entering Eagle River from the north-west, near Sicamous, Shuswap Lake, British Columbia. Freibergite.

4.—NATIVE PLATINUM has been found, in association with gold, on the bars in the North Saskatchewan River, in the neighbourhood of Edmonton, district of Alberta, North-west Territory. Native platinum.

A sample of the material from this locality, received from Mr. William Pearce, consisted of exceedingly minute rounded and flattened grains of native platinum, the largest not exceeding one-fourth of a millimetre in diameter, with intermixed, equally minute scales of native gold. Mr. Johnston found a certain proportion, about one-fourth, of the platinum to be magnetic. No evidence could be obtained of the presence of iridosmine in the particular sample examined.

5.—NATIVE MERCURY. Has been met with, *in situ*, in the form of minute globules scattered through a thin seam of cinnabar traversing a greenish felsite, occurring at the eastern entrance to Seshart Channel, Barclay Sound, Vancouver Island, British Columbia. It had previously been observed, according to Dr. G. M. Dawson, in a Native mercury.

Mineralogical notes–*Con.*

similar form, in some parts of the silver ore of Silver Peak, near Hope, on the Fraser River, in the same province.

Cinnabar.

6.—CINNABAR. This mineral, the localities of occurrence of which, in Canada, were given in a previous report—Ann. Rep. Geol. Surv., Can., vol. ii, p. 9 T, 1886—has more recently been found, *in situ*, traversing a greenish-grey felsite, at the eastern entrance to Seshart Channel, Barclay Sound, Vancouver Island, British Columbia.

Lazulite.

7.—LAZULITE. Amongst the rock specimens collected by the late Mr. James Richardson at the time of his exploration of the Lake Mistassini region, province of Quebec, in 1870, was one which has recently been examined by Mr. R. A. A. Johnston, and found to consist in part of lazulite. The specimen consisting of an intimate association of a bright blue granular lazulite and colourless sub-transparent quartz, constituting bands in a brownish, in parts pale reddish-brown, quartzite.

Metacinnabarite.

8.—METACINNABARITE. The material in question which was sent to the Survey for identification by Mr. W. H. Robertson, came from the "Timothy" claim, west side of Read Island which together with Valdes Islands, from which it is separated by Hoskyn Inlet, lie off the north-east coast of Vancouver Island, British Columbia.

It consisted of a bluish-black (under the lens greyish-black), amorphous, mercuric sulphide, lining or filling cavities and fissures in a light greyish quartz; the latter being also, in parts, flecked with carmine-red cinnabar. The dark sulphide has a metallic lustre and affords a greyish-black streak. Submitted to a careful qualitative examination by Mr. Johnston, it was found to consist of pure mercuric sulphide. There is no record, so far as I am aware, of this mineral having been hitherto recognized as occurring elsewhere than at the "Readington Quicksilver mine," in Lake county, California, where it is said to constitute the most abundant and valuable ore of the mine.

Sphalerite.

9.—SPHALERITE. A brownish-black, fine to somewhat coarse granular, massive zinc-blende has been met with on the north side (about seven miles inland) of Burrard Inlet, opposite Vancouver, British Columbia. The deposit, which is owned by Messrs. T. Tompkins and H. Abbott, is said, by the former gentleman, to be of considerable extent—such being the case it would be of economic importance inasmuch as blende constitutes one of the principal ores

of zinc. A sample of the mineral, which was practically free from gangue, was assayed for gold and silver and with negative results. Mineralogical notes–*Con.*

10.—GRAPHITE. From lot thirty-four, range eight, of the township of Denbigh, Addington county, province of Ontario. Examined for Mr. R. Bowie. Graphite.

A sample of the material from this locality, in which the graphite occurred, for the most part, in the form of layers and patches in a calcareo-siliceous gangue, has been examined by Mr. Johnston, and found to contain 51·67 per cent graphite.

11.—TALC. An almost snow-white talc is found on lot thirty-four of the second range of the township of Clarendon, Frontenac county, Ontario. Examined for Mr. R. Bowie. Talc.

Should the finder's anticipations, as regards the extent of the deposit, be realized, the latter may prove of some economic importance, inasmuch as there is great probability that this material will be found as well adapted for use as a filler in the manufacture of paper, as the talcose mineral found in the town of Edwards, some eleven miles from Gouverneur, St. Lawrence county, in the state of New York.

12.—PYRITE. A crystalline granular, massive, iron-pyrites, through which is disseminated a trifling amount of blende, occurs at the head of Eckstall Inlet, south of Port Essington, Skeena River, British Columbia, where it is said to constitute a vein fifteen feet wide, nearly vertical, running in a north-easterly direction from the shore and traceable for nearly a mile. It has been examined by Mr. Johnston and found to contain a trace of gold and 0·350 of an ounce of silver to the ton of 2,000 lbs., likewise a trace of copper and a little zinc, but no nickel or cobalt. Pyrite.

13.—COOKEITE. ? The material here referred to was collected by Mr. J. J. Driscoll on the Wait-a-bit Creek, which flows into the Columbia River about two miles north of Donald, British Columbia,—where, as this gentleman informs me, it occurs in small quantities, in thin layers in a talcose schist as also in small cavities in the quartz veins which traverse the latter. Cookeite.

The mineral occurs in crystalline foliated translucent masses of a faint greyish-white to white, or silvery-white and pale apple-green colour. In thin folia it is colourless and transparent. Lustre, pearly. Feel, greasy.

Mineralogical notes–*Con.*

Cookeite–*Con.*

It was examined by Mr. Johnston who found that—before the blowpipe it exfoliates like vermiculite and colours the flame intense carmine-red ; in the closed tube gives off water and affords a reaction for fluorine ; it is slightly fusible and gives a blue colour with cobalt solution ; with salt of phosphorus it gives a skeleton of silica. The specimen will be submitted to analysis and its exact composition determined.

The talcose schist above referred to, a hydromica schist, has a foliated structure, a light brownish-grey to light reddish-brown colour and greasy feel. It is made up of minute scales of a hydrous mica disseminated through an earthy admixture of carbonates of lime, magnesia and iron, and ferric hydrate. The hydrous mica, of which it is proposed to make a complete quantitative analysis, contains but trifling amounts of lime and magnesia, but a high percentage of potassa and soda, the latter preponderating. Before the blowpipe fuses on the edges with great difficulty. Affords a faint yet decided reaction for lithium and caesium.

The material of the quartz veins consisted of a white sub-translucent quartz with inclusions of a white, occasionally light reddish, opaque, cleavable calcite, and carrying small quantities of chalcocite, chalcopyrite, a little pyrrhotite and a few crystals of pyrite. It was in parts stained with ferric hydrate and, here and there, with a little blue and green carbonate of copper.

Fibrolite.

14.—FIBROLITE. This mineral, as also cyanite, has been met with by Mr. A. E. Barlow (Survey) in a pegmatite vein cutting Laurentian gneiss, on lot nine, range three, of the township of Dryden, district of Nipissing, Ontario. In the specimens examined it formed layers on a garnetiferous gneiss. Structure, fibrous ; traversed, at right angles to the fibres, by numerous fine fissures. Colour (of fresh surfaces), pale bluish-grey to greyish-white.

Mineral associations of apatite.

15.—MINERAL ASSOCIATIONS OF APATITE. The minerals observed and enumerated by Professor B. J. Harrington (Rep. Geol. Surv., Can., 1877-78, part G) as occurring in the apatite deposits of Ottawa county, province of Quebec, included :

Albite, calcite, chabazite, chalcopyrite, chlorite, epidote, fluorite, galena, garnet, graphite, hematite, hornblende, idocrase, molybdenite, orthoclase, phlogopite, prehnite, pyrite, pyroxene, pyrrhotite, quartz, rutile, scapolite, sphalerite, talc (steatite) ?, titanite, tourmaline, Wilsonite and zircon.

Since then, there has been added to the mineralogical collection in the Museum of this Survey—(1) An association of mag-

netite, apatite and orthoclase, from the township of Huntley, Carleton county, Ontario, collected by Mr. C. W. Willimott; (2) an association of stilbite, chabazite and pyroxene; (3) of stilbite, apatite, pyroxene and phlogopite, and (4) of stilbite, apatite and scapolite, from McLaren's apatite mine, township of Portland East, Ottawa county, province of Quebec, collected by Mr. J. F. Torrance; also (5) an association of Heulandite and chabazite with a little pyrite, found by Mr. Willimott, lining a cavity in pyroxene at the Emerald apatite mine, in the township of Buckingham, also in Ottawa county. Of these, magnetite has already been referred to, by Dr. Harrington, as occurring in apatite-bearing veins in Ontario, and the occurrence of stilbite has been noted by Mr. Torrance; Heulandite, however, has not previously been recognized as occurring in these deposits.

Mineralogical notes–*Con.*

Mineral associations of apatite–*Con.*

16.—Mineral Inclusions in Mica. Of such occurrences there has recently been presented to the Museum of this Survey (1) a plate of phlogopite in which is embedded, parallel to the cleavage planes of the mica, a sharply defined hexagonal plate of molybdenite measuring twelve millimetres across—from the township of Hull, Ottawa county, province of Quebec; (2) a plate of phlogopite between the cleavage planes of which occur some highly distorted octahedra of pyrite, also from the township of Hull; (3) a plate of phlogopite, measuring eight centimetres across, upon the face of which, and almost but not quite covering the same, there occurs a thin layer of pale apple-green, fine fibrous, radiated (arborescent-like) actinolite; (4) a plate of phlogopite having an inclusion of albite, and intimately associated with this, crystals of apatite, pyrite and garnet; and (5) an inclusion of purple fluorite with pyroxene in phlogopite—all from the same township as the preceding. There were previously in the Museum—(6) a plate of phlogopite with inclusions of light blue crystalline calcite—from the township of Wakefield; (7) sheets of muscovite in which are embedded, distorted and more or less flattened, in the direction of the cleavage planes of the mica, crystals of spessartite—from the township of Villeneuve; (8) a section of a crystal of phlogopite in which there occurs a small prism of the same mineral, the vertical axis of which is parallel to the cleavage planes of the inclosing mica—from the township of Templeton, which, together with the two last named townships, is in the county of Ottawa, province of Quebec; (9) a plate of phlogopite in which is embedded, parallel to the cleavage planes of the mica, a prism of apatite thirty-six millimetres in length—from the township of

Mineral inclusions in mica

Mineralogical notes—*Con.*

North Burgess, Lanark county, Ontario; and (10) a specimen of muscovite with lenticular shaped, in the direction of the cleavage planes of the mica, inclusions of white sub-transparent quartz, from Yeo's Island, in the Upper St. Maurice, Portneuf county, province of Quebec.

Miscellaneous examinations.

MISCELLANEOUS EXAMINATIONS.

Semi-anthracite from Main Red Deer River, British Columbia.

1.—SEMI-ANTHRACITE. From the Main Red Deer River, in or near the base of the Rocky Mountains—about one hundred miles north of Anthracite, British Columbia. Examined for Mr. P. McCarthy.

A proximate analysis, by fast coking, gave:

Volatile matter	13·98
Fixed carbon	81·94
Ash	4·08
	100·00

Coke, non-coherent. Colour of ash, white.

This fuel has very nearly the same composition as the semi-anthracite from Bow River, right bank, about a mile and a-half from Canmore station—of which an analysis (No. 50) is given in Annual Report, Geol. Surv., Can., 1885, p. 10 M.

Phosphatic rock from Macintosh Brook, Cape Bretoncounty, Nova Scotia.

2.—PHOSPHATIC ROCK. From the mouth of Macintosh Brook, on the shore below Allan and Donald McAdam's, north shore East Bay, Cape Breton county, Nova Scotia. Collected by Mr. T. C. Weston (Survey).

The mode of occurrence of this rock, as also the results of a microscopic examination of the same by Mr. T. C. Weston, is referred to by Mr. H. Fletcher in the Report of Progress Geol. Surv., Can., for 1876-77, p. 432. It is stated to be, for the most part, composed of fragments of Lingula with some phosphatic nodules. Agreeably with the results of determinations made by Mr. R. A. A. Johnston, it contains 0·56 per cent of phosphoric acid, which corresponds to 1·22 per cent of tribasic phosphate of lime.

Quartz sand from Coal River, lower Missinaibi River, Ontario.

3.—QUARTZ SAND. A sand composed of grains of white translucent quartz with a few intermixed grains of unaltered, or partially weathered, felspar, was met with, by Mr. E. B. Borron, in the course of boring in the post-tertiary deposits at the mouth of Coal River, lower Missinaibi River, about eighty miles above Moose Factory, province of Ontario.

4.—Volcanic Tufa. From Lawn Hill, near the entrance to Skidegate Inlet, Queen Charlotte Island, British Columbia. Geological position, Tertiary. Collected by Dr. G. M. Dawson (Survey). Miscellaneous examinations—*Con.*

This material, of which there is a considerable deposit at the above mentioned locality, very closely resembles in appearance the trass of the Rhine valley, so much so indeed as to lead to the inference that it might not improbably be found to possess, when combined with a rich lime, the same hydraulic properties. Desirous of ascertaining how far this conjecture is borne out by fact, I have experimented with this material in the manner, and with the results, here stated. Volcanic tufa from Lawn Hill, Skidegate Inlet, British Columbia.

The tufa was very finely pulverized, without previous calcination—the other ingredients consisted of a very fine, sharp and angular siliceous sand, and a fat lime slaked to a dry powder with water. The ingredients were mixed, on one occasion by weight, and on the other by volume. The resultant mixture was made into a stiff paste with water and fashioned, in a mould, into circular cakes having a diameter of one inch and a-half and a thickness of one inch. These were immersed in water as soon as made.

In the first series of experiments, lime was the only addition made and the ingredients were mixed by weight, employing respectively one-half, one and two parts of lime to one of tufa. After an immersion of seven days the first of these mixtures had acquired a little firmness, the two latter, however, still retained much of their original plasticity. A further immersion, extending over three weeks, was attended with but slightly better results. The one containing the smallest proportion of lime, although somewhat firmer, readily yielded to pressure between the fingers, whilst the other two, which evidently contained far too large a proportion of lime, were quite tender.

In the second series of experiments, the additions consisted of lime, and lime in conjunction with sand, and the ingredients were mixed by measure. The ratios employed being—half a volume of lime to one volume of tufa (which, with the particular lime employed, equalled a very little over one-third part, by weight, of lime to one part, by weight, of tufa), and one volume of lime and one volume of sand to one volume of tufa. The immersion in water extended over six weeks. A slight consolidation was perceptible after the seventh day, and this became gradually more and more pronounced, but even after four weeks' immersion, the

Miscellaneous examinations—*Con.*

various cakes could still be pierced with a sharp steel point and yielded to pressure between the fingers, and it was not until after the sixth week that they exhibited a tendency to withstand these tests and then not in a perfectly satisfactory manner.

Volcanic tufa from Lawn Hill, Skidegate Inlet, British Columbia—*Con.*

Pozzuolana and trass when finely pulverized, without previous calcination, and mixed, in the same proportions as were used by me in the second series of experiments, with lime or lime and sand, form mortars which harden under water, those of the former in from three to four days, and those of the latter in from four to five days.

The results of the experiments tend to show that this material, in the crude state, in combination with a rich lime, manifests such slight hydraulic activity or power that it would be, thus used, unsuited for the manufacture of a cement intended for constructions under water or in positions subjected to immediate submersions.

GEOLOGICAL SURVEY DEPARTMENT.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

DIVISION OF

MINERAL STATISTICS AND MINES

ANNUAL REPORT

FOR

1890.

ELFRIC DREW INGALL.

Associate of the Royal School of Mines, England,
Mining Engineer to the Geological Survey of Canada.
IN CHARGE.

H. P. BRUMELL
Assistant to the Division.

PUBLISHED BY AUTHORITY OF PARLIAMENT

OTTAWA:
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY.
1891.

NOTE

Except for the figures of imports, which refer to the fiscal year, beginning 1st July, the year used throughout this report is the calendar year, and the ton, that of 2,000 pounds, unless otherwise stated.

The figures given throughout the report referring to exports and imports are compiled from data obtained from the books of the Customs Department, and will occasionally show discrepancies, which, however, there are no means of correcting.

The exports and imports, under the heading of each province, do not necessarily represent the production and consumption of the province *e. g.*, material produced in Ontario is often shipped from Montreal and entered there for export, so falling under the heading, Quebec.

The values of the metallic minerals produced, as per returns to this Department, are calculated on the basis of their metallic contents at the average market price of the metal for 1890. Spot values have been adopted for the figures of production of the non-metallic minerals.

N.E.S.=Not elsewhere specified.

ERRATUM.

Page 3, 2nd line from bottom, for "Exports and Imports," *read* Imports.

ERRATUM.

P. 141 S, line 9 from top.—*After* Where no allowance is made by the buyers *insert* for the copper.

To Alfred R. C. Selwyn, C. M. G., F. R. S., &c.,
Director and Deputy Head,
Geological Survey Department of Canada.

Sir,—I beg herewith to hand you the annual report of the Division of Mineral Statistics and Mines for the year 1890.

Difficulty continues to be experienced in securing the information promptly enough to issue the report earlier, although, as formerly, a preliminary summary statement of the mineral production of the country was issued early in April. In this, the quantities of which no returns had been received, were estimated as nearly as possible. These have been revised since the complete returns became available.

It is hoped, however, that as the mining public become more familiar with the object the Department seeks to attain and its usefulness, and also acquire a better understanding of the confidential treatment of the information given, that a more willing response will be forthcoming from all, and that even those few who now delay the work by not replying to the circulars sent out may be persuaded to act more promptly.

With regard to the general information on mining matters contained in the report, it is hoped it may be found more complete than heretofore.

The plan of reproducing suitable matter from the reports of the provincial mining bureaus has been adopted. This information has been incorporated with our own material, and will thus receive a wider circulation and will tend to make the report a more complete review of the progress of mining and allied industries in the Dominion.

To facilitate the work of compilation the fiscal year has been adopted, instead of the calendar year as heretofore, for the figures of exports and imports. Greater uniformity has been attained by stating the values of the metallic products in terms of the metals contained in

the ores, etc., at the average market price of each for the year, thus following the usual practice as well for these as for the non-metallic products, which, as formerly, are given at their spot value.

Apart from the compilation of the annual report the other functions of the division have been performed, as far as the present means at command would permit.

Numerous enquiries have been received and answered, respecting the mining and mineral resources of the country, often involving considerable research to give the details asked for.

The Directory of Mineral Occurrences has also received further attention, and is now almost complete. The system of signs already used by the Survey for representing mineral occurrences on the maps has been elaborated and extended, so that the distribution of the mineral resources of the country can be shown graphically, and thus afford information on this important subject in a concise form.

The arrangements made with the British Columbia Government,* whereby the aid of their local commissioners has been secured, should insure prompt receipt of information relating to mineral discovery and mining progress in the different districts of that province. It is hoped that it may be found possible to complete arrangements already partly made covering other portions of the Dominion. These would include a correspondent in each mining centre, thus attaining the same result as in British Columbia. Corroborative investigation by an officer of this bureau, where required, would then afford full and reliable information.

In conclusion it is desired to gratefully acknowledge the aid received from various sources. Thanks are due to all—a number too numerous to mention here—who, by answering our circulars or letters, have provided much valuable material for the compilation of the report.

Special mention must again be made of the services rendered by my colleague, Mr. H. P. Brumell, assistant to the Division, for his very important and efficient aid in every branch of the work. Apart from his duties in the compilation of the figures he has been a large contributor to the report; the following articles being specially due to him, viz.:—Abrasive Materials, Petroleum, Natural Gas, Mineral Pigments, Salt, Structural Materials, Gypsum and Manganese.

*Summary Report Geological Survey Department, 1890, p. 11.

Our acknowledgments are also due to the Provincial Departments of Mines of Nova Scotia and British Columbia, and to the Dominion Customs Department for aid received.

I have the honour to be, Sir,

Your obedient servant,

ELFRIC DREW INGALL.

Division of Mineral Statistics and Mines,
July 10th, 1891.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1889 AND 1890.

Product.		1889.		1890.	
		Quantity.	Value.	Quantity.	Value.
Metallic.					
Copper (fine, contained in ore)	Lbs.	6,809,752	$ 885,424	6,013,671	$ 902,050
Gold	Ozs.	72,328	1,295,159	64,046	1.149,776
Iron ore	Tons.	84,181	151,640	76,511	155,380
do pig	"	.....	(b)	.....	(b)
Lead (fine, contained in ore, &c.)	Lbs.	165,100	6,604	113,000	5,085
Nickel (fine, contained in ore, &c.)	"	(a)	(a)	1,435,742	33,232
Platinum	Ozs.	1,000	3,500	.....	4,500
Silver (fine, contained in ore, &c.)	"	383,318	343,848	400,687	420,662
Total, Metallic		.....	2,686,175	.....	3,570,685
Non-metallic.					
Antimony ore	Tons.	55	1,100	26½	625
Arsenic	"	.....	.....	25	1,500
Asbestus	"	6,113	426,554	9,860	1,260,240
Coal	"	2,719,478	5,584,182	3,117,661	6,496,110
Coke	"	54,539	155,043	56,450	166,298
Felspar	"	.....	.....	700	3,500
Fertilizers	"	775	26,606	1,203	31,889
Fire-clay	"	400	4,800	.....	.....
Glass and glassware	.....	.....	150,000	.....	537,130
Graphite	Tons.	242	3,160	175	5,200
Grindstones	"	3,404	30,863	4,884	42,340
Gypsum	"	213,273	205,108	226,509	194,033
Limestone for flux	"	22,122	21,909	18,478	18,361
Manganese ore	"	1,455	32,737	1,328	32,550
Mica	Lbs.	36,529	28,718	770,959	68,074
Mineral pigments—					
Baryta	Tons.	794	15,280	1,842	7,543
Ochres	"			275	5,125
Mineral water	Galls.	424,600	37,360	561,165	66,031
Moulding sand	Tons.	170	850	320	1,410
Petroleum	Brls.	639,991	612,101	765,029	902,734
Phosphate	Tons.	30,988	316,662	31,753	361,045
Precious stones	.....	.....	.....	.....	700
Pyrites	Tons.	72,225	307,292	49,227	123,068
Quartz	"	.....	.....	200	1,000
Salt	"	32,832	129,547	43,754	198,897
Soapstone	"	195	1,170	917	1,239
Structural materials and clay products—					
*Bricks	M	200,561	1,273,884	211,727	1,266,982
*Building stone	C. yds.	341,337	913,691	382,563	964,783
Cement	Brls.	90,474	69,790	102,216	92,405
Flagstones	Sq. ft.	14,000	1,400	17,865	1,643
Granite	Tons.	10,197	79,624	13,307	65,985
*Lime	Bush.	2,948,249	362,848	2,501,079	412,308
Marble	Tons.	980	980	780	10,776
Miscellaneous clay prod'ts	.....	.....	239,385	.....	.....
Pottery	.....	.....	.....	.....	195,242
Carried forward	.....	.....	11,032,644	.....	13,536,766

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1889 AND 1890—*Concluded.*

Product.	1889.		1890.	
	Quantity.	Value.	Quantity.	Value.
Brought forward		$11,032,644		$13,536,766
Non-metallic—Concluded.				
Roofing cement Tons.			1,171	6,502
Sand and gravels (exports) "	283,044	52,647	342,158	65,518
Sewer pipes				348,000
Slate Tons.	6,935	119,160	6,368	100,250
Terra-cotta				90,000
*Tiles M	10,526	134,265	10,521	140,877
Sulphuric acid Lbs.	10,998,713	152,592	11,118,779	145,235
Whiting Brls.			500	500
Total Non-metallic		$ 11,491,308		$ 14,433,648
do Metallic		2,686,175		3,570,685
Estimated value of mineral products not returned (principally structural material)		992,838		995,667
Total		$ 15,170,321		$ 19,000,000
Items left out, 1890—Iron, steel, charcoal and pig iron		(*b*) 4,329,679		

* Incomplete.

(*a*) Owing to the returns of nickel for 1889 being confidential the value had to be included in the last item of the table, viz., estimated values.

(*b*) Statistics of the production of iron, steel and charcoal were not collected for 1890. The pig iron produced was all included under the head of iron ore.

Exports.

Mineral and Mineral Products, Mined or Manufactured in Canada, during 1890.

Product.	Value.	Product.	Value.
Acid, sulphuric	$ 4,393	Mica, crude and cut	$ 19,171
Asbestus, first-class	453,704	do ground	3,297
do second-class	58,973	Nickel	89,568
do third-class	15,853	Oil, crude and refined	18,154
Barytes	1,960	Ore, antimony	1,000
Brick	3,762	do iron	40,690
Coal	2,436,906	do manganese	36,831
Coke	21	do silver	204,142
Copper	398,497	Phosphate	499,369
Fertilizers	5,778	Plumbago	1,529
Gold	706,792	Salt	1,667
Glass and glassware	12,015	Sand and gravel	65,518
Grindstones	18,564	Slate	153
Gypsum, crude	192,254	Stone, unwrought	43,611
do ground	105	do wrought	21,725
Iron and steel, about	275,000	Other articles	7,735
Lime and cement	168,804	Total	5,807,541

Exports.

Products of the Mine during the Fiscal Year, 1890.

Exported to	Value.	Exported to	Value.
United States	$ 3,963,257	Brazil	$ 2,205
Great Britain	630,815	France	1,132
Newfoundland	167,075	Belgium	900
St. Pierre	19,905	Spain	500
Germany	17,067	Danish West Indies	300
British West Indies	12,170	Norway and Sweden	197
Spanish do	11,994		
Sandwich Islands	10,312	Total	4,855,757
Hong Kong	7,254		
Japan	7,200	1889	4,419,170
British Guiana	3,474		
		1888	4,110,937

Imports.

Minerals and Mineral Products, Fiscal Year, 1890.

Product.	Value.	Product.	Value.
Alum and aluminous cake	$ 28,758	Grindstones	$ 20,569
Antimony	17,439	Gypsum	4,064
Arsenic	4,474	Iron and steel	8,473,741
Asbestus and manufactures	13,250	Lead and manufactures of	368,180
Ashes, pot, pearl and soda	2,138	Lime	5,360
Asphaltum	68,454	Litharge	31,401
Baryta	978	Lithographic stone	4,071
Borax	24,845	Manganese oxide	3,192
Brass and manufactures of	554,545	Marble	99,353
Bricks	12,500	Mercury	7,677
do bath	2,225	Mineral water	40,802
do and tiles, fire	96,537	Nickel	75
Buhrstone	2,506	Ochres	14,066
Building stone	132,155	Paraffine wax	15,844
Cement	14,491	Petroleum and manufactures of	515,852
do Portland	313,572	Plaster of Paris	6,004
Chalk	7,221	Platinum	5,215
Clays—		Potash salts	10,787
China	28,167	Precious stones	119,824
Fire	21,366	Salt	309,840
All other, N.E.S	11,044	Sand and gravel	36,768
Coal, anthracite	4,595,727	Silex	2,617
do bituminous	3,528,959	Slate	22,871
do dust, &c	29,818	Soda salts	327,961
do tar and pitch	19,345	Stone or granite, N.E.S	84,396
Coke	133,344	Spelter	71,122
Copper and manufactures of	484,189	Sulphur	44,276
Copperas	4,001	Sulphuric acid	2,927
Earthenware	695,206	Tiles, sewer pipes, &c	77,434
Emery and pumice	19,925	Tin and manufactures of	1,289,756
Fertilizers	46,637	Whiting	27,471
Flagstones	48,995	Yellow metal	98,472
Fullers' earth	1,060	Zinc and manufactures of	99,002
Glass and glassware	1,230,585		
Graphite and manufactures of	36,881	Total	24,472,327

ABRASIVE MATERIALS.

Notwithstanding the many extensive deposits of tripoli, buhrstone, and rocks suitable for the manufacture of whetstones, nothing has been done during the past year in the production of abrasive materials beyond the manufacture of grindstones and a small quantity of scythe-stones at several of the grindstone quarries.

Tripoli.—This material which occurs in the Dominion, generally in lake bottoms, is found in great quantity in New Brunswick and Nova Scotia. In the former province the localities best known are Pollet River Lake, Mechanic's Settlement and Fitzgerald Lake, in King's Co., and Pleasant Lake, St. John Co. New Brunswick.

Of the material from the former locality, an analysis was made in 1879 by Mr. G. C. Hoffmann, Chemist to the Survey, with the following result:—

Silica	80·487
Alumina	3·146
Ferric oxide	0·951
Lime	0·342
Magnesia	0·283
Carbonic acid	0·011
Phosphoric acid	?
Potash and soda	?
Water combined and hygroscopic and organic matter	13·321
	98·541

In the lakes above-mentioned the material is said to be in very considerable quantity, the deposit at Fitzgerald Lake being, throughout the area of the lake, over 10 feet in thickness.

Small quantities have at various times been shipped from these deposits, though in no instance has the shipment exceeded a few tons for experimental purposes. None was shipped from this province during 1890.

In Nova Scotia, the list of lakes already known to afford tripoli is too great to publish here, being scattered over Pictou, Colchester, Cumberland, King's, Halifax, Victoria and Cape Breton counties. Little work has been performed, though, it is believed, small lots of a few tons have been shipped. None was raised during 1890. Nova Scotia.

The following table shows the imports of material classified by the Customs Department as "silex," presumably tripoli, or manufactures of the same:—

ABRASIVE MATERIALS.

TABLE 1.

IMPORTS OF "SILEX."

Fiscal Year.	Cwts.	Value.
1880	5,252	$2,290
1881	3,251	1,659
1882	3,283	1,678
1883	3,543	2,058
1884	3,259	1,709
1885	3,527	1,443
1886	2,520	1,313
1887	14,533	5,073
1888	4,808	2,385
1889	5,130	1,211
1890	1,768	2,617

Pumice Stone.—This material has not as yet been found in Canada. The imports will be found included with those of Emery in table 2.

Emery.—Corundum has not as yet been found in any quantity in Canada, thus making it impossible that there should be any production of emery. The Dominion, however, contains very extensive garnet deposits, which may at any time be worked and produce large quantities of a material which is to a certain extent used as a substitute for emery, though having a less degree of hardness.

The imports of emery, in addition to pumice stone are given in the following table:—

ABRASIVE MATERIALS.

TABLE 2.

IMPORTS OF PUMICE STONE AND EMERY.

Fiscal Year.	Value.
1880	$ 7,854
1881	11,179
1882	15,762
1883	17,823
1884	16,518
1885	14,450
1886	14,458
1887	15,617
1888	18,564
1889	16,888
1890	19,925

As the value of emery wheels is not altogether dependent on the quantity of contained emery, it has been thought better not to include the imports of this manufacture in the preceding table.

Buhrstones.—In the descriptive catalogue of a collection of minerals sent to Philadelphia in 1876, the following description of an area of rocks suitable for buhrstones is given :—

"This buhrstone constitutes a series of veins, cutting an intrusive mass of syenite, which occupies an area of thirty-six square miles, among the Laurentian rocks of Grenville, Chatham and Wentworth. The veins consist of yellowish-brown or flesh-red cellular chert; the colours, in some cases, running in bands parallel to one another and sometimes being rather confusedly mingled, giving the aspect of a breccia. The cells are unequally distributed, some parts being nearly destitute of them, while in others they are very abundant, and of various sizes, from that of a pin's head to an inch in diameter."

This deposit for other than the purpose of obtaining specimens has not yet been opened, nor have any buhrstones been as yet made from Canadian material. The imports are given in the following table :—

ABRASIVE MATERIALS.

TABLE 3.

IMPORTS OF BUHRSTONES.

Fiscal Year.	Value.
1880	$12,049
1881	6,337
1882	15,143
1883	13,242
1884	5,365
1885	4,517
1886	4,062
1887	3,545
1888	4,753
1889	5,465
1890	2,506

Grindstones.—Throughout the area covered by the Carboniferous and Permian rocks in Eastern New Brunswick and Nova Scotia are extensive areas of sandstone, eminently suitable for the manufacture of grindstones. The industry is carried on in the district surrounding Shepody and Cumberland Bay, at the North-East end of the Bay of Fundy; at Newcastle, Northumberland county; and along the south shore of the Baie des Chaleurs from Janeville to Grand Anse, in Gloucester county, New Brunswick; and throughout Pictou and Cumberland counties, Nova Scotia.

Although there are a considerable number of operators, the production is but small, as outside of the Baie des Chaleurs quarries the output is in small quantities from building stone quarries.

Probably the best stone for the manufacture of grindstones is that on the south side of the Baie des Chaleurs, where the industry has been carried on since 1830, and possibly before.

The stone from this district is obtained from beds averaging about six feet in thickness, interstratified with heavy deposits of blue and red shale, pyro-schists and fire clay.

The exposure on the coast at Clifton shows the following section:—

Clay (surface), 10′.
Blue shale, 25′.
Sandstone, 8′ (used in the manufacture of grindstones).
Bituminous shale, 8′.
Fire clay, 6′.
Shale, red (in base of quarry).

Dip very slight, to south-east; strike, north-east.

This section will be approximately repeated along the coast (both east and west), the various beds of sandstone being almost invariably between the blue and the bituminous shales.

The thickness of the beds enables very large stones to be obtained from this district; shipments of stones weighing up to 3 tons being frequently made. The largest stone shipped weighed 7,840 lbs.

As a rule the stone is shipped from Northern New Brunswick in the finished condition, small quantities only of rough hewn ("scabbled") stone being sent away, whereas from Nova Scotia the greater quantity is sent to Boston and other points in the Eastern States in the latter condition to be further manufactured.

The production in New Brunswick during 1890 was, according to returns received at this office, 4,034 tons, valued at $33,804.

For Nova Scotia no returns of production were received. Assuming, however, that the quantity exported was equivalent to that produced, there is for that province a production of 850 tons, valued at $8,536, making a total production of 4,884 tons, valued at $42,340. No grindstones are produced outside of these two provinces.

These figures show a very material increase over those for the year previous, the increase being 1,480 tons, valued at $11,477. The amounts produced during the previous four years were:—

1886	4,000	tons, valued at	$46,545
1887	5,292	" "	64,008
1888	5,764	" "	51,129
1889	3,404	" "	30,863

A considerable proportion of the production of Canadian grindstones finds a market in Boston, where they are sold at an average price of $25 per ton, and enter into direct competition with the Ohio stones, which sell at from $10 to $12 per ton.

The exports by provinces for the last hree years are shown in table 4, while in table 5 are shown the total exports since 1884.

ABRASIVE MATERIALS.

TABLE 4.

EXPORTS OF GRINDSTONES.

Provinces.	1888.	1889.	1890.
Ontario	$ 252		
Quebec		$ 1,387	$ 12
Nova Scotia	11,430	7,150	8,536
New Brunswick	16,494	21,437	10,016
Manitoba		8	
Totals	$28,176	$29,982	$18,564

ABRASIVE MATERIALS.

TABLE 5.

EXPORTS OF GRINDSTONES.

Year.	Value.
1884	$28,186
1885	22,606
1886	24,185
1887	28,769
1888	28,176
1889	29,982
1890	18,564

The imports for the past eleven years are given in the following table which explains itself:—

ABRASIVE MATERIALS.

TABLE 6.

IMPORTS OF GRINDSTONES.

Fiscal Year.	Tons.	Value.
1880	1,044	$11,714
1881	1,359	16,895
1882	2,098	30,654
1883	2,108	31,456
1884	2,074	30,471
1885	1,148	16,065
1886	964	12,803
1887	1,309	14,815
1888	1,721	18,263
1889	2,116	25,564
1890	1,567	20,569

Hone and Whetstones.—A small quantity of scythe stones is made at Clifton and Stonehaven, Northumberland Co., New Brunswick, the value of which is included in that given for grindstones. No hone or whetstones (so-called) were produced during the year, nor has there been any production for several years.

FOSSIL RESIN ("AMBER").

A discovery of considerable importance was reported upon by Mr. J. B. Tyrrell, who, during his summer's work in Northwestern Manitoba, visited an extensive deposit of so-called amber on the west shore of Cedar Lake. This lake is on the Saskatchewan River, of which it is in reality a part, and near its mouth where it empties into Lake Winnipeg, and is distant from the city of Winnipeg about 300 miles.

Mr. Tyrrell in his summary report to the Director of the Survey writes as follows:—

"It occurs mixed with sand and many fragments of partly decayed wood, on a low beach behind a gradually shelving shore and along the face of a deep, wet, spruce swamp. The pieces were for the most part smaller than a pea, but could be readily seen glittering among the sand and vegetable débris. Some pieces were found as large as a robin's egg, and Mr. King informed me that he had collected pieces very much larger. It has evidently been washed up on the shore by the waves, but its exact age has not yet been positively determined.

"The first place at which it was seen was in a small bay behind a limestone point projecting towards the north, but the most extensive

deposit is more than a mile south of this point, where a rounded beach stretches across the margin of a low swamp. This beach is about a mile in length, and from eighty to one hundred and twenty feet in breadth. The "amber" is found most plentifully along its ridge, where it constitutes between five and ten per cent. by volume of the sand and vegetable débris, and holes dug to a depth of two feet show no diminution in its quantity. Towards the edge of the lake, however, the sand is freer, both from fragments of wood and "amber." It is difficult to make an accurate estimate of the quantity of "amber" on this mile of beach, but it may confidently be said to be found throughout the distance in a band thirty feet wide, with a minimum depth of two feet. This band has thus a total bulk of 316,800 cubic feet. A number of specimens collected from various parts of it showed an average of a little over ten per cent. of "amber," which, in natural fragments, weighed forty-six pounds to the cubic foot. The amount of "amber" on this strip of beach would, therefore, be about 31,680 cubic feet, or 1,457,280 pounds. At a minimum value of 25 cents a pound, this would represent a total of $364,320. This estimate refers merely to the material that is now washed up on the ridge of the beach, without considering the source from which it is originally derived."

In Canada* "amber" has been found frequently in the coals and lignites of the North-West, and also occurs at many points in the United States, notably in the Cretaceous and Tertiary beds of New Jersey and Massachusetts. These deposits, however, have not as yet been operated commercially, specimens only having been extracted.

No statistics regarding the market for this substance in Canada are available.

The following table of imports into the United States up to 1885† will prove of interest as illustrating a possible outside market for this substance:

Fiscal Years.	Value.
1869	$ 427
1870	1,433
1871	180
1872	2,426
1873	1,534
1874	1,448
1875	7,169
1876	15,502
1877	17,307
1878	13,215
1879	17,821
1880	36,860
1881	42,400
1882	72,479
1883	40,166
1884	56,301
1885	21,722

* Annual Reports Geological Survey of Canada for the following years:—1873-74, p. 55; 1876-77, pp. 471-3; vol. IV, p. 46T.

† Bulletins U.S. Geological Survey:—Mineral Resources of the United States, by David T. Day, 1886, p. 605.

ANTIMONY.

The only producing antimony deposit in Canada during the past year was that at Rawdon Mines, Hants county, Nova Scotia, though it cannot be said that the mine was actually in operation, as the shipments consisted of material cobbed from the dumps and consigned to Liverpool, England.

Extensive deposits occur in New Brunswick, at Prince William, and at South Ham, Quebec, neither of which properties have, however, been operated for several years.

The production during the past year amounted to 26½ tons, valued at $625, a decrease since the previous year of 28½ tons and $475.

The annual production for the past four years is:—

1887	584	tons, valued at	$10,860
1888	345	do	3,696
1889	55	do	1,100
1890	26½	do	625

Lessened demand by the American companies taking the output of these mines is said to be the cause of the annual decrease in production shown above.

The exports of antimony ore for the past eleven years are as given below:

ANTIMONY.

TABLE 1.

EXPORTS.

YEAR.	Tons.	Value.	YEAR.	Tons.	Value.
1880	40	$ 1,948	1886	665	$ 31,490
1881	34	3,308	1887	229	9,720
1882	323	11,673	1888	352½	6,894
1883	165	4,200	1889	30	695
1884	483	17,875	1890	38	1,000
1885	758	36,250			

The imports of antimony (other than ore, which is not imported) for the corresponding number of years are as follows :—

ANTIMONY.

TABLE 2.

IMPORTS.

Fiscal Year.	Pounds.	Value.
1880	42,247	$ 5,903
1881	.....	7,060
1882	183,597	15,044
1883	105,346	10,355
1884	445,600	15,564
1885	82,012	8,182
1886	89,787	6,951
1887	87,827	7,122
1888	120,125	12,242
1889	119,034	11,206
1890	117,066	17,439

ARSENIC.

The production of arsenic for 1890 has been small. It is all from Deloro, Ontario, and was obtained by resublimating the crude arsenic derived from the condensation chambers at the works of the Canadian Consolidated Gold Mining Company, and at the Malone Mines. These mines, now closed for some years, were formerly worked for gold, the concentrates being said to contain about 25 per cent. of oxide of arsenic. The present production of arsenic is limited to the quantity of crude material obtained as above stated, and also by the small demand. Altogether some 650 tons of refined arsenic have been shipped from the Madoc region since the commencement of operations there. It is to be regretted that more is not being produced, as the Canadian material has been proven to be of very superior quality, owing to its entire freedom from impurities, whereas English and other arsenic frequently contains small amounts of zinc, tin or lead.

An analysis of a carload shipped from Madoc in 1887, gave, according to P. de P. Rickets, Columbia College:

As $_2O_3$ (arsenious oxide)	99·84
Impurities	0·16
	100·00

Two others by Baker Edwards, of Montreal, gave :—

As $_2O_3$ refined	97·5
As $_2O_3$ crude	92·8

The markets of the United States and Canada require about 6,000 tons per annum, nearly all of which is now supplied from England, though there is every probability that in the near future Canada will furnish a large proportion from the practically inexhaustible source of supply in Hastings county.

The amount produced during 1890 was 25 tons, valued at $1,500, or $60 per ton in New York.

The production for the past five years has been:—

	Tons.	Value.	
1886	120	$5,460	At the Mine.
1887	30	1,200	do
1888	30	1,200	do
1889	Nil.	Nil.	do
1890	25	1,500	do

According to the report on the Mineral Resources of the United States, 1885, there were during that year 440 tons of crude and refined arsenic shipped from the Consolidated Company's mine to the United States.

The table of imports is given below.

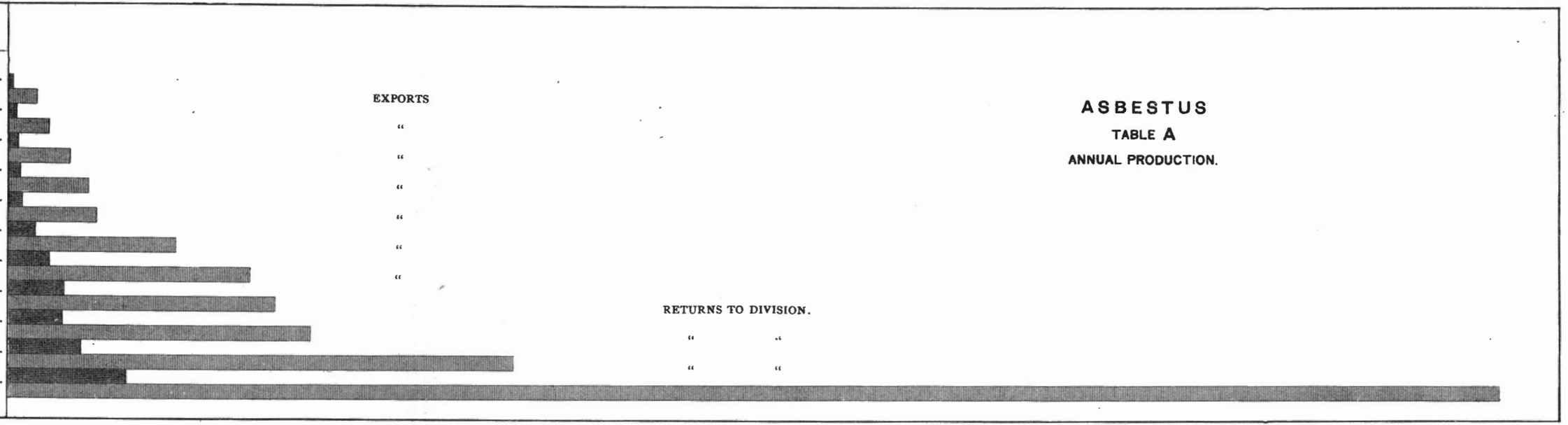
ARSENIC.

TABLE 1.

IMPORTS.

FISCAL YEAR.	Pounds.	Value.
1880	18,197	$ 576
1881	31,417	1,070
1882	138,920	3,962
1883	51,953	1,812
1884	19,337	773
1885	49,080	1,566
1886	30,181	961
1887	32,436	1,116
1888	27,510	1,016
1889	69,269	2,434
1890	138,509	4,474

Year	Tons	Value
	380	$.....
1880	.....	24,700
.....	540	.....
1881	.....	35,100
.....	810	.....
1882	.....	52,650
.....	955	.....
1883	.....	68,750
.....	1,141	.....
1884	.....	75,097
.....	2,440	.....
1885	.....	142,441
.....	3,458	.....
1886	.....	206,251
.....	4,619	.....
1887	.....	226,976
.....	4,404	.....
1888	.....	255,007
.....	6,113	.....
1889	.....	426,554
.....	9,860	.....
1890	.....	1,260,240



ASBESTUS

TABLE A

ANNUAL PRODUCTION.

ASBESTUS.

The production of this mineral during 1890 shows an encouraging increase of over 60 per cent in the amount and about 200 per cent. in the total value, being for 1890, 9,860 tons, with a value of $1,260,240 as computed from returns received as compared with a production for last year of 6,113 tons, with a value of $426,554. (*See* Graphic Table A.) Production.

This result has been brought about by improvements in plant, methods of extraction and especially by the stimulating effect of a considerable increase in prices, the value of a ton of the different grades ranging as follows:—"Thirds," $20 to $50; "seconds," $75 to $100; "firsts," $125 to $150, whilst extra quality of "firsts" ranged as high as $250; the margin of price for the same quality being due to the great difference often existing between the equivalent grades from different mines.

The operations for the extraction of this mineral are almost altogether confined to the districts of Thetford, Black Lake and Coleraine in the County of Megantic, P.Q., which are traversed by the Quebec Central Railway, although there are one or two detached mines outside of this in the same general district of the Eastern Townships. The deposits are all found in the areas of serpentine which are associated with the Cambrian rocks of the district. Operations.

Dr. R. W. Ells has made a special study of the asbestus deposits, during several years spent in making investigations for the Survey, the results of which may be found in the Annual Reports of the Survey. The mode of occurrence of these deposits cannot be better given than by quoting his description of them, in a paper read before the American Institute of Mining Engineers, at its meeting at Ottawa, October, 1889, where he describes as follows:—

"The asbestus industry, although of comparatively recent date, has, since its inception in 1878, rapidly increased in importance, and bids fair to speedily become the leading mining industry of the province. While the occurrence of fibrous serpentine or chrysotile in the Townships has been known for many years, and has been mentioned in the earlier reports of the Geological Survey, its true economic importance remained unrecognized, and it was not until the opening of the Quebec Central Railway across the serpentine belt of Thetford and Coleraine that any importance was attached to this peculiar mineral. Although occurring to some extent with the serpentines of the Laurentian district, north of the Ottawa River, its development in this direction has not as yet been sufficiently studied to warrant a clear expression of opinion as to the actual value of these areas, and the production of asbestus or chrysotile R. W. Ells on "Asbestus Mines."

is as yet entirely confined in Canada to the Eastern Townships, and to the serpentine rocks which are at present regarded as forming a part of the volcanic belt of the lower Cambrian system of Quebec.

"This mineral differs entirely from the actinolite of central Ontario, and the asbestos of the Townships also presents several points of difference when contrasted with that from the Laurentian district. This is seen in the greater softness, silkiness and tenacity of the fibre of much of the former, a property which gives it great value for spinning and for its working into the finer variety of textures to which it is now so extensively applied.

"The stratified rocks associated with the serpentines of the Townships in which the workable asbestos occurs are generally slates of various colours, black, gray, green and purple, with occasionally conglomerate and sandstones, which are often hard and highly quartzose. These are frequently associated with diorites, which often form large mountain masses as at Orford, Ham, Broughton and other points, and which in texture are generally fine-grained, both massive and concretionary, and in colour, range through shades of green to brown.

Distribution. "In the Province of Quebec the serpentine extends for many miles, in a series of interrupted outcrops from the boundary of Vermont, nearly to the extremity of the Gaspé peninsula. At several places, notably in Thetford and Coleraine, and in the Shickshock mountain-range of Gaspé it presents a large development. It is sometimes found in bands of a few yards in breadth, apparently interstratified with the slates and sandstones, and sometimes with diorites, in conjunction with which it forms knoll-like hills or elongated ridges of considerable extent. In many places a gradual transition from the diorites to the serpentines can be observed, and it seems very conclusively settled, both from observation in the field on a large scale and from analyses in the laboratory of the Survey, that much of the serpentine is an alteration-product from dioritic rocks, rich in olivine or some allied mineral. While generally massive, the rock has at times a slaty structure, and in many localities the mass is much shattered and broken. More especially is this latter feature noticeable in quarries or areas where dykes of diorite, but more generally of a whitish granite or granulite, cut the serpentine. This latter rock, which has generally a grayish or grayish-white colour, consists for the most part of orthoclase felspar and quartz, but at times contains an admixture of mica, classing with a true granite. Whatever may be the age of these whitish dykes, which frequently become masses of considerable extent, they certainly are newer than the serpentines which they traverse, as is evidenced clearly by the alteration and shattering of the

mass traversed, along the contact. The view is held by many of those engaged in mining asbestus, that the presence of these smaller dykes exercises a favourable influence on the production and character of the veins, in the same way as the action of diorite dykes upon copper or other metalliferous strata on the production of ore-deposits.

"Among the principal areas of serpentine which are found at so many widely scattered points, the most easterly yet known is at a point called Mount Serpentine, about 10 miles up the Dartmouth River from its outlet in Gaspé basin. The serpentine is here associated with limestone and surrounded by strata of Devonian age. Small veins of asbestus are found in the rock, but not yet in quantity sufficient to be economically valuable. West of this the next observed is the great mass of Mount Albert, whence it extends west in a great ridge for some miles. This mass is known to contain veins of chromic-iron, and traces of asbestus have also been observed, but the area has never yet been carefully explored with a view to ascertain the presence of the mineral in quantity, owing largely to the present difficulty of access.

"In Cranbourne and Ware, to the north of the Chaudière River and in the vicinity of that stream between the villages of St. Joseph and St. Francis several small knolls are seen, in all of which small and irregular veins are visible, but apparently not in quantity sufficient to render them economically important, at least in so far as yet examined. Further to the southwest, in Broughton, Thetford, Coleraine, Wolfestown and Ham, a very great development of these rocks is observed, forming at times mountain-masses from 600 to 900 feet above the surrounding country level, and presenting very peculiar and boldly marked features in the landscape by their rugged outlines and curiously weathered surfaces. The large areas of this division terminate southward at a point termed Ham Mountain, a very prominent peak of diorite which marks the extremity of the ridge. In this great area, which we may style the central area, asbestus can be found at many points in small quantity but at a comparatively few does it occur in quantity and quality sufficient to warrant the expenditure of much capital in its extraction.

"The third area, regarding that of the Shickshocks as the first, begins near the village of Danville, and may be styled the southwestern area. Thence it extends through Melbourne, Brompton, Orford, Bolton and Potton, in a series of disconnected hills, to the American boundary, beyond which the continuation of the serpentines can be traced into Vermont. In these areas, with the exception of the peculiar isolated knoll near Danville, the asbestus has, as yet, been observed in small quantity only, and generally of inferior quality. Large areas of

soapstone are found at points throughout the area, and the associated diorites have a large development. It must, however, be said of this section, that considerable areas, whose outcrops can be seen along the roads which traverse the district, are concealed by a dense forest growth, and the true value of such portions must, for some considerable time, be largely conjectural. In fact, until the forest and soil are completely removed by the action of forest fires, as was the case at Black Lake and Thetford, the search for asbestus is likely to prove difficult and unsatisfactory. It is, however, very evident from the studies already made on this interesting group of rocks in Canada, that all serpentines are not equally productive—a fact very evident even in the heart of the great mining centres themselves, where large areas of the belt are made up of what is known as barren serpentine. As a general rule, however, the rock likely to prove asbestus-producing can be determined by certain peculiarities of texture, colour or weathering.

"At the Thetford mines, and in that portion of Coleraine lying to the northeast of Black Lake, certain conditions favourable to the production of asbestus appear to have prevailed, and have led to the formation of numerous veins, often of large size, which, in places, interlace the rock in all directions. These veins range in size from small threads to a width of 3 to 4 inches, and in rare cases even reach a thickness of over 6 inches. The quality of the fibre, however, varies even in these localities, and while much of it is soft, fine and silky, other portions are characterized by a harshness or stiffness which detracts greatly from its commercial value.

"Several theories have been put forth as to the origin of the asbestus veins. From a careful study of many places throughout the belt, it would seem that the theory of segregation applies equally to these as to quartz veins or other mineral lodes. The fibre of the veins, unless distorted by pressure, is always found at right angles to the sides of the fissure, and frequently in veins of what are regarded as of large size, say from two and a-half to four inches, the continuity of the fibre is broken by a dividing zone or comb, if one may use the expression, of grains of magnetic or chromic-iron. In certain cases, also, the mass of the serpentine appears to lose colour near the veins or in immediate contact with them, but this feature is not always observed.

"The fissures or veins are not always regular or persistent for any very great extent. A small vein at the surface, of half an inch in thickness, may quickly enlarge to one of three inches or more, and, continuing, may die out entirely, while others come in on either side. They have much the aspect of the gash veins in slaty rocks, though there are

many instances are seen where the fibre maintains a tolerably uniform size for considerable distances.

"The containing rocks show the presence of numerous faults, as in other mineral localities, but possibly in the serpentine these are often more plainly marked. These faults throw the veins from side to side, and frequently are of sufficient extent to cut off entirely the working face of a highly productive area, the rock on the other side of the fissure being often entirely barren. The sides of the fault, in such cases, show extensive slickensides, and frequently have great sheets of coarse or woody-fibred, or imperfect asbestus, along the planes of fracture. Occasionally pockets or small veins of chromic iron are found in close proximity to the asbestus.

"Much of the asbestus found at the surface, or in the upper workings, is discoloured. This is generally the case where the rock is shattered by the action of the intrusive dykes, or from some other cause, and the colouring is doubtless due to infiltration of water along the lines of jointing or fracture, becoming less as the rock grows more solid. The quality of the fibre in such cases improves as the mine becomes deeper. A somewhat similar remark may be made as to the quality of the fibre at the surface as compared with that from a lower level, but proceeding from a different cause. Owing to the destruction of the forest over the serpentine-knolls by extensive fires or by the action of the weather, the asbestus veins, which are exposed at the surface, have frequently a certain amount of harshness, which entirely disappears as the vein is opened. This peculiarity is probably due to the action of the fire, by which a certain proportion of the contained water of the mineral is dissipated; and in this connection, also, a very interesting study is afforded by the comparison of the output at the Thetford mines with that from certain areas in the Black Lake District. At the former, the fibre is remarkable for its soft, silky character, and the percentage of harsh fibre is comparatively small. The same is true of certain of the Black Lake mines, but at others, though many veins of good size are also found, a very much larger proportion of the fibre is harsh or brittle. The cause of this difference has long been a subject of speculation to those more immediately interested in the subject, some attributing it to a difference in level of the two localities—a theory, however, which can scarcely be maintained in view of the fact that much of the output from the Black Lake mines, from the higher levels, is of the best quality.

"The presence, however, of large masses of the intrusive granulite near Black Lake, as contrasted with its almost entire absence at Thetford, where it is found generally in small dykes, leads to the inference that to

this intrusion of heated matter may be largely due the lack of softness and silkiness in much of the Black Lake output. The presence of such great masses would have a tendency to dissipate a certain proportion of the contained water from the chrysotile, which is really a hydrous silicate of magnesia, in the same way as the action of the forest fires, though on a much more extended scale. The same effect can be produced by placing a piece of the mineral in the fire or on a sufficiently heated surface, when in a short time it will be found to have lost its softness to a large extent and become harsh and brittle.

"The extraction of asbestus in the present stage of the industry may rather be termed quarrying than mining proper, the workings so far being all open cuts. The rock is blasted out, broken up, carried to the dumps and subsequently cobbed by hand, the latter being generally done by boys. The smaller veins, of a-fourth to a-half inch, are frequently left in the rock of the dump, as not in the present state of the industry repaying the cost of extraction. There is no doubt that with suitable machinery for crushing and cobbing the greater part of most or all of the dumps, which have already reached a large size, would easily pay for working over, while the removal of the dumps themselves, from the fac- of their covering much valuable ground, will very shortly become a net cessity.

Thetford. "The workings at Thetford are at present confined principally to four companies, viz.: King Bros., The Bell Company, Irving, Johnston & Co. and Ross, Ward & Co. These are all situated on a small knoll of serpentine which rises to a height of 80 to 90 feet above the adjacent track of the Quebec Central Railway which traverses the properties. The output from all these mines is practically the same in quality and length of fibre, though in the quarry of Irving, Johnston & Co., veins of extra width, nearly six and a half inches, have been found. This extra length of fibre does not, however, possess any special advantage, since it is generally broken by grains or partings of iron, and for practical purposes good clear fibre of two to three inches, or even less, is quite as valuable as any. In addition to the properties at this place above mentioned, new workings have lately been commenced by Mr. A. H. Murphy, now of Montreal, and by Luck & Mitchell, of Sherbrooke, both of which promise well. These are to the west of the railway, and at a lower level, and some extra work may be involved in the removal of a considerable covering of drift in places. The ground between the railway and the Thetford River, which here marks the western limit of the serpentine, has also been lately proved to some extent, and portions of it found to contain asbestus in satisfactory quantity, but the greater facilities for working the upper levels are such as to give them the preference for the present.

"At Black Lake, four miles south of Thetford mines, four companies are also located. These are the Anglo-Canadian, the Frechette-Dauville, the Scottish-Canadian, and the American Abestus Company, or Wertheim's, at all of which a large amount of work has been done. They are all at higher levels than the mines at Thetford, and the output, as already stated, is not, as a whole, equal in quality comparing the percentage of firsts produced. This will be seen from a statement of the relative percentages of the two districts, though this is again to a certain extent affected by the difference in grading practised by the several companies. Thus from the Thetford area the percentage of firsts ranges from 50 to 70; seconds, from 7 to 30; thirds, from 20 to 40. From the Black Lake district the percentages are: firsts, 10 to 50; seconds, 25 to 20; thirds, 20 to 60. Black Lake.

"Taking the scale of prices and the percentage of the higher grades, it is seen that at the present time, commercially speaking, the properties of Thetford are entitled to the first place. This is to some extent explained by the fact that a considerable proportion of the Black Lake output is off-colour, the areas worked lying partly below the crest of the main serpentine ridge and having a considerable covering of drift. At Thetford, owing to elevation of the knoll on which most of the mines are located, the loose or shattered rock, if it ever existed there, has been largely removed by glacial action, the surface of the rock being frequently polished and striated. It has always been expected that the Black Lake output would increase in value when the shattered surface rock was removed, and this expectation has, to a certain extent, been realized in so far as the workings have proceeded, the rock gradually becoming more solid at greater depths, and the colour and quality of the fibre improving. New workings along the face of the ridge at this place have also disclosed the presence of large veins of excellent material, and greatly superior to that from the lower works, yielding a large percentage of first quality. Here the action of the intrusive granulites has not been felt apparently to any considerable extent, and the conditions in this respect more closely resemble those prevailing at Thetford.

"In estimating the values of asbestus properties, the question of the relative percentages of output should be carefully considered, since, while the number of tons produced by two areas might be approximately equal, and to the uninitiated the properties in consequence be nearly equal in value, the one from the large amount of firsts would be capable of paying very handsome dividends, while the other would require great economy of management and yield far less satisfactory returns.

Danville.

"In addition to the areas just described, several others are worthy of notice. The knoll of serpentine near Danville, of small extent, has been worked for some years by Mr. Jeffrey, of Richmond, with good results. The veins at this place are not large, seldom reaching two inches in width, but the quality of much of the fibre is excellent, and, though small, a considerable number of them produce a good amount of abestus. The proportion of firsts from this mine is at present about 20 per cent., and of seconds 60 per cent., the remainder, of course, being thirds, thus approximating more closely the output of the mines at Black Lake.

"A more curious deposit however, is that known as the Broughton mine. The asbestus here is apparently confined to a single vein, having a hanging wall, in places, of soapstone. This vein was remarkable for its large size when first worked, being at times nearly or quite a foot thick, as well as for the great silkiness and softness of fibre. It had more the aspect of a well-defined vein, and has been worked for a distance of several hundreds of yards, and to a depth of about 70 feet. In the lower workings, however it decreased rapidly in size, and at last split up into minute strings, rendering it worthless. Another peculiar feature observed at one of the mines near Coleraine station is the presence of mica, or a similar mineral, associated with the asbestus veins, or in close proximity to them, and occurring in irregular fissures in the rock, of several inches in width. The rock is much shattered, and the mica is not, in so far as yet observed, found in any of the other mines in this section of the country.

"In many places the serpentine is intimately associated with masses of soapstone. In such cases, while occasional small and irregular veins of asbestus may be seen, in none of those examined has the quantity, with the exception of the vein at Broughton, just described, been found to be of much economic importance."

Methods of working.

The methods of working in the district are very simple, consisting in the opening up of large open pits or quarries from which the rock after a certain amount of selection in the pit is hoisted to surface, those portions containing the asbestus being further broken up and going, finally, to the cobbing sheds. Here, after the water has been driven off by heating on a sheet-iron drying table a force of boys select out the asbestus, further cleaning away the rock and classifying the product according to the length of the fibre into "firsts," "seconds" and "thirds." The grading adopted by the different firms varies very much both according to the length and quality of fibre each obtains. One of the leading firms, however, gives the following definition:—Firsts, over ½ inch; Seconds, ½ inch and under; Thirds, short fibre obtained by screening the refuse and re-picking it to free it from rock as far as possible.

There has been a tendency lately to recognize the necessity of adopting machinery in the treatment of the material especially of that carrying the shorter fibre, and the American Asbestus Company have installed a very complete works for the preparation of their product. Here the material as it comes from the quarry is placed in a very ingenious car with shelves, which is run on a track into a drying oven; the remainder of the process consisting of breaking the dried asbestus rock by means of stone breakers and grading through a system of sieves.

The mining is now mostly done by means of steam or compressed air drills, steam and horse derricks being used for hoisting.

Thetford.

At Thetford, the main workings are on a knoll on the east side of the railroad and here, within a radius of some ten chains, or so, are crowded over 20 pits often where belonging to different companies, with only thin walls of rock between. The waste rock has accumulated in large dumps around the pits and now that the more accessible ground begins to be worked out it is found necessary to remove it to get at the portions thus covered. In order to accomplish this steps are being taken by some of the companies to crush and work over these dumps, thus securing a large amount of asbestus that they contain and removing the waste to barren ground further from the workings.

None of the pits have attained any great depth as yet, the deepest probably measuring not more than 200 feet.

Recently, in several places, unexpected but encouraging results have followed on breaking through the large walls or faces of rock visible in the different pits which were believed for a long time to form the limit of the productive rock. This belief proved to be ill-founded and similarly in removing, to ensure safety, large portions of rock also believed to be barren good asbestus has been found in several cases.

Formerly, operations were mostly confined to the high ground, on the east of the railroad, at Thetford and Black Lake; but recently work has been begun at various points on the lower ground, on the other side with fair results, although, as far as the works have gone, the average of the fibre has been shorter than in the older working.

The chief mine, outside of these districts is situated near Danville, and continues to be worked by Mr. Jeffrey. A little activity is also evident in other portions of the district of which Dr. Ells who visited the localities, speaks as follows :—

Brompton Lake.

" *The Brompton Lake mine, which is the most southerly worked to any extent, has been open to a very considerable depth, and a large

* Summary Report of the Geol. Surv. Dep., 1890.

amount of money has been spent; but the prospects for workable veins in the lower workings are no better than at the surface, and no returns have yet been made. About Orford Pond, on the south side of Orford Mountain, and near Long Lake, at the northern extremity of the same ridge, excavations have been made in thin and irregular seams a fourth of an inch, and in the road west from Knowlton Landing to Bolton Pass, in the serpentine band to the east of the Missisquoi River, some exploratory work has been done without finding asbestus of any economic value, and, in so far as yet ascertained, this portion of the province does not present favourable indications for profitable asbestus mining."

Operators

The names of the chief companies operating and producing in the Quebec district, who give employment to about 1,000 men, are as follows:—

Messrs. King Bros.,	Thetford.
The Bell Asbestus Co.,	
Messrs. Ward, Ross & Co.,	
The Beaver Asbestus Co.,	
The Thetford Asbestus Mining Co.,	
Andrew S. Johnson & Co.	
Messrs. King, Bros.,	Black Lake and Coleraine.
The American Asbestus Co.,	
Messrs. Irwin, Hopper & Co.,	
The United Asbestus Co.,	
Messrs. Steele & Co.,	
The Laurier Mining Co.,	
The Murphy Mining Co.,	
Dr. Jas. Reed,	
The Megantic Mining Co.,	
The Jeffrey Asbestus Mine.	Danville.

The Scottish Canadian Asbestus Company of Black Lake, being still in liquidation, remained idle during the year, but hope to start again shortly.

A little prospecting for this mineral was carried on near St. Francis, Beauce, on the 1st range, S.W., near the Bras River, but, so far, no longer fibre than about $\frac{1}{2}$ inch had been obtained. Prospecting operations in Pontiac county, on the north shore of the Ottawa River, in the vicinity of Calumet Island, are also reported, but with what result was not definitely ascertained.

Ottawa County.

The most interesting feature, outside of the progress in the main districts, is to be found in the work prosecuted with a view to testing deposits in the Laurentian rocks of Ottawa county. Some little work was done on the property of Mr. W. A. Allan, on lots 15 and 16, range V, Portland West. Here, numberless small seams of the mineral are

found in the top of a ridge of serpentinized limestone. Only a small force, however, was at work, and enough had not been done to give a clear idea of the nature of the deposit.

A more extended effort is in progress in the Templeton district on lot 11, range VIII of that township. The mine is situated on a low flat ridge of limestone which has been cleared off by bush fires, so that the rocks can be easily examined. A most interesting structure here presents itself, a peculiar process of alteration having gone on, resulting in a reticulation of serpentine bands or seams throughout the limestone, cores of the latter being surrounded by the former. These cores seem to be clearly cut off from the enclosing serpentine ring, and when small can be lifted out leaving like the kernel of a nut a smooth cavity. The seams of asbestus generally follow the course of the serpentine band around the cores, although little cross seams occasionally traverse the band from side to side. A number of these serpentine bands of very varying sizes joining each other at intervals form the reticulation spoken of. The cores of limestone seem to be much more compact and harder than the general mass of the limestone around. Templeton.

The work at this mine consists of a shaft or pit somewhat curved, as might be expected, sunk on one branch of a loop of serpentine of larger dimensions than the rest. This has been followed to a depth of 50 feet without showing any signs of giving out. The serpentine band at this spot with its accompanying asbestus veins has on surface been traced all round the central core, the outcrop of which is the shape of a flat ellipse, its larger diameter measuring about 50 feet. Operation in Templeton.

The large proportion of the fibre, so far, is quite short, but of good quality; whilst a small quantity of "firsts," measuring up to two inches long and very clean and good, was also obtained. The accompanying serpentine shows very beautiful tints, delicate shades of green and amber prevailing. It is clear and semi-translucent, resembling wax. In cobbing, it breaks away easily and cleanly from the fibre, which is generally very clean and free from imbedded rocky impurities.

Only a small force was at work during 1890, as commencement was only made in the beginning of August, but already a boiler has been erected on the spot supplying steam to a machine drill.

The progress of these developments will be watched with great interest as being made to test not only a new district, but also a formation quite different from that of the now well proved areas of Thetford and Black Lake. There we are dealing with asbestus deposits developed in relatively extensive areas of serpentine, which would seem to have been subjected to extensive fracturing forces, the complicated set of fissures

thus formed allowing free scope for the percolation of waters and providing spaces for the deposition of serpentinous material in the fibrous form.

In the Laurentian districts so far examined the process of formation seems much more obscure. The serpentinous matter is small in proportion to the predominating limestone rock, and would seem to be due rather to a quiet replacement of the carbonate of lime along certain lines by the serpentine, and there seems to be no evidence of any extensive movement or fracturing.

It seems, however, quite possible that at places this alteration process will have gone on far enough to produce very considerable bodies of the serpentine, wherein the veins of asbestus may be found to be both more plentiful and yield a larger proportion of longer fibre.

Exports

The exports and imports are given in Tables Nos. 1 and 2 below:—

ASBESTUS.

TABLE 1.

EXPORTS.

Quality.	1887. (a)		1888.		1889.		1890.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1st class.....	1,761	$130,707	3,625	$262,552	4,579	$319,461	5,453	$453,704
2nd do	566½	23,296	110	5,306	593	27,308	1,172	58,973
3rd do	184	4,826	201	9,884	416	13,375	373	15,853
Totals....	2,511½	$158,829	3,936	$277,742	5,588	$360,144	6,998	$528,530

(a) Second half of year only.

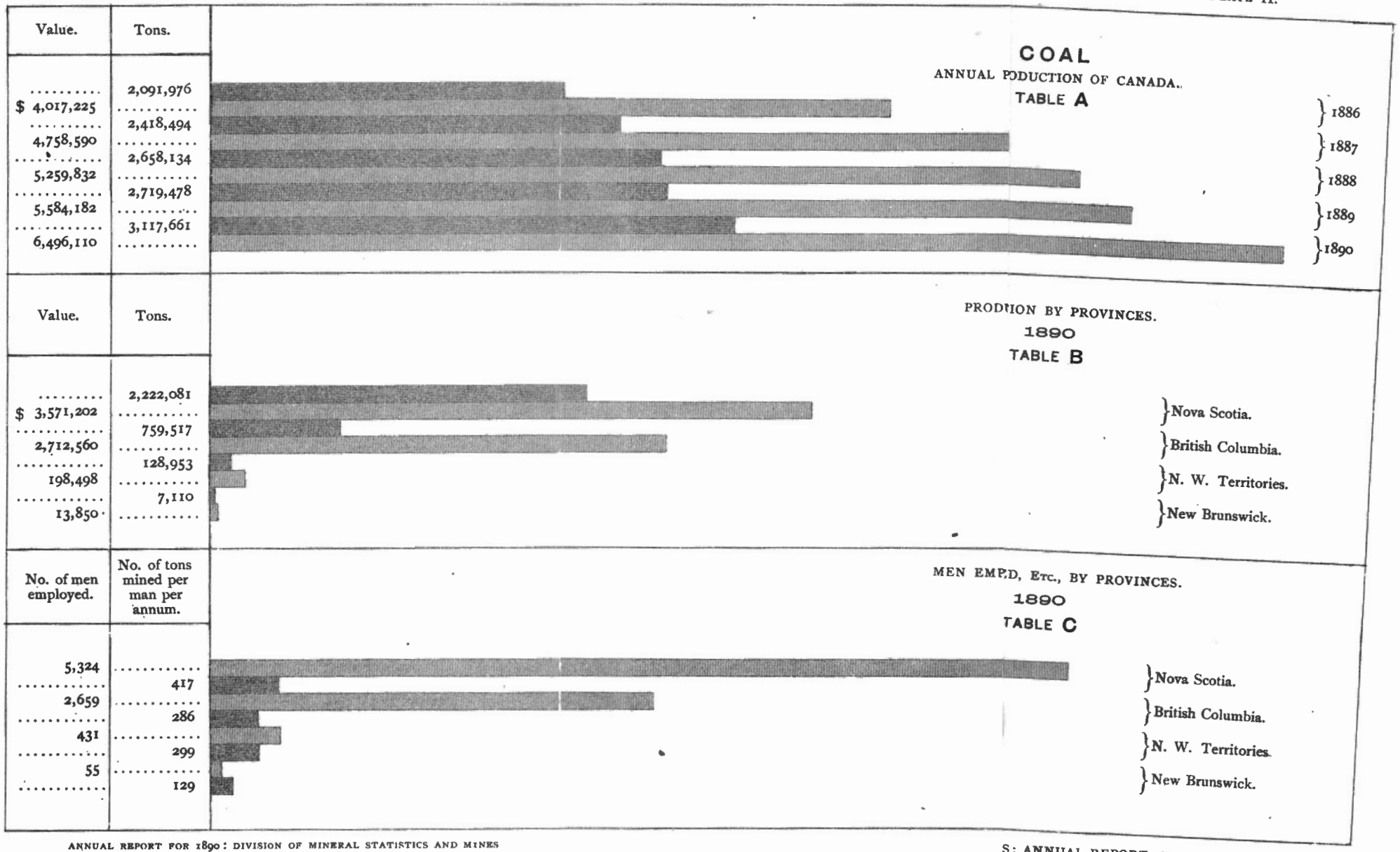
ASBESTUS.

TABLE 2.

Imports

IMPORTS.

Fiscal Year.	Value.
1885.....	$ 674
1886.....	6,831
1887.....	7,836
1888.....	8,793
1889	9,943
1890..	13,250


Value.
Tons.
COAL
ANNUAL PODUCTION OF CANADA.
TABLE A
..... 2,091,976
$ 4,017,225 .....
..... 2,418,494
4,758,590 .....
..... 2,658,134
5,259,832 .....
..... 2,719,478
5,584,182 .....
..... 3,117,661
6,496,110 .....
1886
1887
1888
1889
1890
Value.
Tons.
PRODUCTION BY PROVINCES.
1890
TABLE B
..... 2,222,081
$ 3,571,202 .....
..... 759,517
2,712,560 .....
..... 128,953
198,498 .....
..... 7,110
13,850 .....
Nova Scotia.
British Columbia.
N. W. Territories.
New Brunswick.
No. of men employed.
No. of tons mined per man per annum.
MEN EMP'D, ETC., BY PROVINCES.
1890
TABLE C
5,324 .....
..... 417
2,659 .....
..... 286
431 .....
..... 299
55 .....
..... 129
Nova Scotia.
British Columbia.
N. W. Territories.
New Brunswick.

COAL

TABLE D

NOVA SCOTIA
ANNUAL PRODUCTION.

Year	Tons
1870	700,861
1871	754,031
1872	984,664
1873	1,117,643
1874	977,446
1875	848,395
1876	794,803
1877	848,395
1878	863,081
1879	882,863
1880	1,156,635
1881	1,259,182
1882	1,529,708
1883	1,593,259
1884	1,556,010
1885	1,514,470
1886	1,682,924
1887	1,871,338
1888	1,989,263
1889	1,967,032
1890	2,222,081

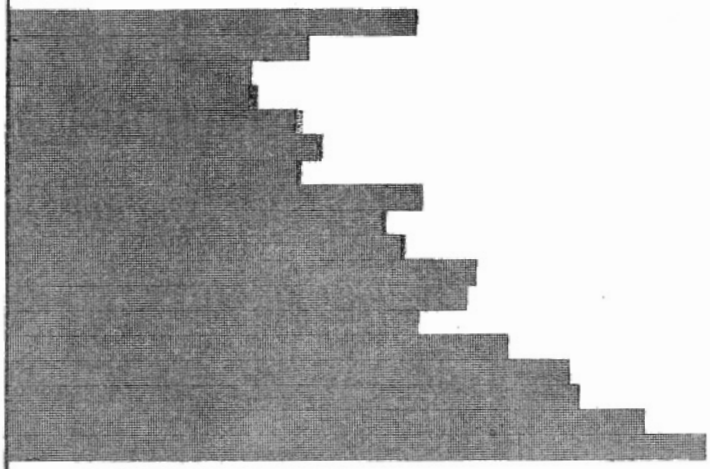
COAL

TABLE E

BRITISH COLUMBIA
ANNUAL PRODUCTION.

Year	Tons
1874	81,574
1875	110,145
1876	131,192
1877	154,052
1878	170,846
1879	241,301
1880	267,595
1881	228,357
1882	282,139
1883	213,299
1884	394,070
1885	365,596
1886	326,636
1887	413,360
1888	548,017
1889	649,409
1890	759,517

Year	Tons
1873	420,683
1874	310,988
1875	250,348
1876	248,638
1877	301,317
1878	327,959
1879	306,648
1880	432,188
1881	395,382
1882	412,682
1883	486,811
1884	474,405
1885	427,937
1886	520,703
1887	580,965
1888	588,627
1889	665,315
1890	724,486



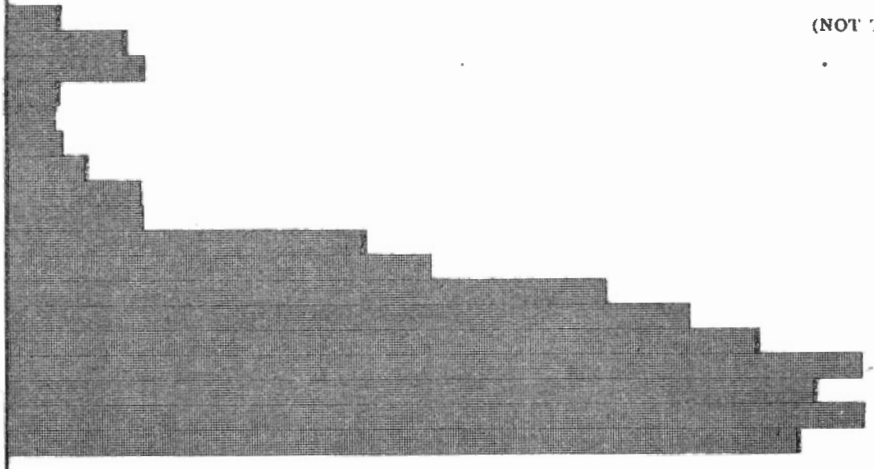
COAL

EXPORTS

(PRODUCE OF CANADA)

TABLE F

Year	Tons
1873	5,403
1874	12,859
1875	14,026
1876	4,995
1877	4,829
1878	5,468
1879	8,468
1880	14,217
1881	14,245
1882	37,576
1883	44,388
1884	62,665
1885	71,003
1886	78,443
1887	89,098
1888	84,316
1889	89,294
1890	82,534



COAL

EXPORTS

(NOT THE PRODUCE OF CANADA)

TABLE G

COAL.

Production.

Operations were carried on during 1890 in Nova Scotia, British Columbia, the North-West Territories and New Brunswick and altogether 3,117,661 tons of coal were raised, value at the pit's mouth, $6,496,110. This shows an increase in quantity over 1889 of 398,183 tons, and in value of $911,928. Comparison with years prior to 1890 is given in the accompanying graphic table A. The production by provinces is also graphically illustrated, and is given in table B, while table C shows the average number of men employed as well as the number of tons mined per man per annum.

The production of Nova Scotia and British Columbia is given in graphic tables D and E, respectively, while that of New Brunswick and the North-West Territories is given for the past four years in table 1, following:

COAL.

TABLE 1.

PRODUCTION IN NEW BRUNSWICK AND NORTH-WEST TERRITORIES.

Year.	New Brunswick.		North-West Territories.	
	Tons.	Value.	Tons.	Value.
1887.....	10,040	$ 23,607	74,152	$ 157,577
1888	5,730	11,050	115,124	183,354
1889.... . ..	5,673	11,133	97,364	179,640
1890.....	7,110	13,850	128,953	198,498

Exports.

The statistics of exports are given in the following tables 2, 3 and 4, and graphic tables F and G, which explain themselves:—

COAL.

TABLE 2.

EXPORTS: THE PRODUCE OF CANADA.

Province.	1889.		1890.	
	Tons.	Value.	Tons.	Value.
Ontario.....	55	$ 193	368	$ 559
Quebec...	7,249	17,848	12,599	32,233
Nova Scotia....	186,608	396,830	202,387	426,070
New Brunswick.....	710	1,728	37	161
Prince Edward Island.....	9	32	142	478
Manitoba..... ..	1	11	71	214
British Columbia.....	470,683	1,918,263	508,882	1,977,191
Totals..... . .	665,315	$2,334,905	724,486	$2,436,906

COAL.

TABLE 3.

Exports.

EXPORTS: NOT THE PRODUCE OF CANADA.

Province.	1889.		1890.	
	Tons.	Value.	Tons.	Value.
Ontario	72,008	$173,382	63,251	$150,258
Quebec	12,625	31,181	13,185	31,042
Nova Scotia	4,483	10,154	5,784	15,055
New Brunswick	178	500	136	395
Manitoba			178	801
Totals	89,294	$215,217	82,534	$197,551

Table 4 gives the exports annually since 1874 from Nova Scotia and British Columbia:—

COAL.

TABLE 4.

Exports: Nova Scotia and British Columbia.

EXPORTS: NOVA SCOTIA AND BRITISH COLUMBIA.

Year.	Nova Scotia.		British Columbia.	
	Tons.	Value.	Tons.	Value.
1874	252,124	$647,539	51,001	$278,180
1875	179,626	404,351	65,842	356,018
1876	126,520	263,543	116,910	627,754
1877	173,389	352,453	118,252	590,263
1878	154,114	293,795	165,734	698,870
1879	113,742	203,407	186,094	608,845
1880	199,552	344,148	219,878	775,008
1881	193,081	311,721	187,791	622,965
1882	216,954	390,121	179,552	628,437
1883	192,795	336,088	271,214	946,271
1884	222,709	430,330	245,478	901,440
1885	176,287	349,650	250,191	1,000,764
1886	240,459	441,693	274,466	960,649
1887	207,941	390,738	356,657	1,262,552
1888	165,863	330,115	405,071	1,605,650
1889	186,608	396,830	470,683	1,918,263
1890	202,387	426,070	508,882	1,977,191

The following tables 5, 6 and 7 show the amounts of coal annually imported into the Dominion since 1880 :—

COAL.

TABLE 5.

IMPORTS OF BITUMINOUS COAL.

Imports Bituminous Coal.

Fiscal Year.	Tons.	Value.
1880	457,049	$1,220,761
1881	587,024	1,741,568
1882	636,374	1,992,081
1883	911,629	2,996,198
1884	1,118,615	3,613,470
1885	1,011,875	3,197,539
1886	930,949	2,591,554
1887	1,149,792	3,126,225
1888	1,231,234	3,451,661
1889	1,248,540	3,255,171
1890	1,409,282	3,528,959

COAL.

TABLE 6.

IMPORTS OF ANTHRACITE COAL.

Imports Anthracite.

Fiscal Year.	Tons.	Value.
1880	516,729	$1,509,960
1881	572,092	2,325,937
1882	638,273	2,666,356
1883	754,891	3,344,936
1884	868,000	3,831,283
1885	910,324	3,909,844
1886	995,425	4,028,050
1887	1,100,165	4,423,062
1888	2,138,627	5,291,875
1889	1,291,705	5,199,481
1890	1,201,335	4,595,727

COAL.

TABLE 7.

Imports Coal Dust.

* IMPORTS OF COAL DUST.

Fiscal Year.	Tons.	Value.
1880	3,565	$ 8,877
1881	337	666
1882	471	900
1883	8,154	10,082
1884	12,782	14,600
1885	20,185	20,412
1886	36,230	36,996
1887	31,401	33,178
1888	28,808	34,730
1889	39,980	47,139
1890	53,104	29,818

* This table includes coal dust and all coal other than that specified as anthracite or bituminous.

Market in Canada.

Assuming that the imports, as given for the fiscal year, are equivalent to those for the calendar year, there is shown to have been a market for coal in Canada during 1890 equal to 4,974,362 tons as follows:—

	Tons.
Production	3,117,661
Imports	2,663,721
	5,781,382
Less—Exports	807,020
	4,974,362

Nova Scotia operators.

Nova Scotia—There were nineteen collieries producing, during 1890, as follows:—

Collieries.	Lessees.
Chignecto	Cumberland Coal Mining Co.
Joggins	Joggins Coal Mining Association.
Salt Springs	
Springhill	Cumberland Railway and Coal Co.
Acadia	Acadia Coal Co.
Black Diamond	
East River	B. G. Gray.
Intercolonial	
Holmes	
Bridgeport	General Mining Association.
Caledonia	Caledonia Coal and Railway Co.
Francklyn	
Glace Bay	Glace Bay Mining Co.
Gowrie	Archibald Blowers.
International	International Coal Co.
Ontario	Halifax Coal and Iron Co.
Reserve	Sydney and Louisburg Coal and R.R. Co.
Sydney	General Mining Association.
Victoria	

The production of each of these is given in the following table which is, as are all those relating to Nova Scotia, taken from the report of the Inspector of Mines for that Province.

COAL.

TABLE 8.

NOVA SCOTIA.

PRODUCTION BY COLLIERIES, 1890.

Colliery.	Tons.	Colliery.	Tons.
Chignecto	11,336	Francklyn	810
Joggins	68,181	Glace Bay	124,848
Salt Springs	157	Gowrie	158,031
Springhill	469,293	International	160,262
Acadia	307,924	Ontario	10,135
Black Diamond	37,270	Reserve	174,615
East River	1,523	Sydney	203,359
Intercolonial	120,668	Victoria	101,841
Holmes	65,303		
Bridgeport	31,610	Total	2,222,081
Caledonia	174,915		

In the following tables certain statistical information is given relating to the coal trade of Nova Scotia, which will explain itself:—

COAL.

TABLE 9.

NOVA SCOTIA.

PRODUCTION, SALES AND COLLIERY CONSUMPTION.

Period.	Production.	Sales.	Colliery Consumption.
	Tons.	Tons.	Tons.
1890—First quarter ... tons	364,428	239,264	37,357
" Second " "	587,806	528,966	53,669
" Third " "	647,488	677,441	47,167
" Fourth " "	622,359	554,773	42,396
" Totals "	2,222,081	2,000,444	180,589
1889 " "	1,967,032	1,741,720	177,106
1888 " "	1,989,263	1,765,895	176,336
1887 " "	1,871,338	1,702,046	156,550
1886 " "	1,682,924	1,538,504	159,512
1885 " "	1,514,470	1,405,051	142,939

COAL.

TABLE 10.

NOVA SCOTIA.

COAL TRADE BY COUNTIES, 1890.

YEAR 1890.	CUMBERLAND.		PICTOU.		CAPE BRETON.		TOTAL.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
First quarter	151,886	137,850	113,275	94,499	99,267	6,915	364,428	239,264
Second "	139,132	122,443	131,437	114,349	317,237	292,174	587,806	528,966
Third "	74,319	67,703	150,200	147,032	422,969	462,706	647,488	677,441
Fourth "	183,629	163,245	137,788	126,290	300,942	265,238	622,359	554,773
Totals...	548,966	491,241	532,700	482,170	1,140,415	1,027,033	2,222,081	2,000,444
1889...	549,294	469,983	483,145	429,500	934,593	842,237	1,967,032	1,741,720

COAL.

TABLE 11.

NOVA SCOTIA.

DISTRIBUTION OF COAL SOLD.

Market.	1889.	1890.
	Tons.	Tons.
Nova Scotia :—		
Transported by land.....	351,995	390,322
" sea..... ...	264,481	283,869
Total..... ...	616,476	674,191
New Brunswick.....	218,595	251,749
Newfoundland.	98,048	107,557
Prince Edward Island.....	61,533	62,544
Quebec	707,612	842,163
West Indies.	4,461	5,284
United States.....	33,584	56,956
Other countries....	1,411	....
Total..... ..	1,741,720	2,000,444

Nova Scotia developments.

Regarding operations in the province, the following notes are taken from the report of the Inspector of Mines above referred to:—

" *Pictou County.*—At the Intercolonial Colliery extensive workings were pushed into the Holmes area, and the coal found to be of good quality. Preparations are being made at this mine for erecting a powerful hoisting engine to draw coal direct from the dip workings, and to do away with the intermediate engine. Further work in the second seam

leads to the hope that next season it will furnish a large supply of coal of good quality. The manufacture of coke has been commenced here and the results are pronounced satisfactory. Nova Scotia developments.

"At the Black Diamond Colliery the extraction of pillars has been continued.

"At the collieries of the Acadia Coal Company a new hoisting engine has been procured for the Acadia Slope. The work of reopening the Ford pit has been steadily carried out. The old workings have been isolated, and the levels, etc., are being driven in the bottom coal, leaving a cover of twelve feet of coal between them and the old workings in the upper portion of the seam.

"*Cape Breton County.*—Some prospecting was done in the rear of Big Pond, East Bay, Cape Breton County. The following analysis of coal was made for the Rev. M. A. McPherson:—

FAST COKING.

Volatile matter	41·79
Fixed carbon	44·98
Ash	13·23
	100·00
Coke, per cent	58·21

"It yields a firm co-herent coke. The gases evolved during coking burnt with a yellow smoky flame. Colour of ash, purplish brown. G. C. Hoffman (Geo. Sur., Canada).

"*Other Counties.*—Discoveries of coal were reported from Parrsboro', Cumberland County, and from Middleton, Annapolis county.

The following information also taken from the report of the Inspector of Mines for Nova Scotia, is by Mr. Wm. Madden, Deputy Inspector for the counties of Pictou and Cumberland, and relates to mines in those counties:—

"*Pictou County.—International Coal Mining Company, Westville.*—During the year an attempt was made to connect the workings of No. 4 slope with the workings of slopes Nos. 1 and 2 for the purpose of hoisting the coal to surface at one outlet. The water, however, became so heavy that the sinking and other necessary operations in this line had to be discontinued and the connection has not been made. In No. 4 they continued drawing pillars until June, when work was stopped, and the men were transferred to No. 1 slope, which was then worked double shift.

"In March, the levels going south in No. 1 slope were driven to the limits of the area on that side, and beyond the barrier, into the adjoining area. In October, they started drawing the pillars near the line. About

Nova Scotia developments.

the same time operations were resumed in the Scott pit, with the idea of testing the coal, which is the second seam in this district, that is, it immediately underlies the seam or vein on which slopes Nos. 1 and 2 and 4 are driven, a vertical distance of about 300 feet separating them, It has been a general idea that this second seam or vein, to the dip, would improve in quality, and the management has fully determined to satisfy themselves upon this point. In this year much labour and care has been bestowed upon the air-ways in the old slopes (Nos. 1 and 2), by in many places repairing and enlarging them ; the results have been satisfactory. It has been decided to make further extensive improvements, by erecting larger and more powerful winding engines on the bank, enabling them to hoist not less than from twelve to fifteen boxes from a depth of from 4,000 to 5,000 feet, instead of only seven boxes, as heretofore, thus permitting them to do away with the underground engine at the 1,700 feet level. The old slopes have been timbered, and rails laid to the 3,300 feet level, in preparation for the changes.

"*Acadia Mines, Westville.*—Work has been very steady at this mine for the past year, pillar working in the 3,100 ft. lift forming the principal feature. It is now nearly finished, and has been very successfully prosecuted, a large percentage of coal having been obtained. In the next lift 3,560 feet, the levels on the north side have been driven 2,000 feet, and are now stopped. On the south side the levels have been driven some 2,500 feet and are still working.

"*Vale Colliery, Acadia.*—McBean Seam.—At this mine, which unfortunately about a year ago caught fire, the coverings of the Travelling slope and East intake were removed on the 22nd March, and left open for a few days, when, the temperature beginning to rise rapidly, it was deemed best to close them up again. It has remained in this situation since that time.

"Six Feet Seam.—Work has not been very actively prosecuted here. In August, in the west side, 3rd Balance, 1,000 ft. lift, they began drawing the pillars. The levels going east and west on this lift were stopped. In the lower lift the levels on both sides are being driven.

"*McGregor Pit, Stellarton.*—At this pit they have been opening up the lower lifts ; the coal is strong and gives off considerable gas, so that it was found necessary to prohibit the use of powder on the lower lift, south side. This made a very difficult job of driving the balance. They have, however, succeeded and started eleven bords on south side balance. The balance west side of south slant is up and bords started off; the air being increased by getting those places through, so that powder is now again used in the lower shift, south side. The balance on south

side north slant is also driven up, and air likewise increased largely. The pillars along the crop have been very successfully won. A new place has been driven to the surface with the view at some future day to utilize it for a hoisting slope, doing away with the shaft and underground engines. Nova Scotia developments.

"*Douglas Slope.*—No. 2.—This slope has been cleaned up and timbered. On 1st September the mine bords and levels going east and west were started to work. The drift which, about six months ago, was driven with the aim of catching the Cage-pit seam, has been excavated through rock and stone, etc., a distance of 250 feet, at which point the cage-pit seam was struck, thus winning a large field of coal for this slope to handle. Boreholes to tap the drift connecting the cage-pit and Foord pit were put through, and the water of 3rd seam is now running to the Foord pit.

"*Black Diamond Mine, Westville.*—This mine has been kept pretty steadily at work during the year, pillar working forming the principal feature. They began some 1,500 feet down the slope drawing the pillars that had been left to support the travelling and main slopes, and are succeeding in getting some very fine clean coal.

"*Lawson Mine.*—A small amount of work has been done here during the year. The ventilation (natural) during July and August gave some trouble. Their pump is not of sufficient capacity, and, in consequence, the water gave them difficulty. Some prospecting was done in the month of October. Twenty-five men were employed in December.

"*Minudie.*—Ten or twelve men worked here for the first three months of the year, taking out some very good coal, supplying local demands; it then remained idle from March to November, when work was again begun, and at my visit in December, twelve men were employed.

"*Chignecto.*—This mine worked on in the usual way until July, when most of the men were dismissed. Some 19 or 20 were, however, retained prospecting until late in the fall, when Mr. Frank Burrows, underground manager, took these men and began taking out coal along the crop-out on the eastern side of their works, and as it can be got water dry, the idea is to keep these men employed for the winter months in readiness for prospecting next spring.

"*Scotia* —Alexander Dewar began taking coal out of what was formerly known as the Scotia area, and on my visit in December he had 3 or 4 men employed."

From the statement of Mr. P. Neville, Deputy Inspector for Cape Breton Island, the following notes have been taken, which will illustrate the year's operations in that part of the province :—

Nova Scotia developments.

"*Gowrie Mines.*—Work has been carried on its usual way, levels extended on both sides of the low lift and rooms broken off. On No. 1 lift west side, the levels have been driven about 99 feet parallel to the stone troubles; it is found, as they advance, that the coal is dipping slightly to the south-west, so that the course of the levels are now going more northerly, gaining more grip on the seam. The management say it is their intention this winter to drive through and come out on the opposite side of the basin.

"*Ontario Mines.*—During last winter pumps were placed below No. 1 level for the purpose of drying the dip workings. The water was lowered by the 10th of June a distance of 200 feet to No. 2 level, and up to the last of September it was lowered to No. 3 level, a distance in all of 460 feet. From that date the pumps seemed to be getting out of order and the water raising. Finally work ceased on the 31st of October and pumps and pipes removed to the surface. The coal mined here during the season was taken from No. 2 section, north side between No. 1 and No. 2 levels. A few pillars have been drawn up and split in No. 3, north side; also six rooms were worked at the face of the solid coal, below No. 1 level, south side.

"*Caledonia Mines.*—Work has been brisk at this mine during the last season. The main deeps have been driven down 300 feet; No. 2 levels, above this, have been extended on the west and east sides, and rooms broke off and worked. A slant road has been driven from this east level coming out at the east side of the pit, for the purpose of drawing coal from that section. A small section of pillars have been drawn and split in the east side rise workings. A new double engine has been imported and placed on surface east of the hoisting shaft for the purpose of drawing the coal from the deeps. Also, preparations are being made to put a double furnace where the single one is now.

"*Little Glace Bay.*—The operations at this colliery during the year has chiefly been the extension of rooms already gained and worked off the levels. The rooms south of the 1,800 feet headway have been worked, and some of them drawn up to the Harbour pit workings.

"*International Mines.*—The pit bottom has been re-timbered; the back deeps have been driven, connecting No. 9 landing; laid and worked No. 8 and 9 landings. No. 6 section has been driven seawards to the barrier and stopped; south side drove and laid angle deeps, from pit bottom level to No. 1 landing on incline deep.

"*Reserve Mines.*—During last winter the east slope was driven down and a new lift of 600 feet gained, and levels turned off east and west. The west levels were driven three chains, and the east eight; back deeps

were also driven and rooms broke off and worked parallel to the level. A new travelling road has been made up the back deep on east side. The barrier between No. 2, east side level, and No. 6, west side, has been pierced for the purpose of letting off the water from that section, which had been filled for a number of years. This done, it was found that the pump on the east side was not equal to the task, and a new pump has been placed at the bottom of the west slope to dry No. 6. Nova Scotia developments.

"*The Emery Mine*, which had been idle for a number of years, and full of water, has this year been pumped out, and a pump placed below the bottom of the pit, by which the water is pumped up the shaft to the surface. This shaft has been repaired, and slides and cages put in. The coal is raised to bank in half-ton boxes. A bank-frame and engine-house have been erected, and an engine and boiler placed therein; also, a branch railway of 400 yards has been built, connecting with the Reserve road. The levels in the west side of the pit have been driven about 700 feet, and headways driven towards the rise; rooms broke off and worked; these rooms are eighteen feet wide; pillars eighteen feet thick; cross-cuts twelve feet, and sixty feet apart. On the east side, the old levels and rooms have been extended, and a pair of dip-slants is being driven, in order to gain a lift of 600 feet.

"*Old Bridgeport.*—Levels and rooms have been extended on the south side of the pit. No mining has been done during the year north of the furnace headway. The band of the shale, spoken of in last year's report, was found to be quite thin in the levels or low rooms, and consequently it was taken down with the top coal, which made the seam about nine feet thick. However, as the levels advanced it was found again to thicken, and the management thought it more profitable to timber and keep it up than take it down. A section of pillars have been drawn from south of mine headway.

"*Gardner Mines.*—This property has been acquired by Messrs. Burchell Brothers. This property has been closed down since 1879, previous to which it was worked by the Gardner Coal Company. It was thoroughly equipped with the best machinery, some of which are still in excellent condition. Work commenced there in the latter part of the summer, getting everything in order to be ready for shipping at the opening of navigation next spring. Engine houses and miners' cottages are being erected.

"*Victoria Mines.*—Work has been carried on at this mine in its usual steady way during the year. The east dips have been extended and a lift of 600 feet gained; this lift being free from water is completely dry; levels have been turned off east and west, and driven 150 yards. A

Nova Scotia.

balance was driven upon the east side and rooms broke off. The levels on No. 2 lift are still being extended in driving up the balance.

"*Sydney Mines.*—I am glad to state that a great improvement have been made in this pit during the year for the safety of men's lives. New travelling ways have been made on the south side, a distance of 1,700 yards. On engine and incline planes, where the roadway was found narrow, additional manholes have been driven between the ones there already, according to law. On the north side bankhead landing, where the road was narrow, the place has been made wider for 300 feet, so that there is now ample room to pass the standing or moving trips. No. 3, or pump deep, has been working since the 27th of May last. This is one of the submerged districts. The deeps have been extended 300 yards in solid coal, and rooms broken off right and left and worked."

The value of Nova Scotia coal has been computed at $1.80 per ton of 2,240 pounds at the pit's mouth, or $1·607 per ton of 2,000 pounds.

New Brunswick.

New Brunswick.—A small quantity of coal was raised in this province during the year, and was the result of the operations of fourteen producers in the neighbourhood of Grand Lake, Queen's and Sunbury counties, from whence it is shipped principally to St. John. The seams are small, and the work of a desultory character, being carried on principally by farmers, who, during the winter months and between the seasons of sowing and harvesting raise small quantities from pits sunk on their properties.

North-West Territories.

North-West Territories.—Returns were received from seven producers, the principal one being the Alberta Railway and Coal Company, operating at Lethbridge, Alberta, the others being in the vicinity of Calgary and Edmonton, where small seams are worked to supply local demands.

Large deposits of coal have been located in the vicinity of Canmore and between that point and Anthracite, and it is confidently expected that the new discoveries, as well as the older workings at Anthracite, will be operated during the present year, as it has been found that the anthracite and semi-anthracite afforded by these deposits are of very superior quality.

Regardingg the deposits at Canmore, Dr. Selwyn, in his summary report for 1890, writes:

"On the 29th of August a short time was spent at Canmore to look at the coal mines newly opened there on the seams on the right bank of the river described, pages B–132 and 133, Annual Report, Geological Survey, Vol. 1, 1885. The three feet seam is now being worked by a slope which starts on a terrace about 200 feet above the river, where a small outcrop

of the measures is exposed dipping 50° to 60° to westward. In a level being driven in to the hill to cross cut the seams, about 100 feet below the slope, the dark shales associated with the coal had been struck at about 30 feet in dipping 30° to north-east, so that there must be either a fault or a steep anticlinal fold along the face of the hill. The coal is much crushed and slickensided. It is apparently a semi-anthracite, like that from Cascade River—see analysis, Part M., Annual Report, Geological Survey, Vol. 1, 1885. There can be little doubt that the Canmore seams are the extension of those of Cascade River and Anthracite on the opposite side of the Bow River valley. The mine is already connected by a branch railway with the station at Canmore; an incline tramway and shipping stages have been constructed at the mine and there is now every convenience for handling a large output."

Dr. Selwyn also visited the Turtle Mountain coal area, of which he writes, in the above referred to report, as follows:—

"In the Turtle Mountain coal field, range 24, township 1, several pits and bore holes have been sunk and in all seams of lignite-coal of workable thickness have been struck. In one pit, now full of water, but said to be 50′ 6″ deep, strata are stated to have been passed through as follows:—

	Feet.	Inches.
Surface	3	0
Dark clay	4	0
Coal	5	6
Clay shale	10	0
Coal	3	6
Sandy brown shale	6	0
Soft whitey brown sandstone	2	0
Sandy clay	6	0
Coal	1	6
Friable whitey brown sandstone	12	0
Bored from bottom of shaft—sandstone	20	0
	73	6

"In another pit, 150 yards south of the one above described and about 15 feet higher, the coal was struck at 40 feet 4′ 6″ thick, then 12 feet sandy shale and thin bands of iron ore; coal 1′ 6″ then bored 25 feet through sandy shale; total 78′ 6″. This is the only pit from which any coal has been raised. An engine with winding gear and shaft house have been erected here and a few tons of coal raised. This section is probably the most reliable, and omitting the upper 5′ 6″ seam of coal given in the first section, which is probably a mistake—the two sections are much alike. The coal or lignite, like that of the Souris at Roche Percée, slacks on exposure and would not bear distant transport. The seams probably underlie the whole of Turtle Mountain, except where deep ravines have been cut out and have been filled in again with the superficial drift

deposits. They will probably be found in places in township 1 from range 19 to 24. They could be mined at small cost, and for use among the settlers in the treeless country to the north and north-west between the Souris River and the Mountain would prove a cheaper and more economical fuel than wood.

"I examined this district in 1883, and in the Summary Report for that year, page 2, it was stated 'the evidence obtained clearly shows that there is every likelihood of workable seams being found here, as on the south flank of the mountains, at the head of Willow Creek in Dakota a seam has already been found showing from 3 to 5 feet of lignite of fair average quality.' The seams now opened are doubtless the extension of those above referred to on Willow Creek, and as soon as railways are constructed to the mines, the lignite could be very advantageously distributed over a wide extent of country in which wood is even now scarce and costly, and yearly becoming more so."

British Columbia.

British Columbia.—The production of coal in British Columbia is that of four collieries, viz.:—

Nanaimo	Colliery,	owned by	The New Westminster Coal Mining and Land Co.
Wellington	"	"	R. Dunsmuir & Sons.
E. Wellington	"	"	East Wellington Coal Co.
Union	"	"	Union Colliery Co.

Statistics regarding their output are given in the following table 12, for comparison with which a similar table, No. 13, published for 1889, is given.

COAL.

TABLE 12.

BRITISH COLUMBIA.

PRODUCTION, SALES, &c., FOR 1890.

Name of Colliery.	Coal raised.	Sold for home consumption.	Sold for exportation.	On hand, 1st Jan., 1889.	On hand, 1st Jan., 1890.	Number of men employed.
	Tons.	Tons.	Tons.	Tons.	Tons.	
Nanaimo.....	436,246	110,141	327,946	10,744	6,802	1,493
Wellington.....	195,436	78,141	119,035	3,416	2,794	646
E. Wellington..	49,954	9,502	39,348	612	1,605	170
Union.	77,881	1,659	82,933	10,431	3,720	350
Totals... .	759,517	199,443	569,262	25,203	14,921	2,659

Coal.

Table 13.

British Columbia.

1889.

Name of Colliery.	Coal raised.	Sold for home consumption.	Sold for exportation.	On hand, Jan. 1st, 1889.	On hand, Jan. 1st, 1890.	Number of men employed.
	Tons.	Tons.	Tons.	Tons.	Tons.	
Nanaimo.....	250,735	44,929	200,800	5,736	10,744	875
Wellington....	306,189	85,707	221,011	4,145	3,416	862
E. Wellington..	57,537	8,552	48,259	112	612	190
Union.	34,948	112	26,645	2,240	10,431	314
Totals	649,409	139,298	491,715	12,233	25,203	2,241

British Columbia developments.

Regarding the operations and development in British Columbia during the year, the following notes are taken from the report of the Minister of Mines of that province:—

Nanaimo Colliery.

"The coal from this colliery was in good demand during the past year.

"*No. 1 Pit, Esplanade, in Nanaimo.*—This mine, forming part of the Nanaimo Colliery, belongs to the New Vancouver Coal Mining and Land Company (Limited). As in the previous year, the workings in this pit have been from what is known as No. 1 and No. 3 North Levels. All the workings from these levels are under the water of the Nanaimo Harbour, and are getting to be very extensive. The No. 1 Level with its windings is in about 2,800 yards from the shaft in a north and westerly direction. In this division of the mine they have taken much coal during the past year, the coal being of a first-class quality, hard, and will average about seven feet thick. They have drifted or run the level in about 800 yards, without a fault or hitch of the smallest kind. Here they have as many employed, considering the distance, as they can take coal away from; and at present they have coal won where they could employ 100 more men than what are now employed in this district of the mine. At the back of the level they are only a few yards from working under Protection Island, under all of which, I have reason to believe, lies this famous and valuable coal. In No. 3 level there has been much prospecting and exploring done. They are now getting out a considerable quantity of good coal, but they do not seem to have got into the extensive field where No. 1 is, although they are working towards it and expect to get in soon.

British Columbia developments.

"*No.* 3 *Pit: (Chase River), Nanaimo Colliery.*—This is mentioned in a previous report as being near to the mouth of Chase River. With the exception of a short stoppage in the early part of the summer this mine has been worked steadily. The coal from here is of a very good quality, and hard. As it is worked on the pillar and stall system and that by a slope, and having got as far as it is intended to go at present, all the mining is at the pillars (coal), which were left behind to support the roof; those pillars being fully one-half of the coal that was in the mine at the start, so that there is yet a large output to be got here.

"*South Field Mine, No.* 1 *and No.* 2.—These mines are now what are known as the South Field mine.

"This mine is worked by a slope from the surface, and is now down about 800 yards, but at present it is not worked in the bottom, and nearly all the coal came out from the south side. It has been the greatest producing mine of the colliery. This coal is of a very good quality, and in some parts is about 18 feet thick, but as in the other mines it had faults now and again to contend with. The coal is mined on the pillar and stall system.

"*No.* 4, *South Field Mine.*—This is the slope mentioned in a former report, and about half a mile from No. 3 pit. It is down about 1,000 yards with a long level to the south side. The company have been to a great expense here, and at times prospects looked favourable, and it was reasonably expected that good coal would be early found here, as they have good coal coming this way from No. 3, and also from bores they put down away to the dip only a few hundred yards ahead; yet, with all those encouragements, the prospects are not looking very favourable; but it is to be hoped that there will before long be a profitable mine here, the location being good, and well situated for other works.

"*No.* 5, *South Field Mine.*—This is a new shaft which the company are putting down to the dip and north of the working of No. 2 slope, after having put down a series of bore holes. The prospects from those holes gave them encouragement to start the above shaft, which is now down 100 feet; and they expect to reach the coal a little over 500 feet from the surface. As the company have got machinery and head gear up, to be used in the sinking, it may be expected that, in the absence of unforeseen accident, the company will get to the coal early in the summer, and this will be quite an acquisition to the proprietors.

"*North Field Mine, Nanaimo Colliery.*—This mine is mentioned in a previous report as being in the northern part of the New Vancouver Coal Company's extensive estate. The mine has been worked contin-

uously during the past year, the coal varying in thickness from three to six feet, and is very hard and of a very good quality. It is in good demand both in the Victoria and California markets, and commands the highest price. British Columbia developments.

"During the past year the company have been sinking another shaft, which is about 70 yards west of the hoisting shaft, and had got down to the coal and connected with the works at the end of December, so that once they get these works arranged this second shaft will be their return or up-cast shaft, and will also form a second connection or outlet with the surface. Little or no gas has ever been seen in this mine."

Wellington Colliery.

"*No.* 3 *Pit, Wellington Colliery.*—This pit, as has been mentioned in a previous report, is in the valley of the Millstone River. The workings are all by way of a slope from the south side of the shaft.

"In this pit much of the work is under the valley, which is sometimes overflowed at very high stages of the river. As well as mining underneath the valley, a great deal of work has been done below the high bluff overlooking the valley. The workings here have only been at pillars (coal), and that under the bluff, as it is not the intention of the manager to take any of the pillars from under the valley, until every other part is worked out; this is done as a safeguard against an inflow of water from the surface. They were working at the pillars up to the 16th May, when there was a strike, and up to the present time there has not been any coal taken out of this mine. Water was being pumped out as usual up to the 26th August, when I was there and went down the mine with Mr. Bryden, the manager. We were satisfied that the gob was heating from the steam and smoke that travelled along the return airway.

"*No.* 5 *Pit, Wellington Colliery.*—This is about the most extensive mine in this colliery. The coal is worked here from the east and west sides, also from an incline on the south, and a slope to the north. As this has been on the pillar and stall system (with the exception of part of the slope that is long wall), there has been much good coal worked here. Now at the south incline and west side, all the mining is at the pillars, which contained about two-thirds of the entire coal; but of course there are many of them by this time taken out. On the east side they are working in the solid coal, and also at the pillars. Down the slope to the north the long wall system works well, but it has to be closely attended to.

British Columbia developments.

"In this slope there is also a considerable amount of work done on the pillar and stall system. Down this slope and also in the east level there is the prospect of having a very extensive mine for many years to come.

"*No. 6 Pit, Wellington Colliery.*—This is the same mine as mentioned in a former report, and about 900 yards east of the No. 4 Pit. Although working, the two shafts are only a short distance from each other; but that small piece is to remain, as it is not the manager's intention to connect those works for some time. This is going to be a very extensive mine, the coal almost lying flat, so that the working is all around the shaft, with a great extent to spread out. The coal is very good and hard, from six to eight feet thick, and worked on the pillar and stall system, which seems to be the best way of mining in this colliery, all things being considered.

"*No. 2 Slope, Wellington Colliery.*—There has been little or no coal mined or work done here during the past year, but the company intend to resume work early in the spring.

East Wellington Colliery.

"This property of the East Wellington Coal Company comprises two shafts, known as No. 1 and No. 2, which are in the valley of the Mill-stream. The shafts are about half a mile apart by a direct course, and are worked as one mine.

"In No. 1 Pit, coal only comes from a few men, and that from the west level, towards the No. 2. The coal is of the usual good quality, and hard, but the company are much troubled with faults of one kind and another. On the east side they are now in a long distance which has proved one continuous fault, with a little black dirt here and there; but as this side is the greater part of their estate, they are determined to find out what is in it, and it is to be hoped that they will yet find a good piece of valuable coal as they have incurred a large outlay. I might say it has been up-hill work all the way.

"*No. 2 Pit, East Wellington Colliery.*—In this pit the company have been working steadily all the year, except for a day now and then. The coal has kept good, and is in good demand in San Francisco, where most of it goes.

Union Colliery, Comox.

"This colliery belongs to the Union Colliery Company. The mines are only a few miles from Comox. This company are working two veins of coal, two mines, known as No. 1 and No. 2 tunnels, or adit levels, going in on the hill side on the south side of the railway, and high above its level. Both of these levels are in about 600 feet, in good hard coal, and from two three feet thick, overlaid by a strong sandstone. The mines here are on the pillar and stall system, and are very safe workings.

British Columbia developments.

"*No.* 1 *Slope, Union Colliery.*—This slope, which is now down about 2,000 feet, has not been extended any distance during the past year, but the levels from it to the north side have been working steadily the most of the year, that is by three levels with the stalls therefrom. The coal has kept good and very hard, and improving a little in thickness, being from three to five feet thick, with a strong roof. There are good indications to show that this seam of coal will improve in thickness, going to the north.

"*No.* 1 *Shaft, Union Colliery.*—This is the shaft mentioned in a former report. There has been much prospecting done here during the past two years, but there has been very little coal taken out. Now it is looking better, and the company have the prospect of yet getting good workable coal, and it is hoped that they will do so after going to so much expense.

"*No.* 2 *Slope, Union Colliery.*—This is a new mine, started during the past summer, and about one mile north of No. 1 slope. Here the coal was easy to get at, and now the company have put a slope down 260 yards. The coal will average six feet thick. This coal is very hard, of good quality, and resembles the Wellington coal, and I may say that it is the most valuable strike of coal that has been made here by this company, and is a good thing for them, also for the settlers of the extensive district of Comox, as well as for the province in general. The company have put down a series of bore-holes away ahead of this slope, which have proved the coal for a long distance.

"*New Vancouver Coal Mining and Land Company, Limited.*—The workings from the No. 1 shaft have now got through under the harbour, with one and three-quarters of a mile to haul the coal, this being about under Protection Island. There was a bore-hole started in this island about three months ago, and pushed with all haste. When at the depth of 588 feet coal was struck, and as it was gone through it proved to be a good workable seam. After going through this, the bore-hole was continued, and at the depth of 650 feet from the surface another seam of coal was struck, which was thought to be a continuation of the first seam of coal that was worked on Newcastle Island, and also in the old No. 3 Pit, Front Street, Nanaimo. As the coal from both those places was of a good quality, there is no reason to think that it is not as good under Protection Island and the waters of Nanaimo Harbour. Near to this bore-hole the company is preparing to sink a shaft, making every preparation to start, so as to lose no time, in order that they may be able to ship coal from this island at as early a date as possible. There is now a wharf built on the island for landing the machinery and materials."

Coke.

Coke. During the year there were produced in Nova Scotia 56,450 tons of oven coke, valued at $166,298, the greater part of which was consumed in the manufacture of iron at Londonderry, N. S. In no other province is oven coke produced, though gas coke is, of course, made in all cities where coal is used in the manufacture of illuminating gas; the coke so obtained being sold locally, whilst no returns of production were collected.

According to direct returns the production during the past year has been,—

1886	35,396	tons	valued at	$101,940
1887	40,428	"	"	135,951
1888	45,373	"	"	134,181
1889	54,539	"	"	155,043

The following table shows the imports of oven coke since 1880:—

COKE.

TABLE I.

IMPORTS OF OVEN COKE.

Fiscal Year.	Tons.	Value
1880	3,837	$19,353
1881	5,492	26,123
1882	8,157	36,670
1883	8,943	38,588
1884	11,207	44,518
1885	11,564	41,391
1886	11,858	39,756
1887	15,110	56,222
1888	25,487	102,334
1889	29,557	91,902
1890	36,564	133,344

Peat.

Peat. In his summary report to the Director of the Geological Survey for 1890, Mr. Robert Chalmers makes the following mention of extensive deposits of peat in that part of New Brunswick in which he was making investigations during the year:—

"Peat is found in extensive bogs along the coast, especially near the Kouchibouguac, the Kouchibouguacis, Aldouane, Richibucto, and in many other places. These bogs are often deep, and produce abundant crops of cranberries. In the interior, large bogs often occur upon the flat, undrained portions of the district, but they are usually shallow, and in many cases support a scrubby growth of hacmatac and black spruce. No use has yet been made of peat in this part of the country."

COPPER.

As in former years the copper product of the year is represented in the shipments of sulphuret ores from the mines of the Eastern Townships of Quebec and those of the copper-nickel ores from Sudbury. Production.

The characteristics of the latter deposits are given later in this report under the head of nickel.

The chief contributors from the Quebec district were the Albert and Crown Mines at Capelton, operated, as formerly, by Messrs. G. H. Nichols & Co., and the Eustis Mining Co., respectively, and the Moulton Hill and Howard Mines, operated by Mr. E. R. Howard. Messrs. G. H. Nichols & Co. have lately started operations at the old Huntingdon Mine, on lot 8, range viii, of Bolton. The others are all situated within a radius of six miles of the town of Sherbrooke, in areas of Pre-Cambrian chloritic, micaceous and talcose schists. The Howard Mine is close to the contact of these, with the Cambrian rocks to the north-west. Quebec.

The workings are on the veins running parallel with the strike of the schists or perhaps rather on belts of the same, impregnated with copper and iron sulphurets. These are of considerable width, in places being said to occasionally attain a thickness of as much as 50 feet in some of the workings of the Capelton Mines, where they have been followed to a depth of over 1,500 feet.

The ores average about four per cent of copper, the percentage of sulphur ranging between 35 and 45 per cent, whilst they also contain a little silver, averaging probably about 4 ounces per ton.

At the Albert Mines Messrs. G. H. Nichols & Co. have very extensive and well equipped works for the utilisation of part of their ore in the manufacture of sulphuric acid, the "fines" being used for this purpose, whilst the higher grade ore is shipped direct to their other works at Laurel Hill, New York, and similarly treated. At the Capelton works, also is a Herreshoff water jacket furnace intended to bring the "cinder" remaining after burning off the sulphur from the ore, to the state of "matte." The great bulk of the ore from the other mines was shipped raw to acid-makers in the United States, although a small proportion was burned and reduced to the state of matte and thus shipped by the Eustis Mining Company.

The amount of copper contained in the mixed silver, lead and copper of the mines of southern British Columbia could not be ascertained as, the official returns give only the total value of the ores for both the copper and silver contents. This, however, does not amount to quite $45,000 and as the greatest value of that lies in the silver, the amount of copper thus overlooked cannot be very considerable. British Columbia.

Nova Scotia. No contribution has been made to the grand total by the province of Nova Scotia this year, the activity in this direction being confined to development work and some little prospecting, of which the Report of the Department of Mines of the province speaks as follows:—

"Some attention has been given to the copper ores of Brierly Brook and Pinkietown, Antigonish county, and a lease has been taken at the former place by Mr. John Grant.

"A good deal of work was performed at the Coxheath Mines, Cape Breton county, and but for the general financial depression, systematic works would have been started last fall. The No. 2 shaft was sunk to the 250 feet level, and a cross cut was driven 134 feet to the north cutting the main, or B. vein, which was found to be 32 feet wide, and to yield a considerable proportion of smelting ore assaying from 10 per cent to 20 per cent copper, with a little silver and gold. On the new vein lying south of the present workings a shaft has been sunk 50 feet in paying ore, and on the surface it has been traced 1,000 feet. No. 1 shaft was unwatered and repaired, and the drill plant prepared, so that a drift would be run into vein B, lying a short distance to the south. The additional drills and compressors alluded to in a previous report have been added to the plant, giving it a strength of ten drills, with two in reserve; and some 3,000 feet of piping has been laid to connect shafts 1 and 3 with the plant at shaft No. 2. On the Argyle area the westward extension of the veins has been further tested, and a point has been selected for a new shaft.

"Mr. J. P. Gragg makes the following return of labour performed during the year 1890:

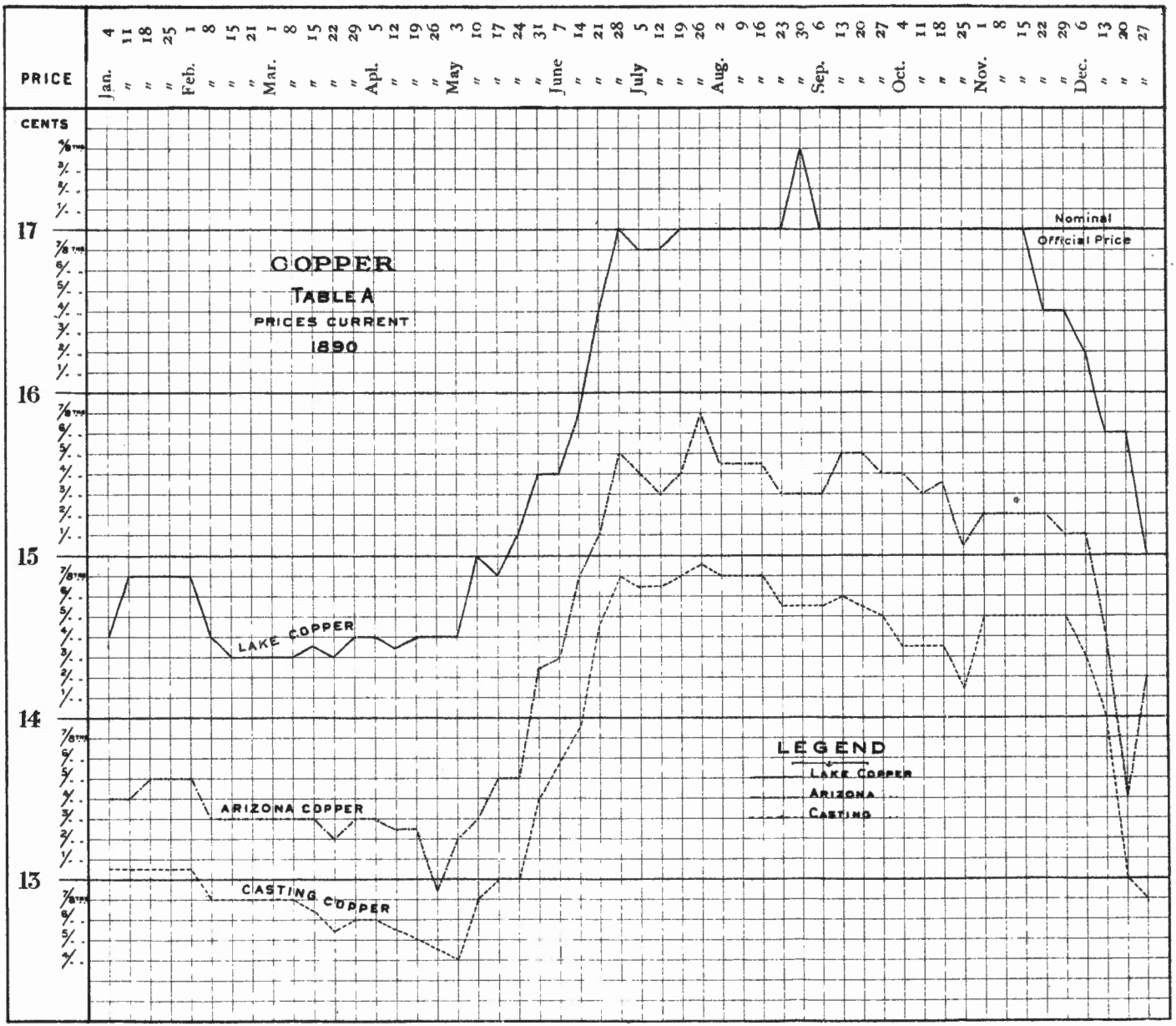
Skilled labour, overground	1,717 days.
Unskilled do	3,380 do
Skilled labour, underground	1,785 do
Unskilled do	1,598 do
Teams and drivers	323 do
Coal teams	360 do

Production. "About 1,000 tons of ore were extracted and banked."

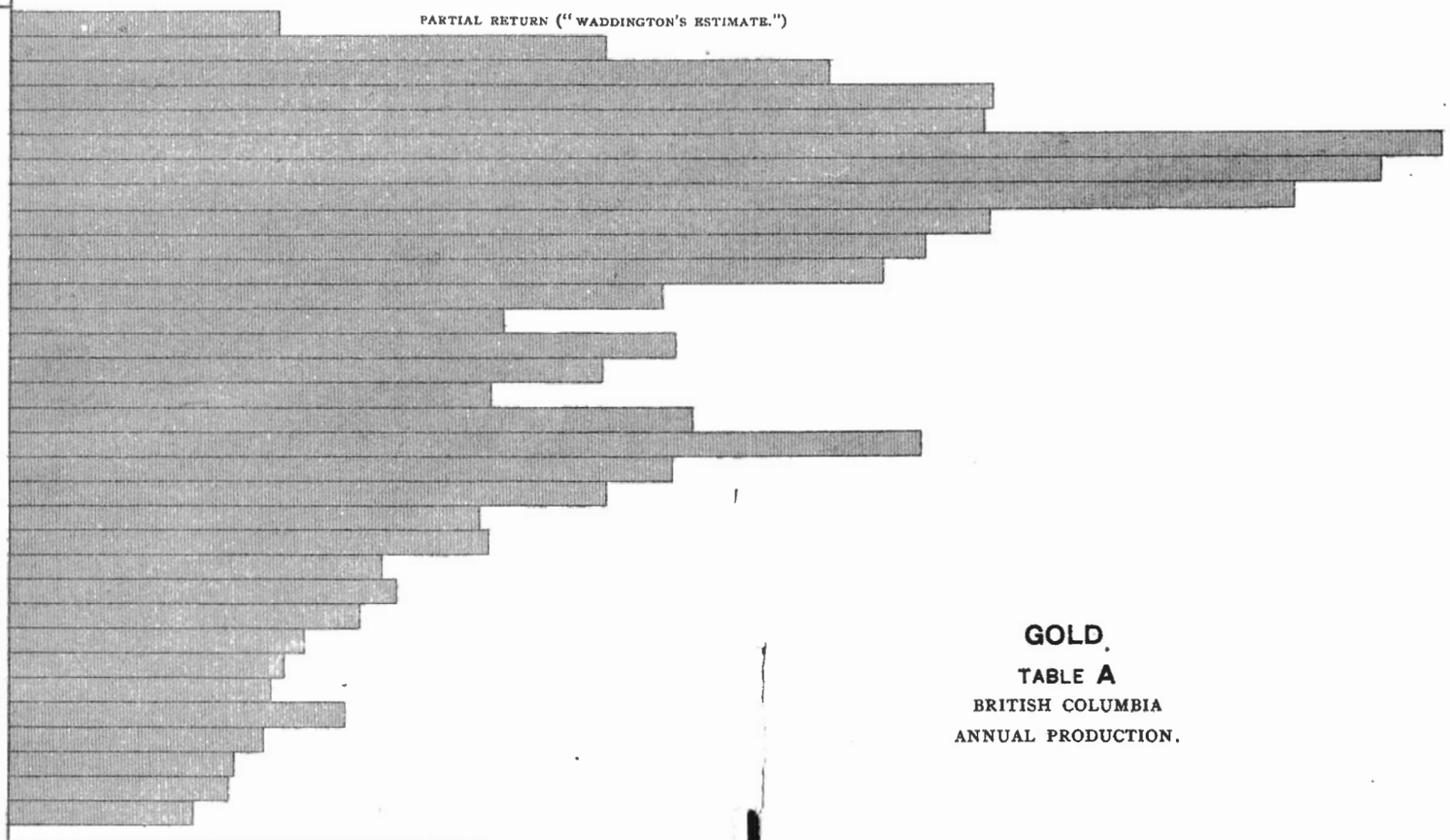
The total amount of copper contained in the ores shipped as before mentioned from the two provinces of Ontario and Quebec was 6,013,671 lbs., which taken at 15 cents, the average market price of the metal for the year, gives a valuation of $902,050.

The production last year was given at 6,809,752 lbs., so that this year shows, on comparison, a falling off of 796,081 lbs.

Prices. Table A shows the fluctuations in the price of the metal for the year as quoted for the three chief brands in the New York market and speaks for itself.


PRICE
CENTS
17
16
15
14
13
Jan. 4 11 18 25
Feb. 1 8 15 21
Mar. 1 8 15 22 29
Apl. 5 12 19 26
May 3 10 17 24 31
June 7 14 21 28
July 5 12 19 26
Aug. 2 9 16 23 30
Sep. 6 13 20 27
Oct. 4 11 18 25
Nov. 1 8 15 22 29
Dec. 6 13 20 27
COPPER
TABLE A
PRICES CURRENT
1890
Nominal
Official Price
LAKE COPPER
ARIZONA COPPER
CASTING COPPER
LEGEND
LAKE COPPER
ARIZONA
CASTING

Year	Value
1858	$705,000
1859	1,615,072
1860	2,228,543
1861	2,666,118
1862	2,656,903
1863	3,913,563
1864	3,735,850
1865	3,491,205
1866	2,662,106
1867	2,480,868
1868	2,372,972
1869	1,774,978
1870	1,336,956
1871	1,799,440
1872	1,610,972
1873	1,305,749
1874	1,844,618
1875	2,474,904
1876	1,786,648
1877	1,608,182
1878	1,275,204
1879	1,290,058
1880	1,013,827
1881	1,046,737
1882	954,085
1883	794,252
1884	736,165
1885	713,738
1886	903,651
1887	693,709
1888	616,731
1889	588,923
1890	494,436



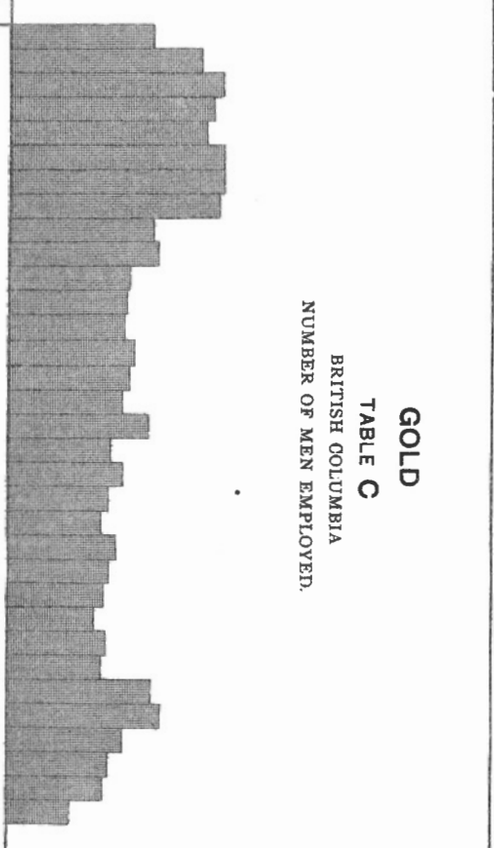
GOLD

TABLE A

BRITISH COLUMBIA

ANNUAL PRODUCTION.

Year	Number
1858	3000
1859	4000
1860	4,400
1861	4,200
1862	4,100
1863	4,400
1864	4,400
1865	4,294
1866	2,982
1867	3,044
1868	2,399
1869	2,369
1870	2,348
1871	2,450
1872	2,400
1873	2,300
1874	2,868
1875	2,024
1876	2,282
1877	1,960
1878	1,883
1879	2,124
1880	1,955
1881	1,898
1882	1,738
1883	1,965
1884	1,858
1885	2,902
1886	3,147
1887	2,342
1888	2,007
1889	1,929
1890	1,342



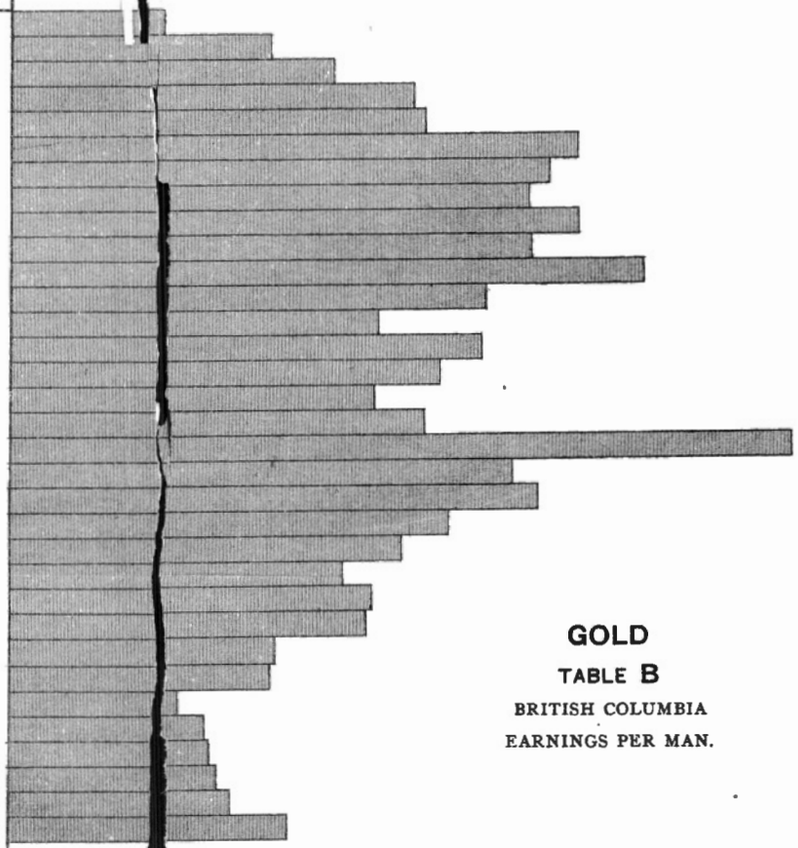
GOLD

TABLE C

BRITISH COLUMBIA

NUMBER OF MEN EMPLOYED.

Year	Value
1858	$235
1859	403
1860	506
1861	634
1862	648
1863	889
1864	849
1865	813
1866	893
1867	814
1868	992
1869	749
1870	569
1871	734
1872	671
1873	567
1874	643
1875	1,223
1876	783
1877	820
1878	677
1879	607
1880	518
1881	551
1882	548
1883	404
1884	396
1885	246
1886	287
1887	296
1888	307
1889	330
1890	423



GOLD

TABLE B

BRITISH COLUMBIA

EARNINGS PER MAN.

The exports and imports are given in Tables 1, 2 and 3.

COPPER.

TABLE 1.

EXPORTS.

Exports.

Year.	Ontario.	Quebec.	Total.
1885		$262,600	$262,600
1886	$16,404	232,855	249,259
1887	3,416	134,550	137,966
1888		257,260	257,260
1889		168,457	168,457
1890	2,219	396,278	398,497

COPPER.

TABLE 2.

IMPORTS: PIGS, OLD AND SCRAP.

Imports.

Fiscal Year.	Pounds.	Value.
1880	31,900	$ 2,130
1881	9,800	1,157
1882	20,200	1,984
1883	124,500	20,273
1884	40,200	3,180
1885	28,600	2,016
1886	82,000	6,969
1887	40,100	2,507
1888	32,300	2,322
1889	32,300	3,288
1890	112,200	11,521

COPPER.

TABLE 3.

IMPORTS: MANUFACTURES.

Fiscal Year.	Value.
1880	$123,061
1881	159,163
1882	220,235
1883	247,141
1884	134,534
1885	181,469
1886	219,420
1887	325,365
1888	303,459
1889	402,216
1890	472,668

Discovery and exploration.

Besides the activity in the chief producing districts already mentioned, a small amount of exploratory work has been done on the areas of Keweenian rocks of the north shore of Lake Superior, the geological parallels of the native copper-bearing formations of the south shore, in which are situated the famous Calumet and Hecla, Tamarack and other similar mines.

Ontario.

This work was prosecuted on the Michipicoten Island and Mamainse areas. At the latter point, the Silver Islet Mining and Land Company had an exploratory party at work further examining the numerous veins and copper-bearing belts proved by former explorations to exist there.

Copper has been known to occur throughout these areas since the earliest times, and numerous attempts have been made to develop them, which, for various reasons, have not met with success. The copper exists in the native form impregnating the beds of trappean rocks and also exists thus in one of the accompanying agglomerate beds on Michipicoten Island. It also occurs native in fissure veins cutting the formation, as well as in the form of various sulphurets in similar veins. The occurrence of argentiferous copper glance is a special feature of this formation, although so far the veins carrying this class of ore have never proved very persistent.

The other areas of these native copper-bearing rocks in Canadian territory are to be found in St. Ignace and other islands in the mouth of Nipigon Bay, L.S., and also the newly-discovered area in the townships of Blake and Crooks, south of Port Arthur, mentioned in last year's report.

Further details relating to the various copper districts of the Dominion will be found in the annual reports of the Geological Survey Department; the British Columbia districts being dealt with by Dr. Dawson in Part R, Annual Report, 1887, and Part B, Annual Report, Vol. IV, 1888-89, whilst the Quebec areas are well described by Dr. Ells in Part K, Annual Report, Vol. IV, and in a report recently issued by Mr. Obalski, the Government Mining Engineer of the province.

GOLD.

Production.

As formerly, British Columbia and Nova Scotia are the main contributors to the total production of this metal, the remainder being furnished by the districts of Beauce in Quebec, the Saskatchewan River washings and an estimated yield from the Yukon district.

The total yield thus obtained amounted to 64,046 ounces, worth $1,149,776, which, compared with last year, shows a falling off of 8,282

ounces and $145,383. This is mainly due to the lesser yield of British Columbia and Nova Scotia, which show deficits, respectively, of $94,487 and $350,039. Regarding the first item it may be said to be due partly to the absence of returns from the Cassiar district and to the continuation of the cause similarly acting for some years, viz., the gradual working out of the placers and the slow development of the quartz-mining industry, which should eventually win back for the province its place as a gold producer.

Nova Scotia.

Of Nova Scotia the report of their Government Department of Mines speaks as follows :—

"The total returns for the year 1890 show that 41,886 tons of quartz were crushed, yielding 24,358 ounces of gold for 160,264 days' labour, compared with 26,155 ounces of gold from 39,160 tons of quartz for 211,548 days' labour. It is to be regretted that there is a falling off in the yield of gold, and no very satisfactory explanation can be offered. It is stated that recently mines have been started on insufficient evidence of permanent values in the veins, and that this past season their producing capabilities have diminished. It will be noticed that more quartz has been crushed, and it is in this direction, that of low grade ore, that the future extension of gold mining in Nova Scotia must be sought for."

The following table gives the yield by provinces :—

GOLD.

TABLE 1.

PRODUCTION BY PROVINCES.

Provinces.	Ounces.	Value.	No. of Men.
Nova Scotia	24,358	$474,990	534
Quebec	75	1,350	25
North-West Territories (including Yukon District)	10,529	179,000	200
British Columbia	29,084	494,436	1,742
	64,046	1,149,776	2,501

The items for Quebec and the North-West Territories are close estimates, the latter including an approximation to the yield of the Yukon Territory in the absence of direct returns.

British Columbia.

Graphic Tables A, B and C, and Table 2, compiled chiefly from data furnished by the report of the Minister of Mines for that province, give

GOLD
TABLE D
NOVA SCOTIA
ANNUAL PRODUCTION

Year	Value
1862	$141,871
1863	272,448
1864	390,349
1865	496,357
1866	491,491
1867	532,563
1868	400,555
1869	348,427
1870	387,392
1871	374,972
1872	255,349
1873	231,122
1874	178,244
1875	218,629
1876	233,585
1877	329,205
1878	245,253
1879	268,328
1880	257,823
1881	209,755
1882	275,090
1883	301,207
1884	313,554
1885	432,971
1886	455,564
1887	413,631
1888	436,939
1889	510,022
1890	474,990

GOLD
TABLE E
NOVA SCOTIA

Year	Quantity
	TONS
1862	6,473
1863	17,000
1864	21,431
1865	24,421
1866	32,157
1867	31,384
1868	32,259
1869	35,144
1870	30,824
1871	30,787
1872	17,089
1873	17,708
1874	13,844
1875	14,810
1876	15,490
1877	17,369
1878	17,989
1879	15,936
1880	13,997
1881	16,556
1882	21,081
1883	25,954
1884	25,186
1885	28,890
1886	29,010
1887	32,280
1888	36,178
1889	39,160
1890	42,749

TONS OF QUARTZ CRUSHED

Year	Value
1862	$21.91
1863	16.02
1864	18.11
1865	20.32
1866	15.28
1867	16.96
1868	12.41
1869	19,91
1870	12.56
1871	12.17
1872	14.81
1873	13.05
1874	12.87
1875	14.89
1876	15.08
1877	19.01
1878	13.63
1879	16.83
1880	18.42
1881	12.66
1882	13.04
1883	11.60
1884	12.44
1885	14.98
1886	15.70
1887	12.81
1888	12.08
1889	13.02
1890	11.11

AVERAGE YIELD OF GOLD PER TON (2000 LBS.) CRUSHED

GOLD
TABLE F
QUEBEC
ANNUAL PRODUCTION.

SECOND HALF OF YEAR ONLY

Year	Value
1877	$12,057
1878	17,937
1879	23,972
1880	33,174
1881	56,661
1882	17,093
1883	17,787
1884	8,720
1885	2,120
1886	3,981
1887	1,604
1888	3,563
1889	1,207
1890	1,350

the details of the industry and also the following figures of the value of gold exported by the banks at Victoria during 1889 :—

Bank of British Columbia.....	$203,111
Messrs. Garesché, Green & Co.....	183,587
Bank of British North America.....	25,331
	$412,029

The total amount of gold produced by the province from 1858 to 1890, inclusive, adds up to $55,192,163.

GOLD.

TABLE 2.

BRITISH COLUMBIA.

YIELD, ETC., BY DISTRICTS.

District.	Divisions.	Whites.	Chinese.	Yield of Gold by Divisions.	Total Yield by Districts.
Cariboo.....	Barkerville.....	74	156	$61,200	
	Lightning Creek.....	27	123	38,000	
	Quesnelle Mouth....	3	107	26,250	
	Keithley Creek.....	40	196	62,800	
		144	582		$188,250
Kootenay....	Western...	443	30	35,000	
	Eastern	8	52	37,400	
		451	82		72,400
Lillooet.....	... .	40	75	71,455	71,455
Yale..... ..	Hope, Yale and Lytton	.....	150	9,000	
	Osoyoos.....	71	29	17,000	
	Similkameen.....	39	79	23,450	
		110	258		49,450
					$381,555
	Total Whites.....	745			
	do Chinese.....	.... . .	997		
	do employed....	1,742			

Nova Scotia.

The details of the statistics regarding the gold mining industry in Nova Scotia, as given by the Government reports of that province will be found in the below given tables, D and E and Nos. 3 and 4.

GOLD.

TABLE 3.

NOVA SCOTIA.

DISTRICT DETAILS.

Districts.	Number of Mines.	Days' Labour.	Mills.	Tons of Quartz Crushed	Yield of Gold per Ton. Oz.	Dwt.	Gr.	Total Yield of Gold. Oz.	Dwt.	Gr.
Brookfield	1	.....	1	2,500	..	13	..	1,643	5	..
Caribou, Moose River	3	17,748	5	6,661	..	4	17	1,576	19	8
Fifteen Mile Stream	2	6,089	2	3,017	..	15	6	2,305	2	18
Lake Catcha	1	4,333	1	1,008	..	15	10	779	5	..
Malaga	6	22,569	3	6,633	..	11	19	3,883	12	12
Montagu	3	6,911	3	1,411	1	12	..	2,263	1	..
Oldham	2	8,469	1	1,122	2	9	10	2,774	13	20
Rawdon	1	6,657	2	1,892	1	..	..	1,899	15	..
Renfrew	2	3,778	2	760	..	6	15	253	10	12
Salmon River	1	19,408	1	6,415	..	6	10	2,070	..	..
Stormont	3	9,130	2	1,052	..	11	17	616	15	12
Uniacke	3	14,196	3	2,525	..	12	18	1,612	2	13
Waverley	4	17,679	3	3,509	..	2	18	482	12	..
Whiteburn	1	11,787	2	960	..	17	2	840	3	1
Unproclaimed, etc	5	11,410	5	3,284	..	8	6	1,357	11	9
	38	160,164	..	42,749	..	11	9	24,358	9	9

GOLD.

TABLE 4.

NOVA SCOTIA.

PRODUCTION OF THE DIFFERENT DISTRICTS FROM 1862 TO 1890 INCLUSIVE.

Districts.	Tons of Quartz Crushed.	TOTAL YIELD. Ozs.	Dwts.	Grs.	Value at $19.50 per oz	Average yield per ton of 2,000 lbs.
Caribou and Moose River	43,959	23,818	11	13	$ 464,462	$10 56
Montague	16,192	32,581	11	16	635,341	39 24
Oldham	38,147	41,242	6	3	804,224	21 08
Renfrew	46,071	31,814	13	2	620,385	13 46
Sherbrooke	165,831	119,648	4	2	2,333,140	14 09
Stormont	22,236	23,240	14	5	453,192	20 36
Tangier	29,122	19,126	15	18	372,970	12 80
Uniacke	37,353	21,850	17	4	426,092	11 41
Waverley	93,081	53,873	19	14	1,050,542	11 28
Salmon River	34,575	10,715	4	0	208,947	6 04
Brookfield	5,663	4,858	4	9	94,735	16 73
Whiteburn	4,985	8,385	15	16	163,522	32 60
Lake Catcha	4,027	6,630	16	3	129,300	32 10
Rawdon	10,879	8,718	14	4	170,015	15 63
Wine Harbour	39,975	27,940	17	1	544,845	13 63
Darr's Hill	39,909	18,715	19	19	364,962	9 14
15 Mile Stream	8,501	4,996	11	17	97,434	11 46
Malaga	11,021	7,859	16	1	153,265	13 90
Unproclaimed, etc	51,629	40,528	17	17	709,314	15 01
Totals	703,156	506,548	9	20	9,877,687	14 03

If comparison is made between tables A and D it should be noted that the former would have to be enlarged five times to bring it to the same scale as the latter. The steady falling off of the yield of the placers of British Columbia is clearly brought out in this table and makes an interesting comparison with the fluctuations of the quartz-mining districts of Nova Scotia. Tables D and E also well illustrate the points already alluded to, viz., the falling off of the total yield, notwithstanding the increase of the number of tons of quartz crushed, thus showing that the ore milled was lower grade than usual.

Quebec.

Table F gives the yield of the metal by the Chaudière and Compton districts, Quebec, as far as ascertainable. The mining in these districts has been of late of a very desultory nature, so that it is difficult to get exact figures, but the falling off since its year of greatest prosperity in 1881 is very apparent.

The figures of the exports of the metal as found in the books of the Customs Department will be found in Table 5.

GOLD.

TABLE 5.

EXPORTS.

Exports.

Provinces.	1887.	1888.	1889.	1890.
	$	$	$	$
Ontario	6,650		2,660	
Nova Scotia	321,379	163,412	191,671	304,521
Manitoba		50	261	
British Columbia	592,300	464,696	414,658	402,271
Totals	920,329	628,158	609,250	706,792

There is no reason to believe that any gold ore is imported into the country and in any case its amount could not be ascertained, as the Customs Department makes no distinction between ore and bullion.

The details of the progress of the industry are as follows:—

Nova Scotia.

The gold of the province occurs in the area of Cambrian rocks forming the Atlantic slope of the peninsula of Nova Scotia, and extending from Canso on the north to Yarmouth on the south.

The enclosing rocks consist of compact quartzites and sandstones locally known as "whin," frequently felspathic, but rarely calcareous, associated with argillaceous slates, in some instances magnesian or chloritic. Nova Scotia.

The veins occur along the denuded crests of anticlinal folds of the strata and carry free gold associated with varying amounts of sulphurets, arsenical pyrites, etc.

The ore is stamped and amalgamated in the batteries, the tailings running out over amalgamated copper plates.

The following notes, reprinted from the Report of the Department of Mines of the province for 1890, give the main features of interest in the industry for the year:—

HALIFAX COUNTY.

"*Montagu.*—Operations have progressed in this district during the past year; the quartz averaging about as high as in the year 1889. Returns were received from the Annand, Kaye and Rose mills. The largest yield was 362 ounces from 120 tons crushed in the Annand mill.

"*Caribou.*—The returns show 1,560 ounces from 6,591 tons, against 1,906 ounces from 7,338 tons in 1889. Returns were received from the Lakelode, Dixon, Touquay, Caffrey and the Moose River Gold Mining Company mills. The returns from the Dixon mill show an average of over an ounce. Mr. Touquay crushed a large amount of surface ground and dump stuff.

"*Waverley.*—The Lake View Mining Company, having completed their new mill, commenced crushing in the fall. It is expected that they will handle in this mill a large amount of quartz, as extensive blocks of ore ground have been won. A new company will operate the Gue and Wilson properties. A concentration and clorination plant has been put up here to treat ores, tailings, etc.

"*Lake Catcha.*—The returns from this mine were good for the first part of the year, but there was little done during the fall.

"*Fifteen Mile Stream.*—The operations of the New Egerton Company, under Mr. Jas. A. Fraser, have been successfully carried on during the past year. The Stanley Company also worked steadily. The returns show 3,017 tons crushed, yielding 2,305 ounces, compared with 786 ounces from 1,416 tons in 1889.

"*Salmon River.*—The approaching completion of the new and powerful mill at this mine will enable an increased output to be maintained next year. The returns show 6,415 tons crushed, and a yield of 2,070 ounces, averaging 6 dwts., 10 grns., against 7,633 tons and 2,032 ounces during

Nova Scotia.

the year 1889. The uniformity of the yield of large amounts of quartz in this mine is worthy of notice. Up to date this mine has yielded 35,270 ounces from 79,456 tons of quartz.

"At Killag crushing has commenced, the December returns of the Killag Company being 51 ounces from 45 tons. At other points in Halifax county there is little new to report.

"The Western Gold Mines were visited by Mr. Madden, Deputy Inspector, who reports that they are worked with proper regard to the safety of the men employed. I append a memo. of his visits:—

"The returns show—

	Tons.	Ozs.	dwt.	Grs.
Brookfield	2,500	1,643	5	0
Malaga	6,198	3,809	18	12
Whiteburn	960	840	0	0

GUYSBORO' COUNTY.

"During the past season little has been done at *Goldenville* and *Wine Harbour*. At *Stormont* litigation has impeded mining, and the returns show a falling off. It is anticipated that this difficulty will be surmounted shortly, and it is to be hoped this district, one of the most promising in the province, will be worked to a greater extent than it has for several years.

"*Oldham.*—The returns show 2,774 ounces from 1,122 tons, compared with 2,709 ounces from 1,391 tons in 1889—the returns being from the Oldham Gold Mining Company. A noticeable yield was from June 23rd to June 30th, when 30 tons 8 cwt. yielded 875½ ounces. A new mill is being built by this company, and additions are being made by the Standard Company to their plant.

"*Rawdon.*—At the close of the year the returns showed 1,899 ounces from 1,892 tons of quartz, etc. A large amount of prospecting has been done in this locality, and at the end of the season it was anticipated that several valuable leads would be opened in the spring. Several lots of surface ground and slate were crushed by the Central Rawdon and the Gould-Northup mill, and yielded well. It is believed by some authorities that the surface is rich enough to be systematically treated.

"*Renfrew.*—Work has not been very successful in this district during the year 1890, the returns amounting to only 253 ounces. The Empress Gold Mining Company have restored their plant injured by fire last summer. Work on the free claim was to be closed at the end of the year.

"*Uniacke.*—The principal returns were from South Uniacke. The Withrows continued working, and the new shaft on the Thompson property was sunk, striking the pay ground, which proved to be richer than to the westward. Nova Scotia.

"*Memo. of visits paid by Mr. Madden, Deputy Inspector, to the Queen's County Mines.*

"*Brookfield Mine.*— * * * Thirty-eight men to work. This mine is in excellent order.

"*Malaga Mine.*— * * * North Lead working west; Rabbit Lead is also being worked. The Chester Lead and Mill Lead are idle under repairs. The management is sinking No. 4, west shaft, and when down about 90 feet more, will crosscut the other leads, and will then have two years' work opened in advance. The Nugget and Boulder workings are under repairs.

"*Boston Mining Company.*— * * * About fifty men employed here erecting buildings and machinery. This mine has heretofore not been furnished with pump or engine, but having now obtained them, expect shortly to utilise them to advantage. The mine is in good order.

"*Caledonia Mine.*— * * * Thirty-six men employed. This year have erected a 10 stamp mill. The engine being connected with the bank head of 5 or 6 shafts by a steel wire rope and a cog-and-pinion-wheel at each bank head, connected with hoisting gear, are enabled to hoist or lower from each shaft independently of the other. A diamond drill is at work boring south at a point 100 feet down the shaft testing the property. Two compressed air drills, capable of boring 4′ in 20 minutes, are at work in this mine; they have sufficient power to start three or four more.

"*Parker Douglas Mine.*— * * * Forty men employed. Seven compressed air drills to work. Hoisting engine same system as Caledonia. Six new hoists during the year. New machinery—boilers, 200 h. p.; boiler, 75 h. p., running the drills; a new rotary pump; fifteen new stamps, making twenty in all; new boiler shed; new compressor house, 45′ x 32′; also a large addition to the mine house; new concentrators. This company has prospected 30 leads bearing gold. They have sunk 160′ in one shaft and cross-cut several other leads; laid railroads on their lead and cross-cuts. The quartz is dropped down shoots into boxes, then taken to main shaft, where the boxes are hoisted and then dumped into shoots carrying the quartz to the mill. This is probably the best equipped mine in the province, and it is in good order.

Nova Scotia. "*Newton Mine.*—Queen's Mining Company. * * * Busy erecting new machinery, the buildings for which are nearly completed.

"*West Mine*, so-called.— * * * Sixty men employed, chiefly engaged building. Also adding some new machinery.

"*Royal Gold Mining Company* for want of machinery are not doing very much, but have the necessary plant on the ground, and are hard at work getting into working shape.

* * * The mines are all being thoroughly repaired, and additions in the shape of the most modern machinery and appliances are being made to the plant.

Speaking of his work in Colchester county, Mr. Fletcher, of this Department, reports as follows of a district visited by him :—

"Great excitement was caused last summer by the reported discovery of gold in a whitish-grey flinty conglomerate consisting almost wholly of pebbles and grains of white quartz, beds of which underlie the Carboniferous limestone from the neighbourhood of Brookfield, far up the Stewiacke River on the north side. The region was proclaimed a gold district and rights of search taken out covering many miles. The attention of prospectors was, moreover, directed to all the conglomerates in the province. That the conglomerate of Gay's River is auriferious has long been well known, and Professor Hind has proved the existence of gold, silver and copper in certain beds of that nature near Baddeck. The Brookfield conglomerate was said to have given rich returns by milling, although a somewhat close examination by panning the dirt in the beds of the streams flowing over it failed to indicate the presence of gold in appreciable quantity. Two samples were sent to Mr. Hoffmann, one from the neighbourhood of the barytes mine, the other from the brook three hundred yards above the Glenbervie mills, but neither of them yielded, on assay, a trace of either silver or gold. Tests subsequently made on a large scale at the mill of one of the gold mines emphatically confirmed the accuracy of Mr. Hoffmann's assays."

Interest having been awakened in the gold regions of the southern end of the province, their further examination was decided upon, and Dr. Selwyn visited the district with Professor Bailey, with whom he arranged for the prosecution of the work. Speaking of his visit he says :—

"On the 17th of June I left Ottawa for Shelburne, Nova Scotia, to visit the gold fields first opened in 1886 at and near Caledonia Corner, and to investigate the probability of the same leads continuing southward and westward into the county of Shelburne, and also to ascertain what would be the best plan of operation in commencing a detailed

examination and survey of these western parts of Nova Scotia in connection with the occurrence of gold, in quartz veins or in placer deposits, or in regard to other economic minerals. I had, in 1870, visited and cursorily examined the same part of the Nova Scotia coast, having then made detailed notes on a journey from Digby *viâ* Weymouth, Cape St. Mary and Salmon River to Yarmouth; and thence to Tuskett, Shelburne, Liverpool and Bridgewater to Lunenburg, the Ovens and Chester, returning to Bridgewater and Liverpool *viâ* New Ross and Dalhousie, and from Liverpool to Annapolis *viâ* Caledonia. The present trip has enabled me to do little more than refresh my memory and to confirm the general accuracy of the conclusions then arrived at respecting the distribution of the granitic and gneissic rocks and the gold bearing series, as subsequently delineated on the geological map. Nova Scotia.

"On the 23rd of June a trip was made 28 miles up the river from Shelburne to Indian Fields, where some pits have been sunk searching for gold. The country here is tolerably open, much of it flat and swampy and covered with drift and a fine granitic gravel or sand, with few exposures of the underlying rocks, though doubtless such would be found by following up the beds of all the brooks and small streams in the district. On the 24th of June I examined the route from Shelburne to Lockport, and thence *viâ* Sable River, Port Joli and Granite River to Liverpool. On the 25th I drove from Liverpool to Caledonia, 30 miles inland, and found the rocks to be alternations of the "whin" and black slates of the Atlantic coast Gold Series or Lower Cambrian, as indicated on the published geological map. The gold field of Whiteburn, six miles south-west of Caledonia, was visited on the 26th. It is of limited extent, on an oval shaped anticline outcrop of the lower "whin" rock, surrounded by the upper black slate. The veins are parallel with the stratification. They are not more than from six to nine inches thick, and are therefore costly to work, as about four feet of hard, barren rock has to be mined in driving or sinking on them. Consequently, though the quartz is of more than average richness the profits are not large. The beds dip about 45° to S.E. On the 27th I left Caledonia for Bear River, on the Annapolis Basin. As regards the extension or recurrence of anticlines like those in which the Malaga and Whiteburn leads occur, further to the south-west, no definite statement can be made. That some such areas should be found in the unsettled country where the boundaries of the counties of Digby, Yarmouth, Shelburne, Queen's and Annapolis meet, and especially along the flanks of the central granite mass, the limits of which have not yet been traced, but which certainly occupies a considerable area in this district and which is crossed, with a width of ten or twelve miles, on the road between Maitland and Bear River, is most probable."

Nova Scotia.

Professor Bailey in his preliminary report to the Director, speaks of the district in these words:—

"About the 25th of July I proceeded, in accordance with your instructions, to the Province of Nova Scotia, and entered upon the study of the geology of Queen's and Shelburne counties. Having been desired by you to give my first attention to the coast, operations upon the latter were begun at the town of Liverpool, and were continuously carried on until the entire coast, from Port Medway harbour, forming the eastern boundary of Queen's county, to Pubnico harbour, forming the western limit of Shelburne, had been examined. This work was found to be unexpectedly easy, owing to the circumstance that almost the entire shore is occupied by fishermen, and bordered by roads which give easy access to any desired point. The comparative uniformity of the rock formations, consisting chiefly of fine grained gneisses, quartzites and mica schists, together with irregular masses of granite, further facilitated their study. The general result of these observations was to show that the crystalline rocks in question, which occupy a belt along the coast of from two to fifteen miles in width, are only a more highly altered condition of the gold-bearing slates and sandstones of the interior."

Quebec.

The gold region still remains under a cloud, and nothing has been done outside of a small amount of washing of the alluvial gravels of the tributaries of the Beauce River at and above the town of St. Francis.

There were only four parties working when the district was visited in September. On the Mill stream near the town of St. Francis, Messrs. McArthur & Coupal were at work, having sunk a shaft to bed rock at some little distance from the stream on its west bank. Some work was also done on the gravels of the Cumberland River under the direction of Captain Richards, whilst on the Famine River the St. Onge Bros. were tunnelling in on the level of the river in search of an old channel they believed to exist. Mr. Louis Gendreau was doing a little work, washing with a short sluice the gravels found at the confluence of the River du Loup and the Chaudière. All of these operations have only yielded a little gold, having been carried on only for short periods, and on a small scale. Besides this there have undoubtedly been small quantities washed out of the river bars by individual prospectors, of which it is evidently impossible to get any record. The water was, however, rather high for this latter class of work this season.

Outside of the Beauce district a small amount of work has been done on the streams of Compton county, chiefly in the township of Ditton.

A certain amount of interest is also being taken in the quartz veins of these districts which, there is reason to believe, might in some cases prove to be remunerative if properly examined and worked. Mr.

Obalski, the Provincial Government engineer, who has been studying this question, gives the following account of his investigations in the "Report of the Crown Lands Department of Quebec" for 1890: Quebec

"Quartz has been very little worked, although a good deal of attention has been awakened of late in the possibilities of the quartz mining industry. It has not been within my power in the time at my disposal to thoroughly investigate this area wherein occur so many quartz veins, but I have visited a certain number of them on which I picked some samples weighing from 3 to 5 pounds. Assays of the ore from these veins by Messrs. Ledoux & Co., of New York, show the presence of only a small proportion of gold, not over 30 cts. per ton. I may also state that having had several pieces from a quartz vein at Jersey Point pounded up and washed down in a pan, two fine particles of gold, unquestionably derived from the quartz, were obtained. Gold of similar character is also reported to have been obtained from a vein of the Famine river, in rear of St. George. These are by no means solitary instances of gold derived from the quartz veins in Beauce, many similar cases being reported from different quarters. We have contributed towards forwarding two tons of quartz from the Jersey vein to be tested by Mr. J. Thompson, South Uniacke (N.S.), in his experimental quartz mill, the latter gentleman having kindly volunteered to crush our quartz specimens. It is greatly to be desired that numerous assays from these veins should be made; and should these assays prove satisfactory and fair averages be given, the result would be highly conducive to the rapid development of this important industry.

"The results, as given by Mr. Thompson, are as follows:

"1. On a lot of 3,000 lbs., 5 dwt. and 18 gr. or 3 dwt. 14 gr. = $3.65 per ton of 2,000 lbs.

"2. On a lot of 800 lbs., 2 dwt. 18 gr. or 6 dwt. 21 gr. = $6.85 per ton.

"*Gold in the Laurentides.*—As already stated in previous reports, some prospecting in search of gold has been made throughout the Laurentian formation. In the county of Joliette, two new companies have been organized. One of these, the '*Compagnie minière du district de Joliette,*' operates lot IV, 6 of the gore of Kildare, near St. Alphonse; assays from a rock heavily charged with magnetic pyrites gave traces of the precious metal.

"The other company, styled: '*Compagnie des Mines d'or de Mattawin,*" is operating a mining property at a place called 'La Barrière,' in the unsurveyed portion of the township of Tracy. From the latter property several samples taken by myself on a small vein a few inches wide,

Quebec.

were assayed by Messrs. Ledoux & Co., New York assayers, and while two of the samples gave traces of gold, a third one gave the following result:—

Gold, 1 ounce 83, per ton of 2,000 lbs.
Silver, 2 do 65, do

"From the various statements here presented, unquestionably worthy of interest and further investigation, no hasty conclusion should be drawn, it being very difficult, from the limited amount of work done, to express any decided opinion as to the auriferous character of this area."

Ontario.

A certain amount of exploration and discovery has been carried on in Ontario. In the Madoc district of Hastings county, the Crescent Gold Mining Company started work late in the fall, re-opening the Feigle mine.

On the north shore of Lake Huron discoveries of gold-bearing veins were reported, and some testing work done on the discoveries.

A small amount of similar work has been done at places on the north shore of Lake Superior, between Sault St Marie and Port Arthur.

Reports come to hand also of renewed interest in the Lake of the Woods district, where small gangs of men have been at work testing a number of the veins. Work has been proceeded with on the reduction works, which are in course of erection at Rat Portage, and which it is expected will shortly be completed. This should favourably affect the development of this promising district, so that it is hoped that we may have to report from thence a production of the metal next year.

North-West Territories.

Of the working for gold on the bars of the Saskatchewan River, Mr. Griesbach, Commandant N.-W.M.P. at Fort Saskatchewan, kindly furnishes the following information:—

"Mining on the river has not been carried on this year to the same extent it was last, owing to continued high water preventing the miners from getting at the 'pay dirt.' The amount of gold taken out of the North Saskatchewan River during the season from, say 50 miles above Edmonton and 50 miles below Fort Saskatchewan, is estimated at between $3,000 and $4,000."

British Columbia.

Placer Mining. Outside of the already mentioned falling off of the yield of gold from the alluvion and its causes there is nothing very new to relate.

An interesting discovery of an old river channel in the Cariboo District is described as follows by Mr. Bowron:—

"The Keithley Creek division of the district has proven most prolific, both as regards the season's output, as well as in the importance of its developments, the particulars of which will, no doubt, be fully reported

by Mr. Stephenson; but as a discovery has been made in this division, which, I think, merits more than passing notice, a few words in addition to what may have been said on the subject will not here be out of place. British Columbia.

"The opinion has prevailed for many years among our most experienced miners from California and Australia that, judging from the formation of the country, there existed, and ultimately would be found, in this district immense obliterated river channels traversing the country upon a higher level than the present streams, which, in crossing the former, in many instances, received therefrom their chief supply of the precious metal. The first of such ancient river channels would now appear to have been discovered on the south side of the South Fork of the Quesnelle River. A Chinese company working up Dancing Bill's Creek, three miles above the Forks (*vide* Mr. Bowman's map), when about a thousand feet from the Quesnelle River, and at an altitude of one hundred and twenty-five feet above the stream, came to a pitch-off in the bed-rock which they were unable to follow, owing to the quantity of water encountered. They continued working ahead as near on a level as the grade to the sluices would allow. This occurred some ten or twelve years ago, and they have continued since that time to work into the hill without finding bed-rock. They use hydraulic pressure in working; but as their water supply is limited, and the face of their cut is now nearly two hundred feet in height, they make but small headway, but are known to have been taking out, with six men working, from five to eight thousand dollars annually. The operations of this company having for some years been watched with interest by the white miners in the vicinity, and the developments seeming to confirm their pre-conceived ideas of an immense 'blind' river channel in the hill, Messrs. Barker, Polley, Burrill & Co. sank two shafts half a mile above the Chinese Company, and back some fifteen hundred feet from the river, behind the rim rock which forms the river bank, and although not reaching bed-rock, owing to the quantity of water encountered, they found similar prospects to those obtained in the Chinese claim. Subsequently, Mr. John Hepburn, of Victoria, located ground below the Chinese, and in running in cuts developed similar pay gravel inside the rim rock, which is regarded as settling the question of a paying channel in the hill beyond a doubt. Messrs. Whittier & Pomeroy below, and the Champion Company above, have also located ground until there are nearly six miles of the channel claimed.

"Some are of the opinion that the channel will ultimately be traced to the Horsefly River, some twenty miles distant. However that may be, it is generally conceded that there must be at least ten miles of the old river bed. As to the richness of the pay, and consequent importance

British Columbia.

of the discovery, I can only say it is estimated that the Chinese Company are taking out at least one thousand dollars per lineal foot of the channel so far as they have worked, and as large river channels are usually very regular in the gold deposits, further comments are unnecessary."

Mr. Stephenson, writing from Quesnelle Forks, gives further particulars of the same discovery as follows:—

"The South Fork of Quesnelle River is at present very promising for hydraulic mining. The *Hop E. Tong*, a Chinese company, have for years been working on *Dancing Bill Gulch*, a small stream that empties into the left hand or south side of the South Fork, about three miles above the Forks. The gulch has cut across what is now proved to be an old channel, with a heavy rim rock between it and the present river. This old channel contains an immense deposit of gravel, which pays them well for hydraulic mining. Last year (1889) the *South Fork Hydraulic Mining Company* located and leased a piece of ground next above the Hop E. Tong Company, up the South Fork. They did some prospecting, sinking two shafts but did not get to the bottom of the channel. They got prospects in sinking those shafts that they considered warranted them in bringing water on to the ground. They have been engaged this season in making a trail to the claim, building a house and running ditch lines. They have located a ditch line fifteen and three-quarter miles long, and have commenced cutting a ditch four feet wide on the bottom, two feet deep, and six feet wide on top. This ditch they will push ahead a considerable distance next season, and will also place in position an hydraulic pipe about 450 feet long, suitable to handle the amount of water which the ditch will carry. Next below the Hop E. Tong, and joining their lower line, the *Victoria Hydraulic Mining Company* have located and leased a considerable piece of ground. This company, under the management of Mr. John Hepburn, with a gang of six to eight men, have been engaged in prospecting for the last three months. Mr. Hepburn tells me he has obtained satisfactory prospects for the work done. Then up the river and joining the South Fork Company, there has lately been another location made, and a company is about to be organized to prospect another section of the same channel."

Discoveries of auriferous gravel of more or less importance at various places in the province are alluded to in the above report, but otherwise the operations in alluvial gold are decreasing in importance.

Quartz Mining.—An increase in the interest taken in prospecting for veins continues to be apparent in most of the mining districts.

Speaking of the Cariboo district the report of the Minister of Mines for the province gives the following:—

"Regarding the development in our quartz or mineral claims, although I regret to say that there has not been that enterprise displayed we so much desire, this season has not been entirely fruitless of results. The destruction by fire of the Government Reduction Works last winter had a most depressing effect upon this branch of our mining industry, but, fortunately, these works, although in operation but a few weeks, had proven their capability to successfully treat the character of ore found here, and consequently justified the Government in rebuilding the same upon a somewhat increased capacity, which undertaking has been accomplished most succesfully under Mr. Martin's supervision, and the works are now in operation again. It is a fact worthy of note that the gross product of the district has been increased by about $5,000 produced from the working of quartz. The Black Jack Quartz Mining Co. have, during the season, prosecuted work on their mine; their shaft being now down to a depth of something over 100 feet, and exposing a valuable body of ore. Their small prospecting mill was kept running a good part of the time until stopped by frost. This company has taken another lot of sulphurets to the test works, which is now under treatment. A most satisfactory test of the ore from this mine was made at "The Cassell Gold Extracting Co.'s Works." Glasgow, Scotland. From 360 pounds of ore sent a result of something over $80 per ton was obtained; the ore worked up to 90 per cent. of the assay value. The advantages of this company's method is that no roasting is required, and the company claim that in ordinary cases ore can be treated for one-fourth the cost of working by the chlorinating process, a circumstance which, if substantiated by further working tests, means wealth to this district. British Columbia.

"The Island Mountain Co. completed their ten-stamp mill, to which is attached four concentrators and an improved rock crusher, and the machinery was put into operation about 20th August, and was found to work satisfactorily. Rock crushing commenced on 25th August, and by 25th September several hundreds of tons were put through. Some difficulty was experienced in getting the silver plates to catch the gold, owing to the presence of some foreign substance coating the plates, but after a time this was partially remedied. Some fifteen or twenty tons of sulphurets were saved and brought to the Government Works for treatment. I learned from Mr. May, who put up the Island Mountain Co.'s mill and superintended the working of the ore, that the test made cannot be regarded as a fair result, inasmuch as the ore was taken from the dumps at the various tunnels belonging to the company, and was mostly surface rock, and only trial runs of each kind of rock."

British Columbia.

In the south-eastern part of the province, in the districts of East and West Kootenay and Yale, considerable activity has prevailed in prospecting for and opening up a number of veins. Some of these might be classed as gold veins proper. Most of the veins of this and other mining camps of these districts, however, are better classed as silver and copper deposits, although carrying more or less gold, some assays running very high in that metal. They will therefore be described in the article on silver. Some of the veins of the Toad Mountain camp, however, might properly be classed as gold veins, and of these Dr. Dawson speaks as follows :—

"*With the exception of the Poorman Mine and other adjacent claims on Eagle Creek, near the west end of Toad Mountain, all the metalliferous deposits so far found occur in the stratified rocks. The exceptional veins traverse a hard dark-grey mica-syenite, and differ in character from the other ores containing auriferous iron pyrites in a quartz gangue."

The following information relating to the year's development of these veins is given in the Report of the Government Gold Commission for the district :—

"The Poorman, on Eagle Creek, has been developed by shafts, tunnels and drifts for a depth of 125 feet and about 600 feet along the ledge. Stoping has been done from the 90 foot level. The stamp mill has not been worked during the whole of the summer, owing to the scarcity of water. Abont 1,200 tons of quartz has been crushed, the returns from which can only be conjectured, as the proprietors do not feel disposed to make them public. None of the sulphurets, which are rich, have yet been treated. The last clean-up produced a gold bar worth over $7,000. Two men are engaged in running a tunnel at the upper end of the mine, which will strike the ledge in about 450 feet, and will be extended 400 feet further to reach the ore deposit in the White-Buchanan mine, which runs parallel to the Poorman, and is owned by the same proprietors. To advance the work as rapidly as possible a Burleigh rock drill will be set up and operated on the opening of navigation.

"On Gold Hill, about 1½ miles south of the Poorman, are located the Wild Cat, Catamount and Forest mines. The first mentioned exhibits a large body of ore composed of quartz impregnated with sulphurets. A tunnel is now in a distance of 115 feet. The vein matter assays from $15 to $30, and is of a free milling character. The vein is 10 feet wide, and is in a formation of hornblende granite. One-half of the claim was bonded by H. Keefer, the railway contractor, for 30 days, which he has since obtained by payment of the amount mentioned in the agreement.

* Annual Report Geogloical Survey Dept., Vol. IV, p. 33 B.

"One mile below where the trail crosses Eagle Creek several promising locations exist, the principal of them being the Paradise, Total Wreck, Pioneer, High Ore, and Wizard. The Paradise has a tunnel 30 feet long, exposing a vein three feet wide carrying excellent ore. The Pioneer shows a body of mineral from 2½ to 6 feet wide. The High Ore has a number of open cuts and a prospect shaft, from which several tons of good-looking quartz has been extracted. British Columbia.

"The Royal Canadian has two tunnels, one a distance of 75 feet, the other 65 feet; width of vein from 2½ to 3 feet, existing in a slate country rock. The stated value of the ledge is said to be from $20 to $30 to the ton. Mr. Johnson, of Sydney, Australia, offered $15,000 for one-half the claim, and agreed to erect a plant to cost as much more, provided one ton of average ore would return $20 to the ton, at the sampling works, Revelstoke.

"On Rover Creek some locations have been made, which promise to become of great value. They are known as the Whitewater, Midas, Snow-water and Columbia. The tunnel in the first mentioned is 90 feet long, showing a ledge 6 feet wide, of a free milling nature. It is a contact vein, the hanging wall being granite and the footwall slate. The average of fifteen assays made amounted to $80 in gold. The return from 1½ tons tested at the sampling works was $110 in gold and $9 silver to the ton. Assays of similar richness were obtained from the Snow-water, which is an extension of the former. A trail has been graded a distance of ten miles, and it is the intention of Mr. Davys, who is one of the principal owners, to obtain the two Huntington mills, belonging to the Cottonwood Gold Mining Company, Toad Mountain, and work them to their fullest capacity.

"The output of ore from the gold belt, extending from Eagle to Rover, is estimated at about 1,800 tons, 1,200 tons of which were extracted from the Poorman, and the remainder the result of prospecting work in the various claims referred to. Of course this will be greatly increased when operations are confined to the production of ore only."

From Yale district, Kamloops division, comes the report that only assessment work has been done on the claims of that vicinity, that the Nicola Milling and Mining Company has suspended operations for the present, and that no new discoveries of veins have been made. From another part of the district however the following discovery is reported.

"*Siwash Creek.* Seven miles north-east from Yale, on which about 20 hardy and industrious miners have worked the entire season, many of them performing assessment work only, there has been found rich quartz carrying free gold.

British Columbia.

"The Roddick Company, I may state, have expended nearly $3,000 in opening their claim by driving tunnels and sinking, finding very rich deposits in free milling ore. Test assays have been made in the province and in California that range from $150 to $2,000 per ton in gold."

The mines of the Rock Creek camp received a certain amount of attention, but that district is kept back for want of communications.

"*Cherry Creek.*—Mr. L. W. Riske, in company with Mr. Donald McIntyre, have completed the erection of their quartz mill on the Monashee Mountain, and hope, after getting their ditch constructed, to convey the water a distance of two or two and a half miles to the mill, when they will at once commence crushing the ore, which is pronounced to be very rich."

Further news of this point is given in the following remarks made by Dr. Dawson :—*

"In the course of the preliminary work done on the Shuswap sheet, the Monashee Mine, situated on the watershed between Cherry Creek and Kettle River, and in process of development by Mr. D. McIntyre, was visited. There are at this place several distinct veins of auriferous quartz in which specks of free gold are frequently visible. These veins, in which points of gold are often visible, traverse Monashee Mountain, composed of quartzite, diabase (?) and limestone strata, near to the margin of a wide granitic mass, which lies to the south. Several small tunnels and openings have been made on the veins, and a small mill has been erected with a view to commencing work on the ore in the spring. A number of small specimens selected from the ore at the mouth of the principal working drift at this place, have proved on assay by Mr. Hoffman, to contain, gold 0·583 oz., silver 2·683 oz. to the ton."

GRAPHITE.

Distribution.

The known deposits of this mineral in the country chiefly occur in the Laurentian rocks of the districts of the north shore of the Ottawa River in the Counties of Argenteuil and Ottawa, Province of Quebec, and in similar rocks in Eastern Ontario along the line of the Kingston and Pembroke Railway.

In both districts they mostly occur in the form of irregular veins, strings or beds in the crystalline limestones of the series or in scales disseminated throughout the same whilst a number of interesting minerals form their associates, notably pyroxene, wollastonite, felspar, quartz, sphene, phlogopite, zircon, idocrase, etc.

*Summary Report Geological Survey Department for 1890.

Mining has also been carried on in the Laurentian rocks of the immediate vicinity of St. John, New Brunswick. Here graphite in a finely divided state is disseminated through the rock and at a few points is found in beds of economic importance. They occur in argillites and sub-crystalline limestones and vary from one to four feet in thickness.

Operations.

At the Walker Mine in Buckingham township, Ottawa county, which was working last year, operations were suspended at the end of February, pending negotiations for the more extended capitalization of the mine.

At this place the graphite is found in the gneissic rocks, showing two modes of occurrence. At places on the property it occurs disseminated through the rock, whilst at others the foliated and columnar varieties occur forming a solid filling in veins traversing the formation. The veins are of varying widths, from a few inches up to 2 feet and the surrounding gneiss has a generally rusty and rotten appearance,

Comparison with foreign graphite.

Allusions to the mode of occurrence of the mineral at the various known localities will be found at various places in the Reports of the Geological Survey and analyses and comparisons of its qualities with those of other countries in "Report on Canadian Graphite" by Mr. Hoffmann, Chemist to the Survey; Report of Progress, Geological Survey, pp. 489–512, 1876-77.

In this pamphlet investigation was made of the specific gravity of a number of Canadian specimens, the percentage of ash, and its composition being also determined on all of which points comparison was made with samples of graphite from New York State and from Ceylon. Experiments were also carried out to determine their relative combustibility with a view, amongst other things, to illustrate the fitness of the home product for the manufacture of crucibles.

The results of the investigation show that as regards ash the Canadian graphite gave more than the Ceylon, but much less than the New York. Speaking of the above mentioned experiments and those on the relative combustibility of the different samples examined the report says:—

"From these experiments it will be seen that in respect to incombustibility the Canadian graphite may claim perfect equality with that of Ceylon; and that consequently—apart from any consideration of the proportion and nature of the associated foreign matter—it is in no wise inferior to the latter as a material for the manufacture of crucibles.

"Prepared according to the present process, the 'dressed graphite' (analyses 5 to 14 inc.) obtained from the beds of the disseminated mineral (analyses 1 and 3) is apt to contain more or less carbonate of lime and oxide of iron; it has however been pointed out, experimentally, (analyses 12 and 14) how readily these admit of removal by a very

simple and inexpensive chemical treatment, leaving the graphite with a very small amount of ash, and that of a nature in no wise prejudicial to its application for the purpose here under consideration. That the graphite from this source, in itself compares favourably with that of Ceylon, will be seen from the above table, 1 and 3."

Methods of preparation.

The plumbago obtained at St. John, N.B., only goes through a simple process of hand picking before being shipped, but at the chief mine of the Ottawa county district works have been erected to crush, wash and otherwise prepare the material.

Here, after passing through a Blake crusher, the rock passes through two batteries of Cornish stamps of 10 heads each. From thence it is carried by water to the buddle floor where there are 6 large circular buddles besides two for finishing. These buddles have fine sieves in the outlets and the separation takes place by the settling of the graphite, which is the lighter material, out towards the circumference, whilst the rocky impurities remain near the centre. The waste water from these passes to catch pits where a further amount of the finer graphite is caught. After passing through the buddles the material goes to a drying furnace and the purer portions are further ground and bolted to produce the best grades.

This mill is capable of handling about 40 tons per day of 24 hours.

During the time of the recent operations, which ceased in February last, only the rock containing disseminated graphite was being mined and treated, carrying, it is said, from 25 to 30 per cent of graphite.

At this place the grades made are as follows:—

Grade.	Uses.	Value.
A. 0	Pencil manufacture and electro-typing	50 to 75 cts. per lb.
A. 1, A. 2	do do fine lubricate	
A. 3, A. 4	Lubricate and shot polishing	4 to 25 do
A. 5, A. 6	Crucible manufacture	
S. P.	Slime products for stove polish manufacture	3 to 6 do
F. F.	Foundry facings	1½ cts. per lb.

Latterly a very interesting application has been made by the Ontario Bolt Company of the rock containing the disseminated plumbago in finishing off and facing a certain grade of small and plain castings. They have found it a greatly improved substitute for the grade of plumbago

formerly used for this purpose as when the castings are rotated with it in the "rumblers" the hardness of the rock helps to wear down their roughnesses whilst the plumbago contained in it gives their surface the necessary polish.

The production for the year amounted to 175 tons, valued at $5,200, against 242 tons and $3,160 for last year. This falling off in the amount, but increase in the value, is due to the fact that one of the chief operators whilst working only a short time made sales of a higher grade article. Production.

The exports and imports are given below in Tables 1, 2 and 3. Exports and imports.

GRAPHITE.

TABLE 1.

EXPORTS.

Year.	New Brunswick.		Ontario.	
	Cwts.	Value.	Cwts.	Value.
1886	8,142	$3,586	.....	.....
1887	6,294	3,017	.....	.....
1888	2,700	1,080	.....	.....
1889	660	422	22	$116
1890	400	160	329	1,369

GRAPHITE.

TABLE 3.

IMPORTS OF BLACKLEAD.

Fiscal Year.	Value.
1880	$18,055
1881	26,544
1882	25,132
1883	21,151
1884	24,002
1885	24,487
1886	23,211
1887	25,766
1888	7,824
1889	11,852
1890	10,276

GRAPHITE.

TABLE 2.

IMPORTS OF RAW AND MANUFACTURED PLUMBAGO.

Fiscal Year.	Plumbago.	Manufactures of Plumbago.
1880	$1,677	$2,738
1881	2,479	1,202
1882	1,028	2,181
1883	3,147	2,141
1884	2,891	2,152
1885	3,729	2,805
1886	5,522	1,408
1887	4,020	2,830
1888	3,802	22,604
1889	3,546	21,789
1890	3,441	26,605

GYPSUM.

Distribution. As in previous years the production of gypsum is afforded by the provinces of Ontario, New Brunswick and Nova Scotia.

Ontario. In Ontario work was carried on by the Alabastine Company at Paris and by Messrs. W. Donaldson & Co., of Mount Healy; L. H. Johnson, of Caledonia; Thomas Martindale, of York; and the Grand River Plaster Company of Gypsum Mines.

The deposits which are characteristic of the lower portion of the Onondaga formation occur on the Grand River from the town of Paris to a short distance below Cayuga or to Gypsum Mines, the site of the Merritt mine, operated by the Grand River Plaster Co.

Although the area containing practically workable deposits of gypsum extends for about forty miles, there are considerable stretches along the river where none has been found, as for instance in the neighbourhood of the city of Brantford. The mode of occurrence is very similar to that of the salt beds of Ontario, as it is found in large lenticular interbedded masses of from 3 to 6 feet at the point of greatest thickness and having a total area, of possibly five or ten square miles.

The series of rocks which includes the gypsum lies horizontally and is cut by the valley of the Grand River, thus affording facilities for mining by simply drifting in either from the river bank or from depressions a short distance inland. The work of extraction is continued to the right or left of these drifts, pillars of gypsum being left for the support of the roof, which in many places consists of either a very

friable shaly limestone or of calcareous clay. In many of the abandoned mines, as well as those at present working, the process of extraction has been continued to a distance of 1,500 feet from the mouth of the level. The area mined in each would cover possibly 20 or 25 acres.

No new developments were made in New Brunswick in this industry during the past year; the production, as in previous years, being altogether that of Albert and Victoria counties. In the former county the Albert Manufacturing Company, of Hillsboro', and E. W. Lynds, of Hopewell Hill, were the only producers. In Victoria county Messrs. McQueen and Stewart, of Andover, took out a small quantity. New Brunswick.

That the shipments from Victoria county were somewhat smaller last year than formerly is due to the fact that the Tobique Valley Railway is only as yet in course of construction, and the producers prefer waiting for its completion, that the cost of handling may be greatly lessened, the distance to market being about 25 or 30 miles, and the cost of transport in consequence heavy.

The geological position of all the New Brunswick gypsum deposits is in the lower Carboniferous formation where they occur, forming large interbedded masses in the limestones and shales.

As in previous years the production of Nova Scotia is in a great measure altogether from deposits in the neighbourhood of the Basin of Mines, the quarries being situated at Wentworth Creek, near Windsor, and at Cheverie, Walton, Stewiacke, etc. A considerable amount was also quarried throughout the various counties of Inverness, Victoria and Antigonish. Nova Scotia.

An analysis of gypsum from the Mabou querry was made by Mr. F. J. Shutt of the Experimental Farm, Ottawa, for Col. C. N. Snow, of Pictou, with the following result:—

"Sulphate of lime	97·53
do magnesia	0·92
Carbonate do	0·98
Insoluble rock matter	0·48
Moisture, etc. (undetermined)	0·09
	100·00

"As this sample contains but 2·5 per cent of foreign matter, it must be considered a very pure specimen of commercial gypsum, and one that is well adapted for all the purposes for which this substance is used."

Although occasionally found in large quantities in Manitoba and Athabasca of a quality suitable at least for the manufacture of land plaster, no production is as yet reported from this province. Manitoba.

Of the deposits, Mr. J. B. Tyrrell, in an article entitled "Gypsum deposits in Northern Manitoba," published in the *Canadian Record of Science*, April, 1889, writes :—

"In the north-west corner of township 32, range VIII, west of the principal meridian, is a rounded hill rising thirty-five feet above the plain, its greatest length being about 600 feet, and its greatest breadth 150 feet. Its surface is overgrown with small canoe-birch. Two holes, each about eight feet deep, have been dug by prospectors in this hill. One at the top shows, below a foot of decomposed material, seven feet of hard, compact, white anhydrite or 'bull plaster,' exhibiting a more or less nodular structure, and breaking on the surface into small irregular fragments. Very little bedding can be detected in the mass. The other hole is in the side of the hill fifteen feet lower down, and shows on top two feet and a half of white clay, consisting of decomposed anhydrite, below which is five feet and a half of white nodular anhydrite similar to that in the other hole. This gives a thickness, almost certainly, of twenty-two feet of this rock, and it is not improbable that the hill is composed entirely of it.

"Again, just north of the ninth base line, and two miles east of the township corner, between ranges VIII and IX, is a poplar-covered hill or ridge, thirty feet high. In various places on this hill are exposures of snow-white gypsum, similar to what has been described above, showing in some cases a thickness of ten feet in one section. The most of it is massive or crypto-crystalline, and lies in regular beds which dip slightly towards the west."

Production.

The total quantity produced in the Dominion during 1890 was 226,509 tons, valued at $94,033, the output by provinces being :—

GYPSUM.

TABLE 1.

PRODUCTION BY PROVINCES.

Provinces.	Tons.	Value.
Nova Scotia	181,285	$154,972
New Brunswick	39,024	30,986
Ontario	6,200	8,075
	226,509	$194,033

The production for the past five years has been :—

1886	162,000 tons,	valued at	$178,742
1887	154,008 "	"	157,277
1888	175,887 "	"	179,393
1889	213,273 "	"	205,108
1890	226,509 "	"	194,033

Manufactures.

Of this production the greater part was exported in the crude state, nearly all of the production of Nova Scotia being shipped as such, while in New Brunswick and Ontario small quantities of plaster of Paris were manufactured as well as land plaster, which was sold locally.

The amount of gypsum ground and sold as land plaster was 5,550 tons, valued at $18,114, and of plaster of Paris 19,460 tons, valued at $71,880. In the manufacture of plaster of Paris there is a loss in weight of material of about 20 per cent. Assuming that such be the case there were therefore 24,325 tons of gypsum used in the production of 19,460 tons of plaster of Paris, a total quantity manufactured in Canada of 29,875 tons, or a little more than one-tenth of the total output.

Besides the foregoing, a quantity of "Alabastine" and "Plastico" was made by the Alabastine Company of Paris, Ont., and a considerable quantity of superior quality rock was shipped by the Albert Manufacturing Company of Hillsboro', N.B., to their works at Newark, N.J., for the manufacture of "terra alba."

Exports.

The exports of crude gypsum are given below :—

GYPSUM.

TABLE 2.

EXPORTS OF CRUDE GYPSUM.

YEARS.	ONTARIO.		NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1874	.....	.....	67,830	$ 68,164	.....	.....	67,830	$ 68,164
1875	.....	.....	86,065	86,193	5,420	$ 5,420	91,485	91,613
1876	120	$ 180	87,720	87,590	4,925	6,616	92,765	94,386
1877	.....	.....	106,950	93,867	5,030	5,030	111,980	98,897
1878	489	675	88,631	76,695	16,335	16,435	105,455	93,805
1879	579	720	95,623	71,353	8,791	8,791	104,993	80,864
1880	875	1,240	125,685	111,833	10,375	10,987	136,935	124,060
1881	657	1,040	110,303	100,284	10,310	15,025	121,270	116,349
1882	1,249	1,946	133,426	121,070	15,597	24,581	150,272	147,597
1883	462	837	145,448	132,834	20,242	35,557	166,152	169,228
1884	688	1,254	107,653	100,446	21,800	32,751	130,141	134,451
1885	525	787	81,887	77,898	15,140	27,730	97,552	106,415
1886	350	538	118,985	114,116	23,498	40,559	142,833	155,213
1887	225	337	112,557	106,910	19,942	39,295	132,724	146,542
1888	670	910	124,818	120,429	20	50	125,508	121,389
1889	483	692	146,204	142,850	31,495	50,862	178,182	194,404
1890	205	256	145,452	139,707	30,034	52,291	175,691	192,254

Ground gypsum, to the value of $105, was exported from the province of New Brunswick during 1890.

Imports. The imports of gypsum crude, ground, and calcined, or plaster of Paris, are given in the three following tables:—

GYPSUM.

TABLE 3.

IMPORTS OF CRUDE GYPSUM.

Fiscal Year.	Tons.	Value.
1880	1,854	$3,203
1881	1,731	3,442
1882	2,132	3,761
1883	1,384	3,001
1884		3,416
1885	1,353	2,354
1886	1,370	2,429
1887	1,557	2,492
1888	1,236	2,193
1889	1,360	2,472
1890	1,050	1,928

GYPSUM.

TABLE 4.

IMPORTS OF GROUND GYPSUM.

Fiscal Year.	Pounds.	Value.
1880	1,606,578	$ 5,948
1881	1,544,714	4,676
1882	759,460	2,576
1883	1,017,905	2,579
1884	687,432	1,936
1885	461,400	1,177
1886	224,119	675
1887	13,266	73
1888	106,068	558
1889	74,390	372
1890	434,400	2,136

IRON

TABLE A

ANNUAL PRODUCTION OF ORE.

Year	Province	Quantity	Value
		TONS	$
1886	B. C.	3,941	7,882
	ONT.	16,032	32,064
	QUE.	.....	.....
	N. S.	49,735	87,036
1887	B. C.	2,796	6,990
	ONT.	16,598	36,218
	QUE.	13,404	26,808
	N. S.	43,532	76,181
1888	B. C.	8,372	14,950
	ONT.	16,894	37,710
	QUE.	10,710	74,509
	N. S.	42,611	74,500
1889	B. C.	15,487	20,742
	ONT.	.....	.....
	QUE.	14,533	33,091
	N. S.	54,161	97,807
1890	B. C.	.....	.....
	ONT.	5,000	12,500
	QUE.	22,305	41,196
	N. S.	49,206	101,684

GYPSUM.

TABLE 5.

IMPORTS OF PLASTER OF PARIS.

Fiscal Year.	Pounds.	Value.
1880	667,676	$ 2,376
1881	574,006	2,864
1882	751,147	4,184
1883	1,448,650	7,867
1884	782,920	5,226
1885	689,521	4,809
1886	820,273	5,463
1887	594,146	4,342
1888	942,338	6,662
1889	1,173,996	8,513
1890	693,435	6,004

IRON.

Production.

Of iron ore, 76,511 tons were produced in Canada during the year 1890, valued at $155,380, showing, compared with 1889, a decrease in quantity of 7,670 tons and an increase in value of $3,740, the latter being attributable to the fact that the ores of Nova Scotia brought a much higher price this year than last. The decrease in quantity may be largely accounted for by the cessation of operations by the Puget Sound Iron Company, of British Columbia, who were operating in 1889. The production by provinces is shown comparatively with that of previous years in the graphic table A.

Of the annual production of iron ore in Nova Scotia the following table 1 will afford ample explanation :—

IRON.

TABLE 1.

NOVA SCOTIA: ANNUAL PRODUCTION OF ORE.

	Tons.
1876	15,274
1877	16,879
1878	36,600
1879	29,889
1880	51,193
1881	39,843
1882	42,135
1883	52,410
1884	54,885
1885	48,129
1886	44,388
1887	43,532
1888	42,611
1889	54,161
1890	49,206

Imports and exports.

No ore was imported into Canada during the year, the only trade statistics available, therefore, are those of exports which are shown in table 2 as follows :—

IRON.

TABLE 2.

EXPORTS OF ORE.

Province.	1887.		1888.		1889.		1890.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario.....	12,244	$38,990	31,161	$36,397	4,108	$10,407	18,601	$38,967
Quebec.....	38	119	10	380	.....	2,700	120	1,640
Nova Scotia.	.....	.....	.....	.....	.....	100	.....	.....
British Columbia.	1,410	3,525	7,300	18,400	13,335	26,680	33	83
Totals.... ...	13,692	42,634		55,177		39,887	18,754	40,690

Developments Nova Scotia,

In Nova Scotia operations were carried on by the Londonderry Iron Company and the New Glasgow Iron, Coal and Railway Company, the latter company as yet only doing development work, while the former are carrying on the business established for many years at Londonderry. Of the iron industry in Nova Scotia Mr. E. Gilpin, jr., Inspector of Mines for that province, writes thus in his report for the year 1890 :—

"Operations have been steadily pursued by the Londonderry Iron Company, both at their mines and their furnaces. Calcining furnaces have been built, and large amounts of spathic ore have been burned. This process greatly increases the percentage of iron in the ore, and makes it more fusible.

"The New Glasgow Iron, Coal and Railway Company have commenced a branch line from Eureka to connect with their furnace at the forks of the East River, and with their mines at Springville. They have continued opening and testing their large and valuable properties.

"Iron ore was mined by this Company at Brookfield. Mr. Leckie, of Londonderry, tested a promising deposit near Pugwash, and discoveries were reported from various localities."

New Brunswick.

No iron ore was mined in New Brunswick during the year. A little work in development was, however, done on a property on the Millstream River, Gloucester county, where according to one of the owners, Mr. John Ellis, of Bathurst, N. B., three cross-cuts had been

made during the year upon a deposit of magnetite. In conversation, Mr. Ellis stated that the vein was 32 feet in width, striking E. and W. and dipping nearly vertically, and had been traced for upwards of one mile and a half. According to an assay by Prof. J. T. Donald, of Montreal, the ore contains,—

Metallic iron	65·85	per cent.
Silica and insoluble matter	8·10	do
Phosphorus	0·01	do
Sulphur	0·17	do

It is understood that a small quantity of ore was taken out in proving the vein, though no shipments have been made.

In the province of Quebec active operations were carried on at the Radnor and Drummondville furnaces and at the Bristol mines on lot 21, range II, Bristol township, county of Pontiac. Quebec.

These furnaces have been in operation for many years and are supplied by bog ore procured in their vicinity; that used at the Radnor furnace being in a large measure dredged from the bottom of Lac à la Tortue. A change in proprietorship is reported from Radnor during the past year, the furnace having passed into the hands of the Canada Iron Furnace Company, Limited, of Montreal, remaining, however, under the superintendence of the late owner, Mr. George McDougall, of Three Rivers. It is the intention of the present owners to increase the capacity of the works by the erection of a new furnace about 45 feet in height, with a 10-feet bosh, having a capacity of about fourteen tons per day, making that of their works about twenty tons per day.

In eastern Ontario but little work was done during the year, the small amount shipped being altogether from the district served by the Kingston and Pembroke Railway Company. Ontario.

In western Ontario, although no active operations were carried on, there have been further discoveries made of very extensive deposits of high grade ore in the regions west and north-west of Port Arthur in Algoma District, the more important being undoubtedly those in the neighbourhood of the Atikokan River, where many square miles of rich iron lands have been taken up and prospected.

Regarding this district, the following extracts from a report addressed to the Deputy Minister of Agriculture for the Province of Ontario, by Mr. W. W. Russell, of Port Arthur, and dated October, 1890, may be taken as a very fair description of the district and its ores:—

"Some five years ago the first discovery of magnetite in this range was made, and a tract taken up by Messrs. Graham & McKellar. The property was shortly afterwards examined by Mr. D. H. Bacon (now

Ontario.

superintendent of the Minnesota Iron Company), and on his report bonded for a long term to a Cleveland party, represented by Major Pickands. No active operations having been begun, the discovery of the iron did not attract general notice in any way, until the finding last fall of another equally extensive and rich deposit, several miles further west on the same range. The result of this was the starting of numerous exploring parties this summer, and the discovery of still other outcrops of the same ore further westward, until now these rich deposits have been traced by outcrops for a length of sixteen miles along the belt.

"Nothing more than a superficial examination of the deposits has been made, in the way of a few surface cross cuts, and an occasional shot to secure unweathered samples; but in many places the ore outcrops boldly, showing a varying width of from ten to fifty feet.

"Before describing these outcrops or surface showings more minutely, I may refer to the geological occurrence of the deposits. They occur as beds in Huronian hornblendic and chloritic schists, which are nearly vertical, having a dip of 86 degrees north, and a strike of N. 75 degrees east. The surface showings indicate that there are several of these beds, the intervening rock having a width of from five to thirty feet. Whether these beds will unite at a depth or maintain their separate identity, is a problem for development work to decide. The Huronian belt has an average width of eight miles, and rests conformably in the folds of the Laurentian rocks, so we may presume its depth (and that of the interbedded magnetite) to be very considerable, practically unlimited.

"The McKellar-Graham property is the most easterly on the range, and its most conspicuous outcrops occur on the summit and both faces of a bluffy ridge running nearly east and west one hundred feet above the level of the Atic Okan River. Mr. D. H. Bacon sampled the surface showing here, taking samples at three inch intervals; and for an aggregate width of eighty feet these samples gave 63½ per cent metallic iron, without more than a trace of titanic acid or phosphorus, and little more than a trace of sulphur. The outcrops here showed three beds of ore.

"Immediately west of the McKellar-Graham property is Sabawe Lake, a sheet of water three miles in length. For some distance west of the lake, in the course of the iron belt, a considerable depth of soil covers everything; this extends to location R400, on which and R401, other outcrops occur very similar to those on the McKellar-Graham property. A similar ridge traverses these locations, and in many places, especially on the southern exposure, which is very steep, large outcrops occur. Having closely examined these and several locations adjoining them on the west, I can speak more definitely of them than of others where my inspection was more cursory; and it may be as well to state

here that the ore throughout this range varies but very slightly in character or grade—it is virtually identical throughout, though in some places where greatly exposed to atmospheric action it is of course leaner. On location R400, where a natural exposure of ore some twenty feet in width occurs, a large number of samples taken at random gave from 66 to 68½ per cent metallic iron. On the location west of this, R401, a surface cross-cut was made this summer which showed 46 feet in width of ore; the full width was not ascertained as the cut was abandoned on account of the depth of overlying soil and large boulders; some of the ore from this cut, when protected by deep soil, gave as high as 71 per cent metallic iron. Ontario.

"A little more than half a mile west of this the ore again outcrops on the south face of a ridge about fifty feet in height, the intervening ground being low; samples from here gave 65 per cent. Half a mile further west a short trench dug in the low ground showed rich ore at a depth of only three feet; no attempt was made to uncover the width of the deposit, the sole object being to locate it. A mile beyond this numerous showings are found along the top and south face of a ridge about 100 feet high; the surface showings here are very extensive, and the ore of the same high grade, 66 to 68 per cent. For nearly three miles beyond this the ground in the line of the deposits is very low, and no attempt to locate the ore by test pits, etc., has been made. As the ground rises, the ore again outcrops and shows at the crossing of the Atic Okan River, which is very rapid at this point.

"To bring the Atic Okan ores to a market, a railway from thirty to fifty miles in length will have to be built from near Carlstadt station on the Canadian Pacific Railway to and along the Atic Okan River. An examination of the route was made by the Canadian Pacific Railway Company last fall, and their engineer reported it a very easy one, estimating the cost of grading at not over $2,000 per mile for four-fifths of the distance, the balance being medium work only, to cost say $10,000 per mile. The company are not disposed to build the road unless a reasonable amount of freight is guaranteed, but are willing to equip and operate the road when built if desired, and to facilitate the successful operation of the mines by cheap freight rates, etc. There is no local traffic for the railway throughout this section, and it is plainly to the interest of the company to promote to the utmost any undertaking that might lead to making this part of the line a remunerative one through local traffic. That they are fully alive to this is very evident in all intercourse on the subject with the chief officials of the company.

"With regard to the market for these ores, and the cost of delivering them thereat: Mining will cost from 75 cents to $1.00 per ton, say $1.00

Ontario.

as an outside estimate. Railroad freight to Port Arthur or Fort William, $1.00 per ton. Lake freight to either of the principal ore ports on Lake Erie, Cleveland or Ashtabula, may be taken as the same as that from Ashland or Two Harbours, the shipping ports of the Gogebic and Vermillion districts. The rate last year and during the present season has been about $1.25 per gross ton, and there is no reason to think this will be exceeded in the future, considering the continual increase in numbers and tonnage of vessels built on the lakes. Shipping charges, insurance, etc., may be taken at 30 cents per ton; duty going into the United States, 75 cents per ton. This will give the total cost delivered at a Lake Erie port of $4.30 per ton. The present value of a high grade Bessemer ore, such as this under consideration, delivered on the docks at Cleveland or Ashtabula is $6.00 per ton, which would leave a net profit of $1.70 per ton.

"The Dominion Government gives a bonus of $2.00 for every ton of pig iron manufactured in Canada, and a portion of the Atic Okan ores might be profitably treated at Port Arthur or Fort William, where other ores for mixing, fluxes and fuel can be brought at low rates. Coal is carried here from Lake Erie ports at from 40 to 50 cents per ton, and coke from 80 cents to $1.00. There is no duty on anthracite coal and coke also is admitted free, if for smelting purposes.

"I append hereto a number of analyses of the Atic Okan ore from different parts of the range.

"ASSAYS OF ATIC OKAN MAGNETITE.

"M'KELLAR-GRAHAM LOCATION.

	Averages by Mr. D. H. Bacon.			Chapman.
	(1)	(2)	(3)	
Silica	6·60	7·30	5·89	2·43
Alumina	1·09	1·80	0·98	0·67
Ferrous ox				23·32
Ferric ox	87·66	86·90	88·36	46·74
Manganese	trace.	trace.	trace.	
*Calcic (? carbonate)	1·28	0·90	1·40	
Magnesia	0·75	0·60	0·75	
Phosphoric acid	0·0079	0·069	0·025	
Titanic acid	none.	none.	none.	none.
Total	94·46	97.57	97·41	
Metallic iron	63·47	62·84	63·97	70·06

"The first three are averages from the three beds sampled by Mr. Bacon, and the last is a single specimen given Prof. Chapman of Toronto.

*The original M. S. is not clear here but the carbonate would evidently be intended.

"AVERAGES TAKEN BY W. W. RUSSELL FROM LOCATIONS R400 AND 401. Ontario.

Assayed by {	Minnesota Iron Co.	F. Hille, Pt. Arthur.	H. M. Currie for Carnegie Bros.
Metallic iron	68·50	65·90	65·702
Silica	2·90	5·80	4·20
Phosphorus	0·015	0·001	0·003
Sulphur	0·052	0·16	Not specified.
Titanic acid	none.	none.	none.

"ASSAYS BY SHARON IRON WORKS, PA., OF SAMPLES FURNISHED BY CAPT. M. N. GARLAND, AS FROM PROPERTY MARKED 'GARLAND LOCATIONS.'

Metallic iron	68·75
Silica	1·41
Phosphorus	0·006
Sulphur	0·185

"ASSAYS OF ATIC OKAN ORE BY GEOLOGICAL SURVEY OF CANADA

G. C. Hoffmann, Assayer.

1. Magnetite from R402:	
Metallic iron	68·579
Titanium	none
2. Magnetite, R400:	
Metallic iron	68·027
Titanium	none
3. Magnetite from R403:	
Metallic iron	64·551
Titanium	none
4. Magnetite from line between Mining Locations 10E and 11E, collected by Smith:	
Metallic iron	65·710
Titanium	none

In British Columbia the mine which was the only producer for some years past did not operate during 1890, so that there is no production to report from this province. The following item regarding a recent discovery is taken from the report of the Minister of Mines for British Columbia:— British Columbia.

"About ten miles east of Lytton, by the side of the Canadian Pacific Railway track, Mr. James Wilson, Superintendent of the C. P. R. telegraphs, is the fortunate owner of an extensive iron deposit, which is represented to me as having indications of becoming a valuable property a few years hence. Already about $1,000 has been expended towards developing this mine by sinking and drifting."

Pig Iron. During 1890 the amount of pig iron produced in Canada from Canadian ores was 21,772 tons, valued at $331,688, showing a decrease, when compared with the year previous, of 4,149 tons and $168,184. Statistics of this industry will be found in the following table where they are shown in comparison with those of the year previous. Pig Iron.

IRON.

TABLE 3.

Pig Iron.

PIG IRON PRODUCTION: CONSUMPTION OF ORE, FUEL, ETC.

Production and Consumption.		1889.		1890.	
		Quantity.	Value.	Quantity.	Value.
Pig Iron made.....	Tons.	25,921	$499,872	21,772	$331,688
Iron Ore consumed.....	"	65,670	126,064	57,304	117,880
Fuel consumed.. Charcoal..	Bush.	755,800	41,568	589,860	29,493
Fuel consumed.. Coke.....	Tons.	33,289	94,791	32,832	97,659
Fuel consumed.. Coal... ..	"	3,044	6,525	1,241	2,638
Flux consumed	"	22,122	21,909	18,478	18,361

The number of furnaces in blast during the year was four, and the entire production was utilized in Canada, as there were no exports reported.

Iron and Steel Manufactures.

Iron and Steel Manufactures. In table 4 will be found statistics regarding exports of iron manufactures produced in Canada, while in tables 5, 6 and 7 will be found the statistics of imports of all iron products other than highly finished iron and steel goods of which the value of the metal alone represents but a small proportion of the whole.

IRON.

TABLE 4.

EXPORTS OF IRON AND STEEL GOODS, THE PRODUCE OF CANADA.

Province.	Scrap Iron.	Iron Stoves.	Iron Castings	Iron, all other and Hardware.	Steel and Manufactures of	1890. Totals.	1889. Totals.
Ontario..... ..	$12,410	$1,517	$5,571	$11,756	$8,404	$39,658	$40,679
Quebec.....	22	665	1,926	38,061	12,853	53,527	66,570
Nova Scotia..... ...	153	753	805	10,974	5,041	17,726	14,914
New Brunswick.	.....	567	.....	8,110	.....	8,677	7,365
Prince Edward Island	.....	12	....	98	.....	110	108
Manitoba.....	.... ..	220	22	332	563	1,137	1,659
British Columbia....	10,040	6	11	1,614	1,218	12,889	13,614
Totals....	22,625	3,740	8,335	70,945	28,079	133,724	144,909

Iron.

Table 5.

Imports: Iron in Slabs, Blooms, Loops and Puddled Bars, etc.

Fiscal Year.	Cwt.	Value.
1880	195,572	$244,601
1881	111,666	111,374
1882	203,888	222,056
1883	258,639	269,818
1884	252,310	264,045
1885	312,329	287,734
1886	273,316	248,461
1887	522,853	421,598
1888	110,279	93,377
1889	80,383	67,181
1890	15,041	15,923

Iron.

Table 6.

Imports of Pig Iron, etc.

Fiscal Year.	Pig Iron, Charcoal.		Pig Iron, all Other.		Pig Iron, Kentledge, &c.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1880	.....	.....	23,159	$371,956	.....	.....	23,159	$371,956
1881	.....	.....	43,630	715,997	.....	.....	43,630	715,997
1882	6,837	$211,791	56,594	811,221	.....	.....	63,431	1,023,012
1883	2,198	58,994	75,295	1,085,755	.....	.....	77,493	1,144,749
1884	2,893	66,602	49,291	653,708	.....	.....	52,184	720,310
1885	1,119	27,333	42,279	545,426	.....	.....	43,398	572,759
1886	3,185	60,086	42,463	528,483	.....	.....	45,648	588,569
1887	3,919	77,420	46,295	554,388	.....	.....	50,214	631,808
1888	.....	.....	.....	.....	48,973	$648,012	48,973	648,012
1889	.....	.....	.....	.....	72,115	864,752	72,115	864,752
1890	.....	.....	.....	.....	87,613	1,148,078	87,613	1,148,078

Iron and Steel Manufactures.

IRON.

TABLE 7.

IMPORTS OF IRON AND STEEL GOODS.*

Fiscal Year.	Value.
1880	$6,620,260
1881	8,484,175
1882	8,578,685
1883	8,613,739
1884	6,143,870
1885	4,606,193
1886	4,698,882
1887	6,084,704
1888	5,147,111
1889	7,108,052
1890	7,260,845

LEAD.

Production. According to returns made to this office there were 113,000 pounds of lead produced during 1890, which at 4½ cents per pound is equivalent to $5,085. This production is altogether that of the provinces of Ontario and Quebec. No operations were undertaken in Nova Scotia and New Brunswick.

Developments Quebec. In Quebec the most important is undoubtedly that known as the Lake Temiscamingue mine on lots 56 to 62, range I of the township of Duhamel, the shaft and workings being on lot 62 near the lake shore. Work was carried on in a desultory way for many years under the management and ownership of Mr. E. V. Wright of Ottawa. During 1890, however, the mine was purchased by American capitalists and active work undertaken, the result being that a shaft already begun was carried to a depth of over 100 feet. From this shaft two drifts were made on the course of the vein, one to the west being 30 feet in length, and known as the 65-foot level, the other in an opposite direction, at about 100 feet from the surface, was carried to a distance of 15 feet, a cross-cut was made at 70 feet which struck the wall on the north-east side at a distance of 20 feet from the shaft. In the 65-foot level a diamond drill test was made to a depth of 75 feet or a total depth of 140 feet from the surface and showed good ore throughout its entire length. On the surface the fissure is plainly shown to be 80 feet in width and has been

*These figures do not include those of hardware, engines, agricultural implements, or other highly finished iron products.

traced for a distance of 1,400 feet in a north-easterly direction. The great drawback to the proper development has always been the distance from railway communication and the difficulties to be contended with as regards shipments. The position of the mine is unfortunate in this respect, its only means of communication being by the waters of the Ottawa River, of which Lake Temiscamingue is a part for a distance of about 100 miles above Mattawa station. The lower 40 miles of this distance is broken in many places by rapids and falls, necessitating frequent transhipment. The first portage is made by means of a narrow gauge railway of eight miles in length, the lower rapids requiring short tramways of from one-half to one mile each. Until the completion of the projected railway from Mattawa station on the Canadian Pacific Railway to Lake Temiscamingue, the cost of laying ore or concentrates on the cars will be in the neighbourhood of $11 per ton. The present owners have a very complete mill and mining plant at the works, consisting of:— Quebec.

1 Blake crusher.
2 pair rolls.
2 revolving screens.
4 jigs.
1 revolving table.
1 Corliss engine.
Ingersoll compressor and drills.

The average of lead in the ore is, according to E. Obalski, Government Mining Engineer for the province of Quebec, 52 per cent with a content of silver equivalent to 26 ounces per ton. Many other occurrences are known throughout the province of Quebec on which however no work was performed during the year.

In Ontario a small amount of development work was done in the neighbourhood of Black Bay, Lake Superior, where several of the old properties as well as some recent discoveries of galena were opened and tested; no shipments were however made. Ontario.

Particulars regarding the lead ores of British Columbia will be found in the article on silver, as the ores of that province are highly argentiferous, and as such have been treated of there. It has been found impossible to obtain the amount of lead ore or lead contents shipped from that province, as the values of all shipments of that metal are included in the total value of the ores for that and the other metals. It is expected that during the present year increased railway and other facilities will be afforded for the shipment of ores and that in consequence there will be a large production of lead to report from that province. British Columbia.

Imports.

The only statistics of the lead trade available are those of the imports, which are given below:—

LEAD.

TABLE 1.

IMPORTS OF LEAD.

FISCAL YEAR	OLD, SCRAP AND PIG.		BARS, BLOCKS, SHEETS.		TOTAL.	
	Cwt.	Value.	Cwt.	Value.	Cwt.	Value.
1880	.....	.....	.....	.....	30,298	$124,117
1881	16,236	$ 56,919	18,222	$70,744	34,458	127,663
1882	36,655	120,870	10,540	35,728	47,195	156,598
1883	48,780	148,759	8,591	28,785	57,371	177,544
1884	39,409	103,413	9,704	28,458	49,113	131,871
1885	36,106	87,038	9,362	24,396	45,468	111,434
1886	39,945	110,947	9,793	28,948	49,738	139,895
1887	61,160	173,477	14,153	41,746	75,313	215,223
1888	68,678	196,845	14,957	45,900	83,635	242,745
1889	74,223	213,132	14,173	43,482	88,396	256,614
1890	101,197	283,096	19,083	59,484	120,280	342,580

LEAD.

TABLE 2.

IMPORTS OF LEAD MANUFACTURES.

Fiscal Year.	Value.
1880	$15,400
1881	22,629
1882	17,282
1883	25,556
1884	31,361
1885	36,340
1886	33,078
1887	19,140
1888	18,816
1889	16,315
1890	25,600

MANGANESE.

Production.

In the lower provinces of Canada are found many extensive deposits of the various ores of manganese, viz.:—Pyrolusite, manganite and wad, which occur, in the case of the crystalline ores, almost without exception, in rocks of Carboniferous age. That the industry has not been neglected may be evidenced by the fact that, since 1868, the exports of high grade ore amount to over 30,000 tons, the greater part of which went to the United States.

The ores are, briefly, as follows:—Pyrolusite, known locally as "grey ore" or "needle manganese," is essentially an anhydrous oxide of manganese having the general formula of MnO_2. Ores.

Manganite, known locally as "blast furnace ore" or "brown ore," is essentially a hydrous sesquioxide of manganese having the general formula Mn_2O_3, H_2O. In appearance it is similar to pyrolusite, except perhaps that it is more generally black, seldom, except in the case of the purer varieties, being greyish black. This ore is readily distinguished from pyrolusite by its streak, which is reddish or brownish black, that of the latter being black to submetallic.

Wad, or bog manganese, is an impure hydrous oxide of manganese occurring generally in bogs or old lake bottoms, in the form of an earthy deposit or in amorphous masses of some size. The composition varies considerably, ranging in content of manganese binoxide from 50 to 75 per cent, with considerable quantities of ferric oxide and small percentages of phosphorus and other impurities.

Throughout the southern part of New Brunswick and in the areas underlain by the Carboniferous limestone are many extensive deposits of manganese which have afforded considerable quantities of high class ore. The most important in this province, owing to its extent and development, is undoubtedly that at Markhamville, where the mines of the Pope Manganese Company are situated. New Brunswick.

Pope Manganese Co.—In the parish of Sussex, Kings Co., and about twelve miles in a direct line south from the town of Sussex, is a small area of Carboniferous limestone, on the north-west side of which are located the mines of the above company. The ore occurs throughout the limestone in the form of beds and pockets, attaining in places large dimensions, as much as 4,000 tons having been produced from one pocket. The discovery of manganese at this point was made in 1862, when it was worked by Mr. Wm. Davidson, of St. John, until 1865, when the property passed into the hands of the Queen Manganese Company, by whom it was operated under the management of Major A. Markham, until the fall of 1889. The Queen Manganese Company then went into liquidation, owing to the failure of the more important members of the company, and the result was the formation in 1890 of the Pope Manganese Company, capital stock $75,000, with the following officers: President, W. C. Pope; treasurer, C. H. Converse; manager and superintendent at mines, A. Markham.

In the extraction of the ore no regular system of mining is attempted nor possible. Owing, however, to the location of the deposits, in a valley cut through the soft limestones, the workings have, until quite recently, taken the form of drifts and open cuts, the hill on the north and west of

New Brunswick.

the property being literally honey-combed with drifts, adits, pits and open cuts. During 1890 Major Markham was making explorations by means of a diamond drill, and had been successful in locating two large ore bodies, both of which were being sunk upon.

Of the ore shipped from this mine two distinct classes are recognized, viz.:—"Blast furnace ore," consisting almost entirely of manganite, and high grade or "grey ore" consisting of pyrolusite.

The following analyses are of "high class manganese ore from Markhamville, New Brunswick," and are taken from "The Mineral Resources of the United States, calendar year 1888," Washington, 1890:—

	No. 1.	No. 2.	No. 3.
Manganese binoxide	98·70	.....	.....
do peroxide	.....	97·25	96·62
Silica	0·55	.....	.....
Iron	0·75	.....	.....
Iron peroxide	.....	0·85	0·78
Barium	Trace.	.....	.....
Baryta and silica	.....	0·95	0·85
Water	.....	Trace.	Trace.
Loss	.....	0·95	1·75

For the treatment of their ore the company have a well-equipped mill, in which the following plant is contained:—1 crusher, 2 Cornish jigs, 1 cyclone pulverizer, 1 Bogardus mill, 1 sizing machine and 1 calcining furnace; while the plant in connecting with the extraction of ore consists of 2 hoisting engines, 2 steam pumps, 2 steam drills, 1 diamond drill, complete, as well as a rotary saw-mill.

Jordan Mountain.—About five miles north of Sussex, and on the western end of Jordan Mountain, is a deposit of manganiferous limestone throughout which is scattered, in a manner similar to that at Markhamville, more or less extensive deposits of pyrolusite and manganite. Since its discovery in 1882, by the present owner, Mr. F. W. Stockton of Sussex, but little has been done, further than a small amount of development work consisting of stripping and an open cut of about eighty feet in length in the bottom of which in August, 1887, was to be seen a lenticular interbedded mass of manganite and pyrolusite. From this open cut about 400 tons of 80 to 85 per cent ore has been extracted.

Brunswick Manganese Company.—The property of this company, consisting of one thousand acres, is situated on a promontory extending into the Bay of Fundy opposite to the village of St. Martin's and known as "Quaco Head." Traversing this high point is a heavy bed of red calcareous shale which is highly charged with manganite, pyrolusite being of much rarer occurrence than in the limestone deposits of the before-mentioned localities. The deposit has been worked in a very desultory manner for many years, energetic operations not having been commenced until the acquisition by the present company, who began

operations by driving a tunnel N. N. W. into the shales which show a bluff face of about 150 feet in height. This tunnel, on 2nd October, 1890, was about sixty feet in length, from which two cross-cuts had been driven at right angles, extending in either direction about twenty feet. In these workings numerous pockets, as well as small scattered masses, of very hard manganite, suitable for blast furnace purposes, had been opened and the ore extracted, though no shipments had been made. New Brunswick.

In connection with the mine a well-equipped mill has been erected, the plant consisting of one cracker, one pair rolls, one revolving screen, two jigs and one 40-horse power engine and boiler. Owing to the position of the mine, every facility is afforded for shipping, the ore being run direct from the mouth of the tunnel and after treatment in the mill loaded into self-dumping cars and run direct to the wharf, where it is possible for vessels to load at almost all seasons.

Assays of the ore by A. M. Cowey, of Cambridge, Mass., are as follows:—

	Compact Variety.	Porous Variety.
Manganese dioxide	71·54	65·00
Insoluble silicates	8·37	6·66
Ferric oxide	2·19	1·75
Phosphorus	0·02	0·04
Calcium	Trace.	Trace.
Metallic manganese	58·20	57·15

A considerable quantity of lime is generally present in the concentrates, which, however, does not interfere with their fitness for use in the manufacture of steel, for which purpose all the ore from this property will be used, a contract having been entered into with the Carnegie Company of Pittsburg.

Gowland Mountain.—A small amount of exploratory work has been done on the north and north-east side of Gowland Mountain, Elgin parish, where the lessees, Messrs. H. A. Whitney, C. J. Butcher *et al*, had, during October, 1890, a small force of men engaged in driving a tunnel and sinking pits, several of which had already been sunk, showing in all of them small quantities of pyrolusite and manganite occurring in a very broken and decomposed granite of pre-Cambrian age. No shipments have as yet been made, nor has there been any material production.

This property is peculiar in affording the only instance in New Brunswick where manganese has been known to occur in appreciable quantity outside of the Carboniferous areas.

New Brunswick.

The following analysis made by Mr. F. D. Adams, assistant chemist to the Geological Survey, is that of a specimen of psilomelane from this property, and was made in 1885 :—

Manganese dioxide, available.....	50·21	per cent.
Ferric oxide..	3·06	do
Insoluble residue	33·78	do

" Agreeably with the results of a qualitative examination, this ore would appear to contain a very appreciable percentage of baryta."

Other localities where manganese, in the form of its crystalline ores, has been noted are, Upham, Waterford, Springfield, Tête-à-Gauche Falls, and many points throughout Albert county. Of one of these, Shepody Mountain, Dr. R. W. Ells, in his report to the Geological Survey for 1884, page 35 E, writes: "The rocks of the mountain" (Shepody Mountain) " rest upon a small outlier of the talco-chloritic schists, which show on the road to the north, leading to Curryville, and are flanked on the east by the grey sandstones of the millstone-grit. On the north-west side a large deposit of manganese was worked for some years, a tunnel being driven into the mountain along the contact with the underlying schists for nearly 1,000 feet, the ore, which consisted of pyrolusite and psilomelane, occurring at the base of the conglomerate in irregular pockets. Operations have been suspended for some years, and the workings have all fallen in. At the mouth of the slope the conglomerates dip N. 15° E. $<$ 15°—20°"

It is understood that negotiations are now pending for the sale of this property by the present owner, Mr. John Murphy.

Crimora Manganese Company.—This company own and are operating a property of 260 acres in extent, known as the Duffy property in Dawson settlement, parish of Hillsboro', Albert county, wherein occur considerable areas of wad. These deposits vary in extent and depth, attaining in some places a thickness of over forty feet, to which depth they have been tested. The ore is covered throughout with peaty matter to the depth of about one foot, beneath which it is found in a good state of purity. The mode of working is very simple, consisting first of cross trenching, by which means the ore is partly drained, after which it is excavated and dried in six pans, each 6 by 50 feet, the result being a dry and almost impalpable powder, which is loaded direct into cars of the Salisbury and Harvey Railway, from the main line of which a spur has been built. It is understood that contracts have been entered into with several steel makers in the United States for a supply of ore from this locality.

A partial analysis of the ore by Mr. W. F. Best, St. John, gave,— New Brunswick.

Manganese binoxide	47·0
Iron oxide	18·0
Vegetable matter	34·0
Loss	1·0
Copper	Trace
Cobalt	Trace
	100·0

Several analyses by John Burwash gave the following percentages of manganese binoxide:—73·6, 35·5, 58·3, 57·6, 70·7, 63·4, and an assay of specimens collected at various points gave an average percentage of 47·4.

Large deposits of wad, pyrolusite and manganite occur throughout the province of Nova Scotia, the harder or crystalline ores occurring, as in New Brunswick, in the greater number of instances in the Carboniferous limestones, whereas wad, the most common of the Nova Scotia ores, exists in the form of surface deposits over widely-scattered areas. Space does not permit of more than a brief mention of the various more important localities, among which may be mentioned that at Teny Cape and the other manganese deposits in the immediate neighbourhood of Minas Basin, Boularderie Island, and throughout the western part of Cape Breton Island. Nova Scotia.

Teny Cape and Minas Basin.—On the south shore of Minas Basin and midway between Noel and Walton is situated the Teny Cape mine, which, since its discovery in 1862, has been operated more or less continuously. The ores, consisting mainly of pyrolusite and manganite, are found in the Carboniferous limestone which is traceable for many miles on the south shore of Minas Basin, the limestone immediately in connection with the ore deposits being highly manganiferous and interstratified with small beds and masses of a manganiferous calc-shale, the whole being usually of a deep red colour. The mode of occurrence is pockety, the ore being found in irregular masses and stringers, which follow the bedding planes and fractures; some of these pockets are of considerable extent, one affording, it is said, upwards of 1,000 tons of high grade ore.

A very considerable proportion of the ore extracted is high grade pyrolusite, selling for from $100 to $125 per ton at the mine, and containing from 85 to 95 per cent of available binoxide.

The following assays taken from an article entitled "Notes on the Manganese ores of Nova Scotia," by E. Gilpin, jr., Proc. Roy. Soc. Can., Vol. II, show the character of the ores obtained from Teny Cape and district.

	Teny Cape (*a*)	Cheverie (*b*)	Douglas
Manganese oxides	85·54	90·15	84·62
Iron peroxide	1·18	2·55	0·60
Baryta	0·89	1·12	0·72
Insoluble matter	3·27	2·80	1·73
Phosphoric acid	0·34	1·03	....
Water	8·54	2·05	5·29
Oxygen	....	....	7·04
	99·76	99·70	100·00

(*a*) Analyst, Dr. Howe.
(*b*) do E. Gilpin, jr.
(*c*) do H. Poole.

Deposits similar to that at Teny Cape have been worked to a smaller extent at Cheverie, Walton, Noel and Shubenacadie, on the south shore of Minas Basin, while on the north shore no important deposits of manganese have been noted, though some of the limonite and other iron ores of the neighbourhood of Londonderry are highly manganiferous; this is also the case with many of the iron ores of both Colchester and Pictou counties.

The following analyses taken also from Mr. Gilpin's article, mentioned above, show the character of some of these ores, the particular cases cited here being of two limonite ores from Springville, Pictou county.

Iron sesquioxide	10·848	48·223
Manganese oxide	62·950	
do peroxide	.....	14·410
Magnesium	1·630	
Lime	7·280	0·015
Alumina	2·880	Trace
Baryta	0·670	
Sulphur	....	0·480
Phosphorus	.....	0·020
Insoluble residue	2·731	25·130
Water of composition	.....	12·530
Moisture	1·450	
	90·439	100·808

Cape Breton.—Among the more important deposits of Cape Breton Island may be mentioned those on Loch Lomond, which have been exploited by the Hon. E. T. Moseley, of Sydney. In the report of the Geological Survey, 1882–84, Mr. Hugh Fletcher writes of the deposits as follows:—"Large deposits of pyrolusite, which promise to be of great importance, have recently been discovered and developed by the Hon. E. T. Moseley, of Sydney, on the south side and near the head of Loch Lomond, in Cape Breton county. The ore is associated with lower Carboniferous rocks and has been worked in two places about three-quarters of a mile apart. At the most easterly of these, in a brook on the farm of Norman Morrison, a tunnel has been driven about thirty feet on a vein about seven inches thick, dipping N. 87° W. $< 25°$ in fine red sandstone overlying reddish and greenish grit, with grains of quartz about the size of wheat and red marly sandstone. The ore is irregularly mixed with red and grey bituminous limestone, red and

greenish shale conglomerate and other rocks blotched with calc-spar. It is in lenticular layers and also intimately mixed with the limestone, being probably of the same nature and origin as the hematite and forming at times a cement for the pebbles of the comglomerate * * * The mines were first worked in 1880. In 1881 about 70 tons, and in the following year 59 tons of excellent ore were shipped to the United States, * * * An analysis of a sample from the Morrison mine afforded Mr. Adams 91·84 per cent of manganese dioxide, only ·12 per cent of ferric oxide and 2·91 per cent of insoluble residue."

Many other deposits, both of crystalline ores and wad, are known to exist throughout the island. One of these on Boularderie Island is said to be quite extensive, and the character of the ore may be judged from the following assays:—

	I.	II.	III.
Manganese peroxide	25·42	11·04	44·33
Iron sesquioxide		12·49	35·50
Insoluble matter		57·76	10·00
Water	33·52		

I and II by G. C. Hoffmann, Chemist Geological Survey. III by E. Gilpin, jr., Trans. Royal Society of Canada, Vol. II, sec. IV.

Quebec.—In many places throughout the province of Quebec are small deposits of manganese, principally in the form of wad. One of these occurs on the St. Louis road, about four miles from Quebec, where it covers an area of about 300 yards square and is about twelve inches in thickness. Similar deposits occur in Stanstead, Bolton, Tring, Aubert Gallion, St. Mary's and other parishes, but nowhere in sufficient quantity for commercial purposes. Quebec.

Of manganese occurring on the Magdalen Islands, Mr. Jas. Richardson, in the report to the Geological Survey, 1879–80, writes :—"Immediately under Demoiselle Hill, on Amherst Island, numerous blocks charged with peroxide of manganese, or pyrolusite, occur among the debris of the fallen cliffs. They are in pieces varying from one pound to ten or fifteen pounds in weight. There can be little doubt that they are derived from a deposit more or less regular in the hill side, but which is now completely concealed by the fallen debris. At a place bearing nearly due west from Cap aux Meules, at the distance of about a mile, and close to the English Mission church, similar pieces to those above-described are very frequently picked up." Assays of this ore, in the same volume, gave :—

Manganese dioxide	45·61 per cent.
Water, hygroscopic	0·10 do

Ontario.—A considerable deposit of manganese is, according to the "Geology of Canada, 1863," reported as occurring on Batchewahnung Ontario.

Bay, Lake Superior. The ore is said to be manganite and to assay 60 per cent of peroxide of manganese. No other occurrences have been reported authentically.

Production. During the year 1890 manganese ore to the extent of 1,328 tons was mined and shipped, the value being, according to direct returns made to this office, $32,550. The price per ton, as shown by the above figures, is about $24.50, which, compared with that of the year previous, shows an increase of $2.00.

The production for the past four years has been,—

1886.....	1,789	tons.....	$41,499
1887.....	1,245	do	43,658
1888	1,801	do	47,944
1889.....	1,455	do	32,737

It was all mined in New Brunswick and Nova Scotia.

According to the reports of the Department of Mines for Nova Scotia, the production of manganese in that province since 1877 has been as follows:—

1877.....	97	tons.	1884.....	302½	tons.
1878.....	127	do	1885.....	353½	do
1879.....	145	do	1886..... (*a*)	427	do
1880.....	223	do	1887.....	691	do
1881.....	231	do	1888.....	88	do
1882.....	205	do	1889.....	67	do
1883.....	150	do	1890.....	112	do

(*a*.) 250 tons from Cornwallis should more correctly be classed as an ochre.

Exports. The following tables give the exports of manganese ore since 1868, the greater proportion in latter years going to the United States:—

MANGANESE.

TABLE 1.

EXPORTS OF MANGANESE ORE PRIOR TO 1873.

FISCAL YEARS.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1868.....	156	$4,700	861	$19,019	1,017	$23,719
1869.....	156	4,695	332	6,174	488	10,869
1870.....	1,256	4,102	146	3,580	1,402	7,682
1871.....	102	1,608	954	8,180	1,056	9,788
1872.....	131	4,005	1,075	24,495	1,206	28,500
1873.....	.....	.....	838	17,171	838	17,171

MANGANESE.

TABLE 2.

EXPORTS OF MANGANESE ORE SINCE 1873.

YEARS.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1873			1,031	$20,192	1,031	$20,192
1874	6	$ 12	776	16,961	782	16,973
1875		200	194	5,314	203	5,514
1876	21	723	391	7,316	412	8,039
1877	106	3,699	785	12,210	891	15,909
1878	106	4,889	520	5,971	626	10,860
1879	154	7,420	1,732	20,016	1,886	27,436
1880	79	3,090	2,100	31,707	2,179	34,797
1881	200	18,022	1,504	22,532	1,704	40,554
1882	123	11,520	771	14,227	894	25,747
1883	313	8,635	1,013	16,708	1,326	25,343
1884	134	1,054	469	9,035	603	20,089
1885	77	5,054	1,607	29,595	1,684	34,649
1886	(a) 441	854	1,377	27,484	(a)1,818	58,338
1887	578	14,240	837	20,562	1,415	34,802
1888	87	5,759	1,094	16,073	1,181	21,832
1889	59	3,024	1,377	26,326	1,436	29,350
1890	177	2,583	1,729	34,248	1,906	36,831

(a.) 250 tons from Cornwallis included in this quantity more properly come under the heading mineral pigments.

The imports of oxide of manganese (presumably manufactured) into Canada can only be given for the past seven years and are as follows:— Imports.

MANGANESE.

TABLE 3.

IMPORTS: OXIDE OF MANGANESE.

Fiscal Year.	Pounds.	Value.
1884	3,989	$ 258
1885	36,778	1,794
1886	44,967	1,753
1887	59,655	2,933
1888	65,014	3,022
1889	52,241	2,182
1890	67,452	3,192

MICA.

This industry has come to the front lately, on account of the demand for the mineral for electrical purposes.

Mica ; occurrence, etc.

The sources of the mica mined during the year have been the deposits occurring in the Laurentian rocks of the valley of the Gatineau River, Ottawa county, P.Q., and of that section of country in Eastern Ontario tributary to the Kingston and Pembroke Railway,—the former district with headquarters at Ottawa and the latter at the village of Sydenham.

Nearly all the shipments of the year have consisted of the quality known as "amber" or "brown" mica, which is a magnesia mica of the phlogopite species, as distinguished from the "muscovite" or potash mica, which has been commonly used for stove purposes. This latter variety was, until recently, shipped from the Villeneuve mica mine, in the township of the same name, Ottawa county, P.Q., which, however, has ceased operations.

This "amber mica" of the trade occurs chiefly in the crystalline limestone of the Laurentian system, and occasionally also in the pyroxenic belts of the same. It occurs as aggregates of crystals of various sizes, or in veins of more or less regularity, and is generally associated with more or less phosphate, forming a very common associated mineral, in the deposits proper of this substance. Some of the worked deposits, however, yield it free from intermixed substances.

Some of the mines have yielded crystals of considerable size, having been known to produce cut sheets as large as 24 x 14 inches, whilst a crystal lately found in one of the mines in the Gatineau district measured three feet across and over five feet in length.

The potash mica or muscovite occurs generally, as at the Villeneuve mine, in the coarsely crystallized granitic veins and intrusions, of which it forms a constituent, along with the associated felspar and quartz.

On none of the mines have very considerable developments been made, the depth attained not exceeding 168 feet in the deepest of them, which has been worked for some years, whilst the length of the vein explored at that place would be comprised within 210 feet, and the average force of men employed at this mine would not range over 30. Returns were received from eight operators, but the grand total was augmented considerably by the product of desultory mining by small producers, of whose output, however, a close estimate was obtained.

From some of the mines mica is shipped only in the uncut state as selected crystals, whilst others have cutting sheds, and send away their product in this shape, the waste resulting from this process is sold, to be ground and used in the manufacture of lubricants, fireproof roofing, cement, ornamental pigments, etc.

The proportion of this waste to the yield of cut mica is considerable, as it takes from 7 to 10 or even 20 tons of selected crystals to yield 1 ton of clean cut mica.

Owing to the desultory nature of much of the mining done and reti- Production.
cence on the part of some producers, considerable difficulty has been experienced in getting the exact amount and value of the marketed production of this mineral for 1890. Direct returns give 770,959 lbs. of all sorts of mica, valued at $68,074. A firm in the trade gave us $72,000 as their estimate of the value of the whole marketed product of of mica, but consider the total quantity, given above as marketed, as altogether too high.

The above totals, as computed from direct returns, are made up as follows:—

MICA.

TABLE 1.

PRODUCTION.

—	Quantity.	Value.	Average Value.
Electrical mica..	400,559 lbs.	$58,625	About $292.25 per ton.
Stove "	3,400 "	8,500	" 2.50 per lb.
Waste "	367,000 "	949	" 5.00 per ton.
	770,959 lbs.	68,074	

Most of the Canadian mica is marketed in the United States, being Markets and prices.
taken by manufacturers of electrical machinery; a small proportion of this quality being sold for similar purposes in the Dominion itself. Some dealers call for it ready cut, whilst others prefer to get it in the shape of selected crystals and cut for themselves. This causes a great variation in the value of the product as shipped from the mine, and makes it hard to strike an average price, which difficulty is emphasized by the great difference in value between the large and small sizes.

Block mica for electrical purposes sells at different prices per ton, according to the size which each block will cut clear of all cracks and flaws, the prices varying all the way from $25 to $200 per ton according to their excellence in this respect.

The demand for waste and small crystals for the various purposes already mentioned is not nearly equal to the possible supply, as the quality called for is not only produced in large quantities as a waste product in cutting the larger crystals, but could also be afforded by the smaller crystals occurring so plentifully in many cases in some of the phosphate deposits of the same district and obtained in working them.

Mica; uses. For lubricator manufactures it must, of course, be free from grit. Thus, to be worked at a profit, a deposit must yield a good proportion of crystals of sufficient dimensions and clear enough from faults to cut to good sizes.

The darker colour of the magnesia micas (phlogopite and biotite), whilst not affecting them for the electrical trade, renders them less fitted for use in the construction of stoves than the clearer potash mica (muscovite), whilst the frequency with which the latter is stained by deposition of iron oxides between the laminæ and its consequently lowered insulating power militates against its fitness for electrical purposes.

The stove trade also calls in general for larger sizes on the average than the electrical trade, which latter provides the greater part of the consumption.

The 35 per cent. duty imposed on mica entering the United States by the McKinley tariff will, of course, lessen considerably the profits of this industry.

Exports. The value of this mineral exported is given in the books of the Customs Department as follows:—

Mica, crude and cut	$19,171
" ground	3,297
	$22,468

But it is evident that all that was exported was not entered, or was entered at much below its true value.

Imports into U. S. A. The following figures of the imports of mica into the United States illustrate the extent of the chief market for the Canadian production of this mineral. For the calendar year 1890 the total amount from all countries was valued at $220,702. The total for the fiscal year ending 30th June, 1890, was $146,975, made up as under:—

Germany	$ 3,506
England	64,611
Canada	25,105
British East Indies	49,058
Sweden and Norway	4,695
	$146,975

Electrical Trade demands. In answer to enquiries, the Edison General Electric Company of the United States kindly furnish the following information regarding the requirements of the electrical trade with regard to mica:—

"The bulk of mica used by us is Canadian mica, which is known in the market as 'Amber Mica,' being of amber colour and clear. It is

essential that the mica should be smooth, free from wrinkles or crevices, it must split readily, and must be flexible, so much so that a piece of mica ·010″ thick would bend to a curvature of about 3″ diameter without cracking. Mica that has dark spots or coloured spots similar to rainbow colours, or what is known as smoky mica, is not at all suitable for electrical purposes. Mica must also stand a flame of intense heat without crumbling up or showing any disintegration.

"We give you below the principal sizes of mica used by us, and would say that at the present time we have orders out for some of the sizes, ranging from 200 to 600 pounds:

COMMUTATOR MICA.

1½	×	4	inches.
1¼	×	6⅝	"
1⅝	×	4¼	"
1⅜	×	6½	"
1⅜	×	8	"
1¾	×	8	"
2	×	5	"
2½	×	5	"
2	×	7	"
2	×	12	"
2½	×	12	"
4	×	4	"
5	×	8	"

BINDING MICA.

1¼″ wide."

Discovery and development.

Mention is made of mica in the reports on the recently-surveyed townships of Cleland and Gladman, in the report of the Commissioner of Crown Lands for Ontario for 1890. The former township is twelve miles south-east from Sudbury, and the report states "there has been a mining location surveyed in the northern part of the township, where I saw some fine deposits of white mica, which had been stripped and some blasting done." The other township, Gladman, is situated some 20 miles north of Lake Nipissing, and the survey report speaks of "large quartz veins seen all over the township and on the shores of a small lake, in which were found some very fine specimens of white mica." The rock of the vicinity was granitic.

MINERAL PIGMENTS.

Baryta.

Baryta.—Of the many extensive deposits of baryta (sulphate of barium or heavy spar) in Canada, only two were being mined during the past year and the production was small. The most important is undoubtedly that of McKellar's Island in Lake Superior, now operated by

Baryta.

the United States Baryta Company, of Cleveland, Ohio; the other deposit is that of Messrs. A. G. Peuchen & Co., of Toronto, in the township of Hull, Quebec, where the mineral occurs in a strong and well-defined vein of about three feet in width.

The vein at McKellar's Island is perhaps the largest on the continent, and is certainly the most extensive in Canada, attaining a gross thickness of about sixty feet, which, whilst made up in a great measure of calcite and quartz, carries, however, a rib of considerable thickness of clear baryta.

The production for the year amounted to 1,842 tons, valued at $7,543 at the point of production, all of which, with the exception of a small amount used in Toronto, was exported to the United States.

The imports of baryta for the past eleven years are given below:—

MINERAL PIGMENTS.

TABLE 1.

IMPORTS OF BARYTA.

Fiscal Year.	Cwt.	Value.
1880	2,230	$1,525
1881	3,740	1,011
1882	497	303
1883	.....	185
1884	.....	229
1885	7	14
1886	.....	62
1887	379	676
1888	236	214
1889	1,332	987
1890	1,322	978

Ochres.

Ochres.—Ochres were produced during the past year in Ontario and Quebec, in the former province in the townships of Walsingham and Esquesing, and in Quebec in the neighbourhood of Three Rivers. These deposits have all been operated in previous years, so that there is no newly-worked discovery to report.

The so-called paint beds of Campbellville, Halton county, Ontario, are now drawn upon to furnish the colouring material for certain varieties of terra cotta produced by the various terra cotta makers in that neighbourhood.

A new brand of metallic paint has during the past two years sprung into prominence, viz., the "Magnetic Paint" made by the Wm. Johnson Company, of Montreal. This paint is made directly from the ochres of Point du Lac and vicinity, deposits similar to which occur throughout

the province. The paint, as prepared and sold by the above firm, has proved itself to be of excellent quality, affording a very good colour for indoor work and an exceptional paint for outdoor work, such as structural iron work, bridges, &c.

Canadian ochres prepared by this firm are now being sold in England and South America, as well as in large quantities in the United States.

The production of ochres for the past year was 275 tons, valued at $5,125. Compared with last year, this shows a decrease of 519 tons. The production of ochres for the past four years has been as follows:—

1887	385	tons, valued at	$	2,233
1888	397	"	"	7,900
1889	794	"	"	15,280
1890	275	"	"	5,125

The imports for the past eleven years are given below:—

MINERAL PIGMENTS.

TABLE 2.

IMPORTS OF OCHRES.

Fiscal Year.	Pounds.	Value.
1880	571,454	$ 6,544
1881	677,115	8,972
1882	731,526	8,202
1883	898,376	10,375
1884	533,416	6,398
1885	1,119,177	12,782
1886	1,100,243	12,267
1887	1,460,128	17,067
1888	1,725,460	17,664
1889	1,342,783	12,994
1890	1,394,811	14,066

Litharge.—Although considerable quantities of this substance are used annually in Canada, not only for paint, but in the purification of petroleum, no effort has as yet been made to produce it in the country. The only statistics, therefore, available are the imports which are given below:— Litharge.

MINERAL PIGMENTS.

TABLE 3.

IMPORTS OF LITHARGE.

Fiscal Year.	Cwt.	Value.
1880.....	3,041	$14,334
1881.....	6,126	22,129
1882	4,900	16,651
1883	1,532	6,173
1884.....	5,235	18,132
1885..	4,990	16,156
1886....	4,928	16,003
1887.....	6,397	21,865
1888.....	7,010	23,808
1889.....	8,089	31,082
1890.....	9,453	31,401

MINERAL WATER.

Although a comparatively old industry, the production of mineral waters has increased to a very considerable extent during the past few years. That the consumption is yearly becoming much greater is evidenced by the great growth in the quantities imported.

No new features geologically, nor to any great extent geographically, are afforded by the facts relating to the production of mineral waters during the year, the celebrated springs at St. Leon, St. Hyacinthe and Ste. Genevieve in Quebec, and Caledonia and Winchester Springs in Ontario, affording as in former years the greater proportion of the total production.

Nova Scotia.

In Nova Scotia a locality that has been known and resorted to for many years has lately sprung into greater prominence, and now affords a very considerable quantity of a water of rare medicinal properties. The locality referred to is known as Wilmot Spa Springs, in the village of Wilmot, where the water is used to a large extent in the manufacture of soda water, &c.

New Brunswick.

In New Brunswick the spring at Apohaqui has for the first year an output to report. The water is alkaline and is very similar in composition and taste to the celebrated Vichy water. An analysis by W. F. Best, of St. John, gave for 100,000 parts of water,—

	Grains.
Potassium sulphate	·50
do chloride	1·08
Calcium carbonate	1·25
Sodium chloride	76·00
do bicarbonate	201·60
Magnesium	Traces.
Iron	Traces.
Silica	·90
Organic matter	Traces.
Grains	281·33

This water has proved itself an excellent emulsifier of the fatty oils, particularly of cod liver oil, for which purpose it is eminently suitable.

Ontario and Quebec.

Of the springs in Ontario and Quebec little need be said, as outside of that at Brechin, on Lake Simcoe, they are well known, and without an exception report large increases in their production. Regarding Brechin a word may be said here. The spring is situated near the village of Brechin, on Brechin Beach, and at an elevation of about fifty feet above Lake Simcoe. The water known and sold as "Eudo mineral water" gave, on analysis by Mr. Thos. Heys, of Toronto, the following content per imperial gallon:—

	Grains.
Bicarbonate of soda	35·000
Sulphate of potash	3·968
Chloride of sodium	201·096
do of potassium	5·480
do of magnesium	35·344
do of calcium	42·176
Carbonate of iron	2·160
Silica and alumina	1·744
Free ammonia	·120
Organic ammonia	·008
Grains	327·096

	Cubic inches.
Sulphuretted hydrogen	105·20
Carbonic acid gas	5·728

N. W. Territories.

Throughout the North-West Territories so many of the waters are alkaline or saline that special mention of any is not necessary.

British Columbia.

* Returns were received from British Columbia of water afforded by the "Harrison mineral spring," which is now being aerated and bottled and sold extensively throughout the province.

Outside of those waters shipped from their point of production, very considerable quantities are annually used on the spot at the various sanitariums throughout the Dominion, notably that at Banff, N.W.T., Preston, London, Winchester and Caledonia in Ontario, St. Leon in Quebec, and Wilmot, N.S.

Production.

The production for the past year was 561,165 gallons, valued at $66,031, showing an increase over the previous year of 136,565 gallons and $28,671. The quantities produced and shipped for the past three years, according to returns received at this office, have been :—

1888	124,850 gallons	$11,456
1889	424,600 "	37,360
1890	561,165 "	66,031

Exports and Imports.

The quantities exported (if any) are but slight, and are not taken cognizance of as such by the Customs Department. The imports are however given for the past eleven years in the following table :—

MINERAL WATERS.

TABLE 1.

IMPORTS.

Fiscal Year.	Value.
1880	$15,721
1881	17,913
1882	27,909
1883	28,130
1884	27,879
1885	32,674
1886	22,142
1887	33,314
1888	38,046
1889	30,343
1890	40,802

Most of the waters imported are from Europe, small quantities only being from the United States.

* *See* Geological Survey of Canada, Annual Report, Vol. IV, 1888-89, pp. 13 to 16 r.

MISCELLANEOUS.

The production of those substances for which separate articles are not deemed necessary may be found in the following table:— Production.

MISCELLANEOUS.

TABLE 1.

PRODUCTION.

Product.	1889.		1890.	
	Quantity.	Value.	Quantity.	Value.
Felspar..	... .	.....	700 tons	$ 3,500
Glass	....	$150,000	... .	537,130
Moulding sand.	170 tons	850	320 tons	1,410
Platinum	... .	3,500	.....	4,500
Quartz.....	.....	.....	200 tons	1,000
Soapstone.. ..	195 tons	1,170	917 do	1,239
Whiting.	. .....	.....	500 bbls	500

Felspar.—During 1890 the production of felspar amounted to 700 tons, valued at $3,500. Of this the greater part is exported, going to Trenton, N. J., and other china and earthenware producing centres in the United States, a small quantity only being used in domestic factories, notably at St. Johns, Quebec, where it is used in the manufacture of sanitary pottery and china. On account of its superior quality and freedom from impurity the Canadian felspar is particularly valuable and an increased output is confidently looked for. Felspar.

Glass.—As the result of the operations of four producers there was an output in Canada during 1890 of $537,130 worth of glass and glassware. This production consisted entirely of "green" and "flint" glass and a small amount of brown glass bottles, there being no window-glass manufactured in the Dominion. The production for the two previous years, as returned to this office, was in 1888 $375,000 and in 1889 $150,000. Glass.

That nearly all this production is utilized in Canada is established by the fact that the value of the exports amounted to only $12,015 during the year, as follows:—

Ontario.....	$1,374
Quebec.....	9,858
Nova Scotia.....	409
New Brunswick.....	269
Manitoba.....	92
British Columbia	13

The exports for the past four years were:—

1887	$1,030
1888	1,739
1889	6,287
1890	12,015

The following table shows the value of glass imported for the past eleven years:—

MISCELLANEOUS.

TABLE 2.

IMPORTS OF GLASS AND GLASSWARE.

Fiscal Year.	Value.
1880	$ 650,092
1881	889,803
1882	1,184,716
1883	1,176,912
1884	996,483
1885	1,020,882
1886	1,144,222
1887	1,269,288
1888	1,203,537
1889	1,205,090
1890	1,230,585

In the figures given above for the year 1890 is included an importation of window-glass of $311,753.

Moulding sand.

Moulding Sand.—In the report of the Department of Mines, Nova Scotia, for 1890, the production of moulding sand in that province is stated to have been 320 tons from Newport, near Windsor, and from River Hébert. Outside of those for Nova Scotia, no figures were obtained of the production of moulding sand, which, on account of the many foundries using local sands, must be considerable.

Platinum.

Platinum.—As in previous years, the production of platinum is altogether that of British Columbia, where it is found associated with gold in placer deposits, more especially on the Tulameen and Similkameen rivers and tributaries.

According to the report of the Minister of Mines of British Columbia, the production in that province during the year 1890 had a value of $4,500, showing over 1889 an increase of $1,000. The annual production since 1887 has been:

1887	$5,600
1888	6,000
1889	3,500
1890	4,500

The following table gives the imports of this metal in all forms :—

MISCELLANEOUS.

TABLE 3.

IMPORTS OF PLATINUM.

Fiscal Year.	Value.
1883	$ 113
1884	576
1885	792
1886	1,154
1887	1,422
1888	13,475
1889	3,167
1890	5,215

Soapstone.—During 1890 there was a production of soapstone of 917 tons, valued at $1,239, all of which was utilized in the manufacture of roofing cement, for which purpose it is ground and mixed with a certain proportion of mica or actinolite fibre. Soapstone.

Whiting.—The production of this material, as in previous years, is but small, amounting to only 500 barrels, having a spot value of $500. The only works in operation are situated at Marlbank, Ont., where Messrs. W. P. & A. N. Allan manufacture whiting from the marl found at that place. These works were not visited by any of the staff, nor is the method of manufacture known, though it is presumed that it is the same as that adopted in the manufacture elsewhere, viz. :— grinding and lævigation. Whiting.

According to the following table of imports, there was during 1890 a market in Canada for 96,243 cwts. or 28,295 barrels of 340 pounds each, having a value, including freight and charges, of $27,471, or about 97 cents per barrel. As the material produced at Marlbank is sold for $1 per barrel in the face of foreign importations, and as there are in many parts of Canada marl-beds similar to that at Marlbank, it does not seem unreasonable to suppose that ere long the manufacture of whiting will acquire much greater proportions.

MISCELLANEOUS.

TABLE 4.

IMPORTS OF WHITING.

Fiscal Year.	Cwts.	Value.
1880	84,115	$26,092
1881	47,480	16,637
1882	36,270	16,318
1883	76,012	29,334
1884	76,268	28,230
1885	67,441	23,492
1886	65,124	25,533
1887	47,246	15,191
1888	76,619	20,508
1889	84,658	22,735
1890	96,243	27,471

Chalk.

Chalk.—The following table illustrates the imports of chalk and cliff-stone, and represents the consumption of those materials in Canada, as there is no home production, chalk not being known to occur in the Dominion.

MISCELLANEOUS.

TABLE 5.

IMPORTS OF CHALK.

Fiscal Year.	Value.
1880	$2,117
1881	2,768
1882	2,882
1883	5,067
1884	2,589
1885	8,003
1886	6,583
1887	5,635
1888	5,865
1889	5,336
1890	7,221

Mercury.

Mercury.—Although known for many years to occur in British Columbia, no efforts to exploit the known deposits have as yet been made, though it is said that a company of Victoria capitalists has recently been formed for the purpose of developing a deposit lately found on Sechart Channel, Barclay Sound, where ore said to afford 20 lbs. of mercury to the ton is stated to occur in no inconsiderable quantity. The localities in British Columbia where this metal is known to exist, though in small quantity, are, according to Dr. G. M. Dawson, in his

report on "The Mineral Wealth of British Columbia," Geological Survey Report, 1887:—"Ebenezer mine," 3 miles from Golden; on the north side of the Homathco river; near Boston Bar, Fraser river; 12 miles above Kelly's Lake creek, Fraser river; and Silver Peak, near Hope.

As there is no production to report from Canada the only statistics available are those of the imports given below. Imports.

MISCELLANEOUS.

TABLE 6.

IMPORTS OF MERCURY.

Fiscal Year.	Pounds.	Value.
1882.	2,443	$ 965
1883.	7,410	2,991
1884.	5,848	2,441
1885.	14,490	4,781
1886.	13,316	7,142
1887.	18,409	10,618
1888.	27,951	14,943
1889.	22,931	11,844
1890.	15,912	7,677

Tin and Zinc.—The following tables give the imports of these metals, neither of which have as yet been produced in Canada:— Tin and zinc imports.

MISCELLANEOUS.

TABLE 7.

IMPORTS OF TIN AND TINWARE.

Fiscal Year.	Value.
1880.	$ 281,880
1881.	413,924
1882.	790,285
1883.	1,274,150
1884.	1,018,493
1885.	1,060,883
1886.	1,117,368
1887.	1,187,312
1888.	1,164,273
1889.	1,243,794
1890.	1,289,756

MISCELLANEOUS.

TABLE 8.

IMPORTS OF ZINC IN BLOCKS, PIGS AND SHEETS.

Fiscal Year.	Cwts.	Value.
1880	13,805	$67,881
1881	20,920	94,015
1882	15,021	76,631
1883	22,765	94,799
1884	18,945	77,373
1885	20,954	70,598
1886	23,146	85,599
1887	26,142	98,557
1888	16,407	65,827
1889	19,782	83,935
1890	18,236	92,530

MISCELLANEOUS.

TABLE 9.

IMPORTS OF ZINC, MANUFACTURES OF.

Fiscal Year.	Value.
1880	$ 8,327
1881	20,178
1882	15,526
1883	22,599
1884	11,952
1885	9,459
1886	7,345
1887	6,561
1888	7,402
1889	7,233
1890	6,472

MISCELLANEOUS.

TABLE 10.

IMPORTS OF SPELTER.

Fiscal Year.	Cwts.	Value.
1880	1,073	$ 5,310
1881	2,904	12,276
1882	1,654	7,779
1883	1,274	5,196
1884	2,239	10,417
1885	3,325	10,875
1886	5,432	18,238
1887	6,908	25,007
1888	7,772	29,762
1889	8,750	37,403
1890	14,570	71,122

NATURAL GAS.*

Successful operations were carried on in only two counties during the year 1890, namely, those of Essex and Welland, in Ontario, in the former of which and in the neighbourhood of Sherks Station the Provincial Natural Gas and Fuel Company have finished their series of 13 wells, from all of which, with one exception, heavy flows of gas were obtained. Ontario. Provincial Natural Gas and Fuel Co.

This company has now from its producing wells a daily flow of gas equivalent to 30,895,000 cubic feet per day, as follows:—

No.	1	2,050,000
"	2	375,000
"	3	600,000
"	4	2,200,000
"	5	8,500,000
"	6	70,000
"	7	3,000,000
"	8	Abandoned
"	9	3,500,000
"	10	4,500,000
"	11	300,000
"	12	5,500,000
"	13	300,000
		30,895,000

A pipe line connection was being made with the city of Buffalo during the latter part of the year, and it was expected that during the spring of 1891 that city would be largely supplied with gas from this Canadian field. Pipe line to Buffalo.

As an experiment the Provincial Company have sunk a new well, No. 14, to the Trenton limestone, to test the gas-producing properties of that formation. The effort was not, however, crowned with success, as the limestones were found to be quite barren at that point.

This well is useful, however, in defining somewhat accurately the north-east boundary of the gas-bearing area, the location of the well being lot 6, concession XV, township of Bertie. The usual gas-bearing horizon was struck at 762 feet and was found to be quite barren, though small quantities of gas were found in the red sandstone overlying these beds.

Other operators have been busy throughout this county, notably the Messrs. Cronmiller and White, John Reeb, Messrs. Carroll Bros., Edward Near and — Hopkins. The well sunk by Messrs. Cronmiller and White

* A very detailed report on the oil and gas wells of Ontario by Mr. H. P. Brumell is now nearly completed and will shortly be published by the Geological Survey. It will give the fullest information regarding distribution and operations in search of gas in that province.

is on lot 29, concession I, township of Humberstone, and attained a depth of 800 feet, gas to the extent of 6,000 cubic feet only being found at 675 feet.

Mr. John Reeb's well is situated on lot 6, con. I, township of Wainfleet, and was sunk to a depth of 820 feet, wherein, at a depth of 685 feet, gas, having a measured daily flow of 400,000 cubic feet, was obtained.

Messrs. Carroll Bros. drilled on lot 4, con. I, Humberstone township, and obtained gas at 883 feet, the depth of the well being 917 feet and the flow of gas 990,000 cubic feet per day.

The Near and Hopkins wells each afford about 400,000 cubic feet of gas per day, and are on adjoining lots, the former being located on lot 29, con. II, Humberstone township, while the Hopkins well is on lot 28 of the same concession.

In all of the wells drilled in the county of Welland the gas, when obtained, is found in a white friable sandstone, near the summit of the Medina formation, according to the following record, which is that of No. 1 well belonging to the Provincial Company:—

Record of No. 1 well.

Character of Beds.	Thickness.	Formation.
Surface deposits	2 feet.	Drift.
Dark grey limestone	25 "	Corniferous.
Drab and grey dolomites, black shales and gypsum	390 "	Onondaga.
Grey dolomite passing into brown	240 "	Guelph and Niagara.
Black shales	50 "	Niagara.
White crystalline dolomite, grey towards bottom	30 "	Clinton.
Red sandstone	55 "	Medina.
Red shale	10 "	
Blue shale	5 "	
White sandstone	5 "	
Blue shale	20 "	
White sandstone	15 "	Gas horizon.

Lincoln County.

In the adjoining county, Lincoln, no further operations were undertaken, the ill success of efforts of previous years acting as a strong deterrent upon any further expenditure of money.

In Wentworth county, adjoining Lincoln, to the west, this has, however, not been the case, as several attempts to find gas in the neighbourhood were made without success. Wentworth County.

In Perth county a boring was made during the year by the Stratford Natural Gas Company, wherein a depth of 2,386 feet was attained without encountering gas or oil. The Trenton limestone, in which it was expected gas would be obtained, was struck at 2,360 feet, and was found to be "flooded," a heavy salt water seam being opened at 2,384 feet. This was not cased off, and the well at 2,386 feet was abandoned. Perth County.

In Kent county Messrs. Walker & Sons have drilled two wells, without, however, obtaining gas. Kent County.

Of one of these drilled on lot 10, concession XI, township of Oxford, and known as the "Ravey" well, the following record was obtained through the courtesy of the driller, Mr. J. S. Hyland:—

	Feet.
Surface	160
Limestone	81
Shale, white	70
Limestone, grey	90
do pink	154
Sandstone, (?) pure white	30
do grey	45
Limestone, grey	285
Sandstone (?), fine	85
Total depth	1,000

The other sunk on lot 23, con. XIV of the same township, and known as the "Grant" well, was not finished at the time of my visit to the district, being only 500 feet in depth, of which the following was the record:—

	Feet.
Surface	240
Limestone	10
do pink and grey	140
do white	20
Sandstone (?), fine grey	30
do and limestone, grey and white	60

In neither of these two wells was gas obtained, though oil in small quantities was noted at 470 and 410 feet, respectively.

In Kent county, in addition to the work done by Messrs. Walker & Sons, mentioned above, a certain amount of work has been carried on,

notably the well sunk by the Citizens' Gas Company of Blenheim, where in a boring 900 feet deep small flows of gas were obtained at 700 and 800 feet.

Essex County. In Essex county extensive drilling operations were in progress at various points, more especially in the district between Essex Centre, Harrow and Leamington. At Essex Centre the Central Gas and Oil Company of that place have finished a well 1,200 feet in depth without, however, any economic result, as neither gas nor oil were obtained. The Citizens' Gas, Oil and Piping Company, of Kingsville, during the year drilled on the road allowance, west of the well known as "Coste No. 1," where a daily flow of gas amounting to over 7,000,000 cubic feet per day was obtained; this gas is now being utilized in lighting the streets of Kingsville, to which town it has been piped. The drilling of this well was the cause of considerable litigation between the owners and the Ontario Natural Gas and Fuel Company, the owners of "Coste No. 1." The result of the suit was, however, in favour of the former company, the injunction given at the instance of the latter not being sustained.

The Union Gas Company have, it is understood, undertaken operations in the county, in that part between "The Marsh" and Essex Centre, with what result, however, we are unacquainted. Various other operators have been working throughout the county, but owing to lack of time it was found impossible to visit and ascertain the result and extent of their operations.

Outside the foregoing but little work has been done throughout Ontario in the search for gas, though that product is being found, in small quantities as heretofore, in the petroleum wells which are constantly being sunk in Enniskillen township.

Quebec. In the Province of Quebec no active operations were undertaken during 1890, though small finds of gas were reported during the year, notably from the area covered by the drift deposits to the south and south-east of the River St. Lawrence. The gas was in all instances obtained in wells sunk or bored for water, and flowed from the sands and gravel underlying the clay deposits. The flows were small.

Regarding the rest of the Dominion there is nothing of importance to report, nor have any boring operations in search of gas been undertaken.

Available production of Ontario. In January, 1891, there was in Ontario an available daily flow of gas of over 50,000,000 cubic feet, very little of which was at that time being put to practical use.

NICKEL.

The chief producing district of the Dominion, so far of the ores of this metal, has its centre at Sudbury, at the junction of the Canadian Pacific Railway main line and the Algoma branch. Sudbury District.

The discoveries of deposits of nickeliferous pyrrhotite in this district since the inception of prospecting in 1883 have been very numerous. They occur in a belt of country, running about E.N.E. and W.S.W. from Sudbury village, which is about four or five miles wide. It extends from the shores of Wahnapitae Lake, some fifteen miles east of Sudbury, and has been proved nickeliferous as far as Nelson, on the Algoma branch, making a total distance of some fifty miles. Up to the end of the year some twenty well-authenticated deposits had been located, not to mention many others of which little is as yet known.

About thirty miles north-west of Sudbury, on the main line of the Canadian Pacific Railway, is the Straight Lake area, with dimensions about six miles by two. It is in the vicinity of the station of that name, and contains several promising deposits.

Apart from prospecting work, the activity this year has been confined to the operations of the three chief companies, viz.:—The Canadian Copper Company, with headquarters at Cleveland, Ohio, and operating the "Copper Cliff," "Stobie" and "Evans" mines. The Dominion Mineral Company, with headquarters in Montreal, and operating the "Dominion" mine, and Messrs. H. H. Vivian & Co., of Swansea, England, operating the "Murray" mine. Operators.

All these mines are within a radius of about six miles of Sudbury. The "Copper Cliff" and "Evans," on the Algoma branch, and the "Murray" on the main line, west of the villlage, whilst the "Stobie" and "Dominion" find outlet by means of a short branch line. These mines give employment directly to some 780 men.

A description of the mode of occurrence of these deposits and of the processes of extraction adopted cannot be better given than it is in the paper written by Mr. A. E. Barlow and given below. His official connection with the staff of the Geological Survey as well as with the work undertaken by the Department in the study of the district enables him to speak with special authority on its geological features. Further details concerning the geology metallurgical processes, &c., will be found, by reference to the article on nickel in the volume on the Mineral Resources of the United States for 1888, issued by the Geological Survey of that country; to a paper on the Sudbury ore deposits by E.D. Peters, formerly manager for the Canada Copper Co., in vol. XVIII, Trans. American Inst. Mining Engineers; and to a paper by Dr. R. Bell

entitled "The Nickel and Copper Deposits of Sudbury district, Canada." Transactions Geological Society of America, Vol. 2, pp. 125.140.

ON THE NICKEL AND COPPER DEPOSITS OF SUDBURY, ONT.*

By Alfred E. Barlow, M.A., Geological Survey Department.

Geological associations of deposits.

"The presence of large deposits of nickel and copper in the district of Algoma, Ontario, has of late years attracted world wide attention, in the first place on account of their immense and apparently inexhaustible character, but latterly because of the proposed application of nickel in alloy with steel to improve the quality of the latter. The existence of workable deposits of copper in this region was a fact that had long been known, and as far back as 1770 a company had been formed and attempts made to mine this metal, but the difficulty of procuring and maintaining miners at so great a distance from any centre of civilization, the remoteness of any market for the ore, as well as the absence of facilities for transportation, rendered these first attempts abortive. However, in 1846, owing to the activity in prospecting and locating mineral lands on the southern shore of Lake Superior, and a favourable report by Mr. W. E. Logan, then newly appointed Provincial Geologist, some enterprising Canadians banded themselves together into two associations called "The Montreal Mining Company," and the "Upper Canada Mining Company." The former company having purchased, amongst others, what was then known as "The Bruce mines" location, and on account of the richness of the deposit decided to commence active work at this locality, while the Upper Canada Company proceeded to develop and work what was known as the "Wallace mine," at the mouth of the Whitefish River. The Montreal Mining Company continued their operations from 1846 to 1865, when, from a variety of causes, the work proving unremunerative, they sold out the whole of their claim to the "West Canada Mining Company," who had previously leased and worked the western half of the location under the name of the Wellington mine. This company continued working till 1876 when, owing to unsatisfactory results, work was suspended and has not been resumed since. The Wallace mine was chosen on account of its promising character and proximity to civilization, and is chiefly remarkable as having been the first place in Canada in which the presence of nickel had been detected.

Wallace Mine.

"According to Mr. Alex. Murray, of the Geological Survey of Canada, who made an examination of the location in 1848, 'No true vein can be discovered, but the ore occurs at the contact of quartzose and chloritic slates with diorite, as bunches and strings of pyritous matter, inter-

*Read before the Ottawa Field Naturalist Club.

laminated irregularly with the slates, and distributed in specks and patches in the diorite. Abundant evidence of disturbance is displayed in irregularities of dip and intrusion of the diorite. The material collected for assay was chosen as free as possible from copper pyrites, but nearly two-fifths of the specimen consisted of earthy materials, which might readily be separated by dressing.' (See Report Geological Survey of Canada, 1848–49, p. 42—45). Dr. T. Sterry Hunt, in his report on this ore, says that "the specimen is a steel grey arseniuret, the species not determined, with white iron pyrites and probably some arsenical sulphuret of iron.' The mass, weighing 45 oz., was reduced to powder and submitted to analysis, with the following results:— Analyses of ore.

Iron	24·78
Nickel, with trace of cobalt	8·26
Arsenic	3·57
Sulphur	22·63
Copper	·06
Earthy materials	40·01
	99·31

"In the process of washing the ore, the earthy parts being removed by washing, the composition of the ore in 100 parts, as deduced by calculation from the above, would be—

Iron	41·79
Nickel and cobalt	13·93
Arsenic	6·02
Sulphur	38·16
Copper	·10

"From the small proportion of arsenic the nickel must, in part at least, be present in a state of sulphuret, a fact which is, indeed, made evident by the spontaneous oxidation of the ore. The nickel from this source contained about three parts in a thousand of cobalt. In conclusion, he remarks that in the same bands of rocks we may detect the presence of nickel and cobalt, a prophecy which has since been amply verified.

"A mass of copper pyrites from the same mine weighing 9½ lbs. was also assayed, which yielded 11·6 per cent of metallic copper. Acting on these and other favourable reports, the company began to sink shafts to test the extent and the quality of the ore, and one of these shafts at least attained a depth of 10 or 15 fathoms. Work was carried on energetically for some years, but the enterprise was finally abandoned, as the quantity of ore did not seem sufficient to justify further expenditure.

"In his report for 1856, Mr. Alex. Murray (see Report Geological Survey of Canada, 1853-56, p. 180) mentions the occurrence of a 'dingy

History of discovery.

green magnetic trap' associated with red syenite in the north-west corner of the township of Waters on Salter's meridian line. Specimens of this trap were given to Dr. Hunt for analysis, and the result of his investigation showed that it contained magnetic iron ore and magnetic iron pyrites, generally distributed through the rock, the former in very small grains; titaniferous iron was found associated with the magnetic ore and a small quantity of nickel and copper. The variation of the magnetic needle near this mass was from ten to fifteen degrees west of the true meridian. It can thus be seen that even at this early period of its history the officers of the Geological Survey were aware of the existence of nickel in this region, and had pointed out the probability that workable deposits would be found. Years passed by and the inaccessible nature of the country deterred prospectors from making very detailed exploration or examination, so that it was not till 1883, when the Canadian Pacific Railway was in course of construction, that the first discoveries of any consequence were made, since which time the whole belt of the Huronian district has been overrun with eager prospectors and miners. A not infrequent accident in newly settled districts led to the first important discovery. Judge McNaughton, stipendiary magistrate at Sudbury, had been lost in the woods to the west of that village, and diligent search was at once instituted for him. A party consisting of Dr. Howey and two others found the judge seated on the small eminence which then marked the site of what is now known as the "Murray mine." Early in 1884 the Canadian Pacific Railway made a cutting for their main line through this small hill, about 3½ miles north-west of Sudbury, and on July 12th of the same year Dr. Selwyn made a careful examination of the location and pronounced the lode to be one of the most promising he had yet seen in Canada. Other discoveries soon followed, and the McConnell, Lady Macdonald, Stobie, Blezard, Copper Cliff and Evans mines were all located. At first the wildest notions were entertained as to the extent of these deposits, and the most exaggerated reports circulated as to their value. It was even confidently asserted that these were immensely important discoveries, and would revolutionize the whole copper trade and render other mines then in operation quite unremunerative. Rounded hills of gossan, indicating the presence of the more solid and unaltered ore beneath, occur at intervals for miles in a southwesterly direction, conforming rudely to the strike of the rocks in the vicinity. This circumstance is all that seems to have justified the early discoverers in describing the deposits as veritable mountains of solid ore, many miles in extent and hundreds of feet thick. Closer investigation revealed the fact that these surface gossans everywhere indicate the presence of the ore beneath, and that the ore itself occurs in lenticular masses, entirely

separated from one another, whose longer axes correspond with the strike of the enclosing rock. This gossan has resulted, as is usual, from the formation of peroxide and hydrated peroxide of iron, due to the decomposition of the pyrrhotite and chalcopyrite which gives a prevailing red or reddish brown colour to the upper portion of the deposit. This covering of iron oxide is sometimes as much as six feet in depth. although usually it is only two or three feet, gradually merging itself into the unaltered ore beneath. During the last few years prospectors have not been idle, and at the present time about twenty very promising deposits of these ores have been "located" and "taken up." The McAllister mine, now called the Lady Macdonald mine, was the first property on which any work was done in the summer of 1885, although later in the fall the Evans mine was opened up and some preliminary tests made. On 6th January, 1886, the Canadian Copper Company was formed with a subscribed and paid up capital of $2,000,000, which was afterwards increased to $2,500,000, to operate the Copper Cliff, Stobie and Evans mines. History of discovery and development.

"On May 1st, 1886, work was started in earnest at the Copper Cliff mine, and later on in the same year both the Stobie and Evans mines were opened up, and with the exception of a few months last summer, when, on account of some difference with the Canadian Pacific Railway, the Stobie was shut down, these three mines have been in active operation ever since. The chief business of the Canadian Copper Company is done at Copper Cliff, for here they have prepared a well equipped roast yard, two smelting furnaces, laboratory and offices, and other things requisite for carrying on this mining on an extensive scale. The Stobie and Evans mines are provided with excellent rock houses, but all their ore is brought by branch railways to Copper Cliff to be roasted and smelted. In 1889 the Dominion Mineral Company was formed to operate the Blezard mine, and later on they purchased the Worthington mine from the original owners. During the past summer this company have had their smelter in operation, and both their mines are being energetically developed. During the summer of 1889 the Murray mine was prospected under bond by Messrs. Henry H. Vivian & Co., Swansea, England, and in October of the same year they purchased it. About the end of last September, everything being ready, the smelter "was blown in" and set to work on some ore which had been previously roasted. All three companies are now prosecuting the work vigourously, and the output of these mines has already reached very large proportions. The whole district has been prospected, and I think that a very conservative estimate would now place the number of promising deposits at twenty.

Geological conditions of occurrence of ore bodies.

"The Huronian system in which these ore deposits occur may be regarded as the oldest series of sedimentary strata of which we have at present any certain knowledge. Amongst the more important of these rocks may be mentioned quartzites, greywackes, conglomerates, slates, evenly laminated gneisses, felsites, hydromica, chloritic, epidotic, hornblendic and micaceous schists and narrow bands of cherty limestone. Most of these clastic rocks have been derived from the waste of older felspathic material, and hitherto it has been most generally supposed and stated that the Laurentian gneiss was the source from which the sediments had been derived. The Huronian conglomerates, however, hold no pebbles that are undeniably referable to the Laurentian, and the origin of the syenitic, quarzose and jaspery pebbles is still a matter of doubt. The microscope can throw no certain light on the original character of some of these rocks, for very often metamorphism and recrystallization has gone on to such an extent that the former structure has been either partially or completely obliterated. A close study of these uncertain rocks in the field, aided by the use of the microscope in the laboratory, will eventually enable us to assign them their proper place. We have thus numerous sedimentary rocks showing the various stages of this metamorphism, from the typical sandstone or greywacke, composed of well-rounded grains of quartz and felspar, to the compact felsite, which contains no trace of its original clastic structure. Associated with these sedimentary strata are certain undoubted eruptive and irruptive rocks, among which may be mentioned many varieties of diabase, diorite and gabbro. Besides these igneous rocks, there are some granites and gneisses concerning whose origin many are in doubt. After a close and careful study of these rocks, which have usually been classified as Laurentian, and their relations with the true Huronian stratified deposits, I have been fully convinced of their irruptive nature. These granites and gneisses probably represent the original crust of the earth which has undergone refusion, and was in a molten or plastic condition at a period subsequent to the hardening of the Huronian sediments. The earth gradually cooling from a state of original incandescence, had reached that stage in the process when it admitted of being surrounded by an ocean nearly, if not quite, universal. Then began that tearing down and building up which has since gone on in forming the sediments which subsequently hardened into rocks. The first formed crust was necessarily thin and weak, and it is therefore not surprising that there were frequent irruptions, accompanied by the fusion of the lower portion at least of the first formed deposits.

"It is unnecessary here to go into all the facts of the case, as my views have already been stated at some length in a paper read before

this club on 27th February of last year. Suffice it to say that the fuller examinations of last summer have served to further strengthen these views. Both clastic eruptive and irruptive rocks have been subjected to intense pressure, as evidenced by the extensive cataclastic structure which has been developed in both series of rocks. Frequently the rocks show a pyroclastic origin, and volcanic tuffs and breccias are very commonly met with. The relations of the diabase or basic irruptive rocks with the surrounding sedimentary strata was closely examined in a large number of instances, and revealed the fact that the diabase is apparently of later age, as it breaks through and alters the bedded Huronian. The occurrence of these masses of diabase with a surrounding breccia or agglomerate in many cases would seem to point to the fact that they are the bases of Huronian volcanoes, which continued in action after the latest sediment had been deposited. Some of these diabasic masses send out dykes which ramify through and alter the surrounding strata, these dykes frequently containing fragments of highly metamorphosed Huronian quartzite. These masses are usually lenticular, although occasionally rudely circular or oval in outline, and their longer axes correspond in general with the strike of the enclosing rock. They vary in breadth from a few chains to half a mile, or even more, and frequently extend for miles in length. The origin of the nickel and copper is closely connected with this diabase or gabbro, and the formation of the fissures containing these ores was no doubt due to the disruptive forces of the intrusion, and the contraction caused by the subsequent cooling of the igneous rock matter. These fissures were necessarily most frequently formed along the line of contact with the cooler sedimentary strata, although in certain cases they were formed in the midst of the igneous mass itself. In nearly every case, therefore, the deposits of nickel and copper occur close to the contact of the diabase with the stratified rocks, although in a few cases they are found in the diabase near its junction with granite or micropegmatite. Another proof of the common genesis of these ores and the enclosing diabase is that the diabase itself commonly contains these sulphides disseminated through its mass, these impregnations occasionally forming such considerable and rich deposits as to be workable.

Geological conditions of occurrence of ore bodies.

"All geologists who have examined these deposits agree that they are not true fissure veins, and although at times a certain sloping surface is obtained which seems to have a uniform inclination, yet it seems certain that there are no regular walls in the miner's sense of the term, and at both sides of the deposits the enclosing rock is impregnated more or less with the pyritous matter. Though mining is thus rendered somewhat difficult and uncertain on account of the absence of the walls and irregu-

Characteristics of ore bodies.

Characteristics of ore bodies.

larity in the distribution of the ore, so that there is no means of knowing in what direction to drive the levels, this uncertainty is more than compensated by the extent and massiveness of the deposit when found. The ore bodies like the masses of diabase with which they are so intimately associated are lens or pod-shaped and 'pinch out' in both directions. This structure is also characteristic of their downward extension, and the deposits have been very truly likened to a string of sausages, so that when one lenticular body of ore gives out another commences close at hand, which in its turn gives place to another, and though at the Copper Cliff they are down about 600 feet on a slope of 45°, the quantity and quality of the ore shows no diminution. I have occasionally found true veins of quartz holding this pyrrhotite, but such evidences of secondary action are extremely rare and proves nothing in regard to the origin of the more massive deposits. The ores and the associated diabase were therefore in all probability simultaneously introduced in a molten condition, the particles of pyritous matter aggregating themselves together in obedience to the law of mutual attraction. The ore bodies were, therefore, not contemporaneous with the stratified Huronian, although there is nothing to prove that they do not belong to the close of the Huronian period. Mr. Ferrier, of the Geological Survey, has noticed the occurrence of this nickeliferous pyrrhotite in a specimen of chloritic schist and gneissic granite, which had been taken to show the contact between the two rocks.

"The ore itself is a mixture of pyrrhotite, a monosulphide of iron ($Fe_7 S_8$) and chalcopyrite, a sulphide of copper and iron ($Cu Fe S_2$). The two minerals are not so intimately commingled as to form a perfect homogeneous mass, but one may be described as occurring in pockets, spots, bunches or threads in the other. The chalcopyrite is not so closely intermixed with the pyrrhotite, but isolates itself rather in spots and patches enclosed by massive pyrrhotite, so that it is not hard to separate considerable masses of chalcopyrite that will assay over 30 per cent of copper, or pyrrhotite that will only show traces of that metal. In practice, however, careful examination and trial have proved that the two minerals are too intimately associated to make sorting by hand at all practicable, and the pyrrhotite is very often so feebly magnetic as to preclude the possibility of separation by magnetism. Although the chalcopyrite seldom occurs free from the pyrrhotite, large and massive deposits of the latter occur comparatively free from copper. In this connection Dr. Peters mentions a stope which, having furnished about 2,000 tons of pyrrhotite, gave place, just before the end boundaries were reached, to a deposit which afforded nearly 20 tons of almost pure chalcopyrite. In some instances these ore bodies show a brecciated

character, large angular or partially rounded boulders or 'horses' of almost barren rock being mingled with the ore, which seem to evidence the disruptive force of the intrusive mass, while in others, as at the Worthington mine, the diabase in which the ore occurs has developed a concretionary structure while cooling, and large irregularly rounded concretions, which, on weathering, peel off in concentric layers, are cemented together, so to speak, by a very pure chalcopyrite and highly nickeliferous pyrrhotite. The concretions themselves usually contain more or less pyritous matter disseminated through them, but are usually cast aside as too barren for the roast heap. The pyrrhotite varies in colour from steel-grey to bronze-yellow, and the chalcopyrite is the usual brass or deep yellow colour. Both tarnish readily, and very beautiful iridescent specimens can be easily obtained from the ore heap or scattered around the works. These sulphides, therefore, may be said to occur in three distinct ways— Characteristics of ore bodies.

"1st. As contact deposits of pyrrhotite and chalcopyrite situated between the clastic rocks, such as felsites, quartzites, etc., and igneous diabase or gabbro, or between these latter and granite or micropegmatite. Good examples of the former are furnished by the Evans, Stobie and Copper Cliff, while the Murray mine may be cited as illustrating the latter.

"2nd. As impregnations of these minerals through the diabase or gabbro, which are sometimes so rich and considerable as to form workable deposits. These sulphides are in no case present as disseminations through the clastic rocks very distant from the diabase or gabbro, which seems clear evidence that they have been brought up by the latter.

"3rd. As segregated veins which may have been filled subsequently to the irruption which brought up the more massive deposits. These veins are not very common, although certain portions of the more massive deposits may have been dissolved out and re-deposited along certain faults and fissures.

"The composition of the ore varies according to the preponderance of either the pyrrhotite or chalcopyrite in the specimen examined. The pyrrhotite may be said roughly to be composed of 40 per cent sulphur and 60 per cent iron, with a varying proportion of the iron replaced by nickel, while the chalcopyrite contains 35 per cent sulphur, 35 per cent copper and 30 per cent iron. The mines of the Canadian Copper Company, as the name of the company indicates, were first opened for their copper contents, and it was not until considerable work had been done that nickel was discovered to be present in the ore. A large shipment of ore had been made to New York, and a chemist Composition of ore.

there who was making a volumetric determination of the copper contents by the Potassium Cyanide process, was struck by the great variation in his results, which led him to make a more minute examination of the ore, when he found that nickel was present. The ore has now become of more value on account of its nickel than its copper contents, and Dr. Peters himself greatly doubted if the mines would pay to work for copper alone. The percentage of nickel and copper varies greatly, as might be expected, but assays of nine samples from the different mines of the Canadian Copper Company, made in November, 1888, will show the usual percentage of these metals. These assays were made by Mr. Francis L. Sperry, and show a range in the percentage of nickel from 1·12 per cent to 4·21 per cent with an average of 2·38 per cent., while the copper varied from 4·03 per cent to 9·98 per cent, with an average of 6·44 per cent. A minute proportion of cobalt also occurs in the pyrrhotite usually about $\frac{1}{50}$th as much as the nickel present. Mr. G. C. Hoffman assayed four samples from this district which I collected last summer, and these showed the nickel contents to vary from 1·95 per cent to 3·10 per cent with an average of 2·25 per cent. Three of these samples contained traces of cobalt, which are included in the above percentage of nickel. The nickel is usually spoken of as replacing an equal quantity of iron in the pyrrhotite; but the discovery of undoubted crystals of millerite or sulphide of nickel 150 feet below the surface at Copper Cliff Mine, as well as the more recent recognition of polydymite, a ferriferous sulphide of nickel, at the Vermilion Mine, in the township of Denison, seems to justify the assumption that in the more highly nickeliferous deposits of the region at least, the nickel is also present as a sulphide, disseminated through the ore mass like the iron and copper.

"This view is also borne out by Dr. Hunt's analysis of the ore of the old Wallace mine which seems precisely analogous to some of the richer deposits nearer the Canadian Pacific Railway. Traces of gold and silver, as also platinum are also usually found in these ores, and in this connection it was thought advisable to call your attention to the detection of what Messrs. Clarke & Catlett call a 'platiniferous nickel ore from Canada.' They say (see article xxxix, page 372, *American Journal of Science*, 1889.) During the autumn of 1888 we received, through two different channels, samples of nickel ores taken from the mines of the Canadian Copper Company at Sudbury, Ont. From one source we obtained two masses of sulphides to be examined for nickel and copper, from the other came similar sulphides together with a series of soil and gravel-like material (gossan), seven samples in all. In the latter case an examination for platinum was requested, and in five of the samples abovementioned it was found the gravel yielded 74·85 ozs. of metals of the

platinum group to the ton of 2,000 lbs. The sulphide ores submitted to us from Sudbury were all of a similar character. They consisted of mixed masses in which a grey readily-tarnishing substance was predominant with some chalcopyrite, possibly some pyrite and a very little quartz. Two samples were examined in mass: one gave 31·41 per cent nickel with a little copper, and the other gave 35·39 per cent nickel and 5·2 per cent copper. The nickel mineral itself proved to be a sulphide of nickel and iron, and as ores of that composition are not common, it was thought advisable to examine the substance further. It is steel-grey massive and exceedingly alterable in the air with a specific gravity of 4·5. An analysis of carefully selected material gave:—

Nickel	41·96
Iron	15·57
Silica	1·02
Copper	·62
Sulphur	40·80

"These figures give approximately the formula $Ni_3 Fe S_5$. Neither cobalt nor arsenic could be detected. If we deduct silica together with the copper reckoned as admixed chalcopyrite and re-calculate the remainder of the analysis to 100 per cent we get the following figures:—

Nickel	43·18
Iron	15·47
Sulphur	41·35

"In short the mineral has the composition of $Ni_4 S_5$ with about $\frac{1}{4}$th of the nickel replaced by iron, which seems to agree with Laspeyres polydymite of which it is doubtless a ferriferous variety. Probably in most cases the nickeliferous constituent of pyrrhotite is millerite, but other sulphides like polydymite may occur too. The polydymite which was selected for the above analysis came from the mass in which the average of 35·39 per cent nickel and 5·20 per cent copper had previously been found.

"The mass weighed several kilograms and was remarkably free from quartz. The same mass, with two smaller pieces resembling it, were also examined for platinum. The results were as follows, "A" representing the large mass in which the polydymite was determined:— Platinum assays.

A	2·55 oz.	platinum per ton, or	·0087	per cent.
B	1·8 oz.	do	·0060	do
C	7 oz.	do	·024	do

"Probably the platinum exists in the ore as sperrylite, although this point was not proved. The amount of platinum in the mass most thoroughly examined would require to form sperrylite only about ·007.

per cent of arsenic, which is too small a quantity for detection by ordinary analysis. That platinum should exist in appreciable quantities in an ore of such a character is something quite extraordinary, but whether it could be profitably extracted is an open question. Sperrylite.

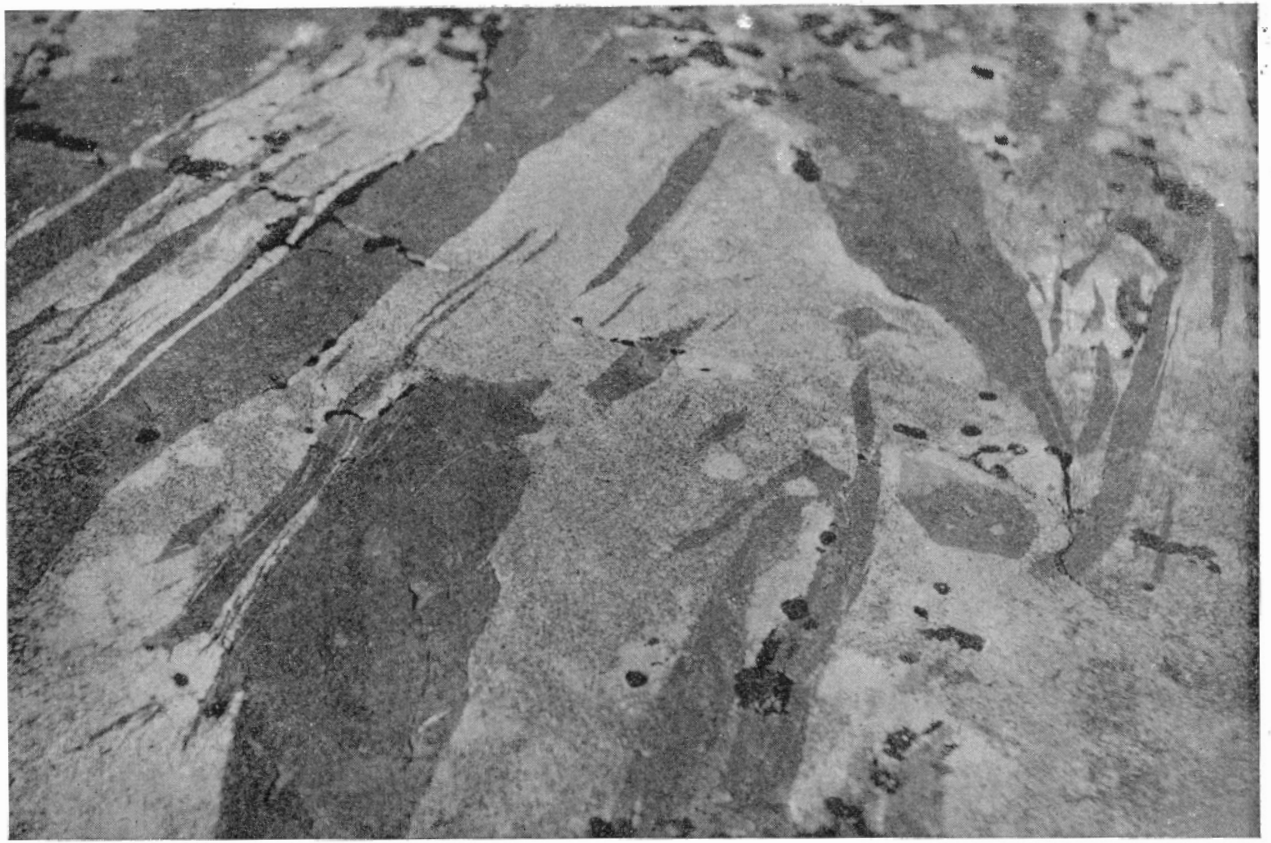
Sperrylite was first found at the Vermilion mine in the gossan or loose material, and was named after Mr. Francis L. Sperry, of the C. C. C., by Messrs. Horace L. Wells and S. L. Penfield, of the Sheffield Scientific School, who examined and described this new species. It is isometric; simple cubes are common, octahedrons are exceptional, while the majority of the crystals are combinations of the cube and octahedron. H.—Between six and seven, as it scratches felspar but not quartz. The crystals have no distinct cleavage, but are very brittle and break with an irregular, probably conchoidal fracture. The chemical composition, according to the mean of two analyses was as follows :—

Arsenic	40·98
Antimony	·50
Platinum	52·57
Rhodium	·72
Palladium	trace.
Cassiterite or oxide of tin	4·62

"The composition is therefore represented by the formula $Pt\,As_2$, a small portion of the platinum being replaced respectively by rhodium and antimony. The colour of the mineral was nearly tin white or about the same as metallic platinum. The fine powder is black. Nearly all the grains showed extremely brilliant crystal faces, though most of the crystals were fragmentary in size they were usually $\frac{1}{50}$—$\frac{1}{500}$th of an inch in diameter. Sp. Gr. 10·602.

Metallurgical treatment.

Roasting.—"The metallurgical treatment of this ore commences at the roast yard whither it is conveyed, and, being piled in convenient heaps on previously laid cordwood, is exposed at high temperatures without fusion, or, at most, incipient fusion, to the action of a current of air. The objects of this roasting are, 1st, an oxidation of the iron, and, incidentally, of the sulphur, as complete as is possible without involving an undue loss of copper in the slags of the following smelting, and, 2nd, the expulsion of arsenic, if there is any present. If the oxidation be very imperfect the resulting matte will contain so much iron that its bringing forward will be unduly costly, while, if the oxidation be too thorough, an undue loss of metal will occur on smelting the roasted ore. At Copper Cliff the Canadian Copper Company have spared neither trouble nor expense in the construction and equipment of their roast yard. The natural rough and uneven surface has been cleared and levelled, and the whole given a gentle slope, which, with carefully made drains serves to remove at once any rain or surface water. These precautions have to be taken to

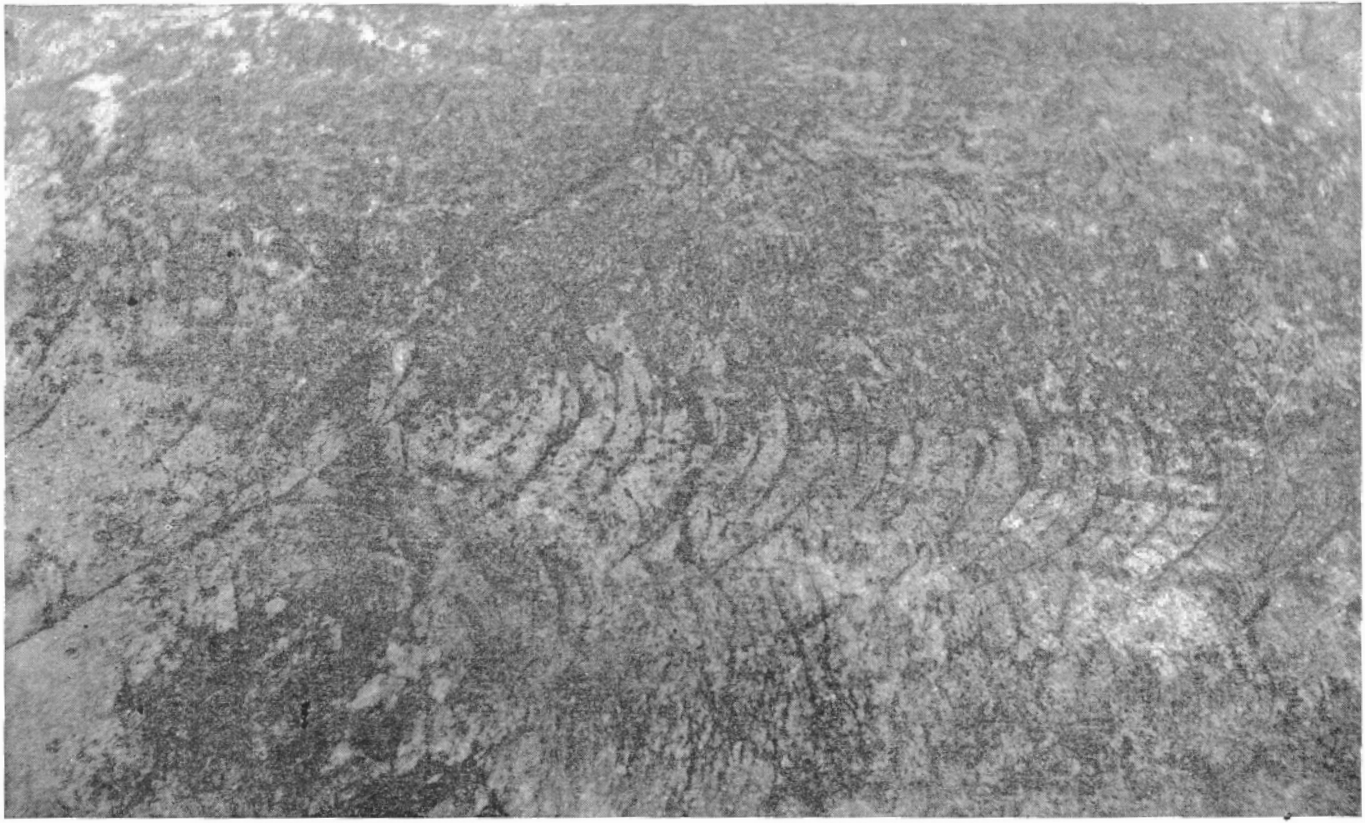


A. C. Lawson, Photo., 1889.

CONTACT OF LAURENTIAN AND KEEWATIN ON THE NORTH SIDE OF SAGANAGA LAKE, SHEWING SHARPLY ANGULAR SCATTERED FRAGMENTS OF HORNBLENDE SCHIST ENCLOSED IN HORNBLENDE-GRANITE GNEISS.

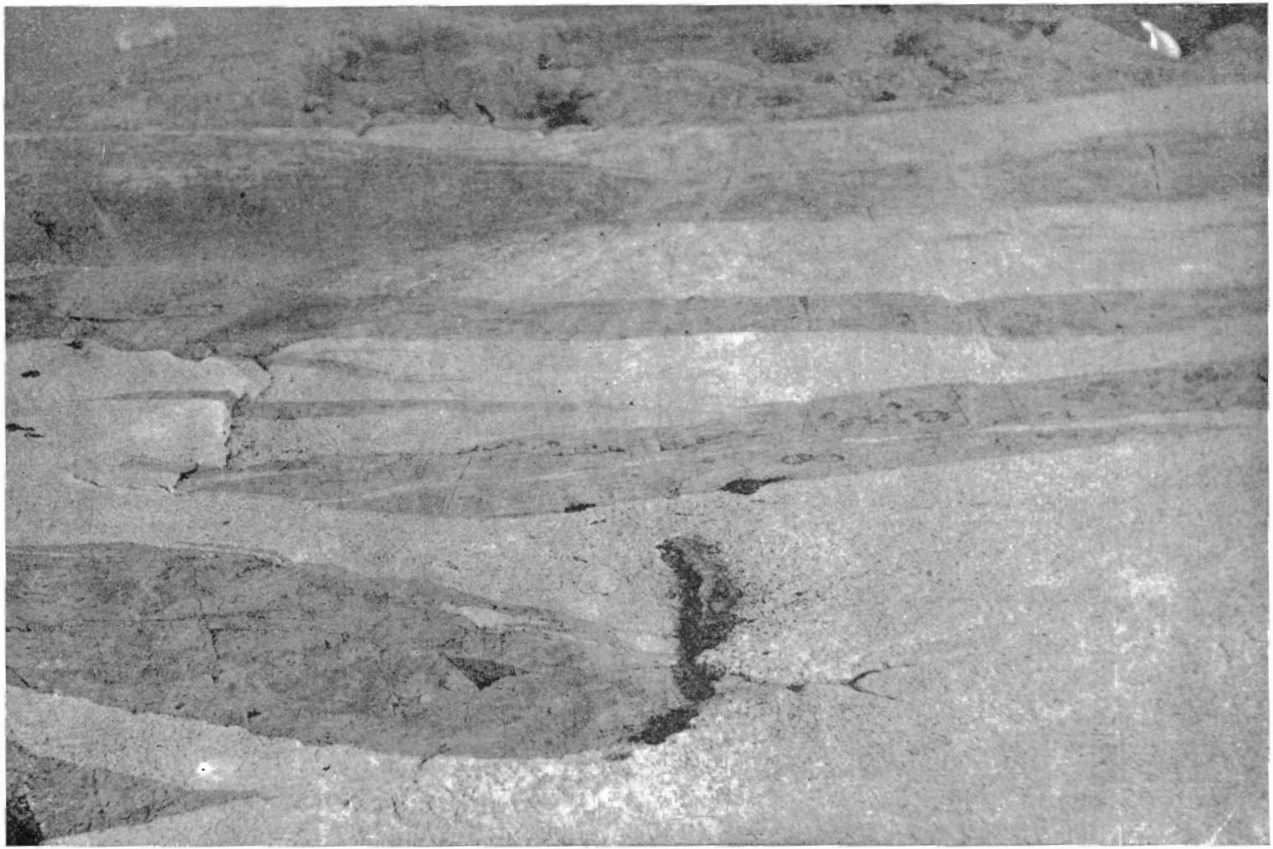
A. C. Lawson, Photo., 1889.

CONTACT OF LAURENTIAN GRANITE-GNEISS AND KEEWATIN SCHISTS, ON THE NORTH SIDE OF CACHE BAY, SAGANAGA LAKE, SHEWING BIFURCATING DYKE OF THE FORMER CUTTING THE LATTER.



A. C. Lawson, Photo., 1889.

GLACIAL GROOVES WITH "CHATTER" CRACKS, ON LAURENTIAN GNEISS, BASSWOOD LAKE.



A. C. Lawson, Photo., 1889.

CONTACT OF LAURENTIAN AND KEEWATIN ON THE NORTH SIDE OF SAGANAGA LAKE, SHEWING LENTICULAR SHEETS OF HORNBLENDE SCHIST ENCLOSED IN HORNBLENDE-GRANITE GNEISS, SIMULATING BEDDING.

prevent loss of copper as soluble sulphate of copper, which is liable to be washed out by the rain.

"At the Murray mine a large shed has been erected to roast ore during the winter months, with openings in the roof to allow of the escape of sulphurous fumes, but during last summer they had no regular roast yard, and the few heaps burnt could only be placed where the surface of the ground would permit. This was also the case at the Blezard and Worthington mines, and the mechanical loss alone from this carelessness must have been of considerable moment. The shaft of the Copper Cliff mine, on an incline of 45°, has reached already a depth of nearly 600 feet. It is provided with a double skip road, the skips dumping automatically at the mouth of the breaker in the top of the rock house. Here the ore is sledged to a proper size for the 15 x 9 in. Blake crusher set to about $1\frac{3}{4}$ inches, which has a capacity of nearly 20 tons an hour. It is then passed through a revolving screen where it is sized into three classes for the succeeding operation of roasting. The coarse size passes a 4-inch ring, the medium or ragging a $1\frac{3}{4}$-inch ring, while the fines pass through one $\frac{3}{4}$ of an inch in diameter. Each of these sizes falls into a separate bin under which a car runs. Thus the ore is loaded automatically into cars holding $1\frac{1}{2}$ tons, whence it is transported to the upper story of the ore shed. There it falls into a series of bins from which it is loaded by means of inclined steel shutes into the cars and taken up a rather steep grade to a high trestle which extends the whole length of the roast yard. The only wood that can be obtained is dead pine, a good deal of the surrounding district having been burnt over about 20 years ago. This can be procured very cheaply, and although it does not roast the ores as thoroughly as hard wood, it makes very fair and economical fuel, and serves on account of its short fierce heat to ignite the pile, and this once started continues burning on account of its sulphur contents. These piles are built as follows:—The place selected is first covered with about six inches of fine ore distributed as evenly as possible over the clay soil. Sticks of cordwood of nearly uniform size should be placed side by side across both sides and ends of the rectangular area. The whole interior of this can be filled in with old stumps, roots, ties or cordwood, but in such a way as to form a level and solid bed for the ore to rest on. Over all this is placed small wood and chips to fill up all interstices, care being taken to provide small canals filled with kindlings at intervals of 8 to 10 feet leading from the outer air to the chimneys along the centre of the heap. These chimneys which assist in rapidly and certainly kindling the whole heap are usually built of four sticks or old boards, so fixed together as to leave an opening and communicating below with the draught passages. Five or six of Roasting.

Roasting.

these chimneys suffice for each pile, and they should project 2 feet above the upper surface of the heap, so that no pieces of ore could fall into the flue opening. The coarsest class of ore is first thrown on, then the ragging or medium, on top of which is scattered a layer of rotten wood or chips, and lastly the whole heap is covered over with fines till it reaches a height of about 6 feet. The whole structure should then form a shapely rectangular pile with sharp corners and as steeply sloping sides as the ore will naturally lie on without rolling (about 45°). Only a portion of the fine ore is put on at first, the rest being shovelled on after the fire is fairly started. The best way to light the pile is to place a quantity of ignited cotton waste saturated with coal oil down each of the chimneys. About twelve hours after firing the whole heap should be pouring forth dense yellow fumes of sulphurous acid. Great attention is at first paid to the pile to prevent undue local heating which frequently causes partial fusion of the ore, and this can at once be prevented by covering the place with more fines. This heap should then burn from 50 to 70 days when the outer covering of raw or partially roasted ore is removed, and the remainder of the heap conveyed a few yards in wheelbarrows to a sunken railroad which runs alongside of the roast-yard. When filled, the cars are pushed up another steep grade along a track running over the bins back of the smelter. The sloping sides and corners of a pile are frequently covered with almost raw ore, this evil being often remedied by placing ignited sticks of cordwood around the whole structure, or by building a new pile in the passageway between two others which have been almost burned out, the latter plan adding very materially to the capacity of the roast yard. After this operation the ore is invariably so thoroughly roasted that it is necessary to add from 10 to 25 per cent of raw fine ore during the smelting to prevent the matte from being too rich. Each pile usually contains about 600 tons of ore, and requires 30 cords of wood to roast it. The roast yard at Copper Cliff is nearly half a mile long by 100 feet wide, while each pile occupies a space of 40×80 feet, room being left to get round them, and for drains. The present capacity is about 60,000 tons, which, with a little extra work, could be increased to 90,000 tons. Working full power each roast bed can be used four times a year, counting the time in making, roasting and clearing the beds. The yearly capacity would therefore be 240,000 tons, and by increasing the space, 360,000 tons. The unroasted ore contains from 35 to 40 per cent sulphur, and assays of a large number of samples of the roast heaps have varied from $2\frac{1}{2}$ to 8 per cent of sulphur. One analysis taken at random which may be taken as a fair sample of all the rest, gave 5·40 per cent copper, 2·43 per cent nickel, 7·92 per cent sulphur and 25 per cent iron, lime, mag-

nesia, etc., and the residue chiefly hornblende. Up to 1st October, 1890, 56,534 tons had been taken to the roast yard.

"*Smelting of the Ore.* There are two smelting furnaces at Copper Cliff, and the building which contains these is 65 feet long by 40 feet wide. Thirty-five feet of this length is on a level with the ground, while the rest of the floor is 8½ feet higher, and it is on this upper flat that the ore and fuel bins are situated. The daily capacity of each of these furnaces is 125 tons, although one of the furnaces has reduced 187 tons of ore in one day, and the furnace manager says that 135 tons could be reduced without much forcing. The furnace itself is a steel plate water jacket of the Herreshof patent, made in Sherbrooke, P. Q., by the Jenckes Manufacturing Company. It is nearly oval in form, the longer diameter at the tuyères being 6 ft. 6 in., while the shorter one is 3 ft. 3 in. There are 11 2½ in. tuyères through which the blast enters from a Baker's rotary blower under a pressure of about 9 ounces per square inch. It is 9 feet high from these tuyères to the charging door, and is an unbroken water jacket from the cast iron bottom up. It is made of rolled steel with only a two inch water space, and not a single brick of any description. The well is a circular, cast-iron water jacketed vessel, mounted on four strong wheels for convenience of moving it when repairs are necessary, and so made that the hole in one side connects with the outlet hole of the furnace, which is also thoroughly protected by water and it is through this that the matte and slag flow out of the furnace as rapidly as formed. They thus escape the influence of the blast, and prevent what Vivian calls 'the sole objection to blast furnaces' the so-called 'sows' or 'salamanders' as great masses of metallic iron which choke up the furnace and tie up large quantities of copper and other metals. The charging door is situated on the upper floor, as also the bins for roast ore and coke. The coke used is from Connellsville, Pa., and is brought by way of the Great Lakes and the Sault Branch of the C.P.R. The charge for the furnace consists of 1,800 or 2,000 lbs. of ore and coke mixed, one ton of coke usually sufficing for eight tons of ore. The mass as it melts gathers at the bottom of the furnace, and flows through the outlet into the well or reservoir, where the heavier and metallic portions sink to the bottom while the lighter slag remains on the surface, running in a continuous stream over the jacketed spout into pots on wheels, which are removed when filled, an empty one always being ready to take the vacant place. The matte is drawn off at intervals of 15 or 20 minutes through a separated bronze water-cooled tap-hole casting, near the bottom of the well, and which is filled as usual with a clay plug that can readily be removed with a few blows from a steel bar. The smelting of the ores is greatly facilitated by the basic character of

Smelting.

Smelting.

the accompanying gangue rock, for instead of quartz and acid silicates there is chiefly hornblende and very fusible felspars. This circumstance, as well as a judicious mixture of the different qualities of ore obviates the necessity of any flux, which is a very fortunate circumstance, as limestone is somewhat distant and suitable iron ore difficult to procure. The slag buggies or pots are made as strongly and lightly as possible, are case-hardened and shaped like inverted hollow cones, and before each tap are thickly washed with clay water to prevent the matte from welding to the iron mould. This matte is sampled and weighed and allowed to cool before being dumped from the pots and the slag also is sampled and assayed once every 24 hours, so that an accurate record can be kept of the composition of both. An average of two analyses of this matte in February and March, 1889, will probably give us the usual composition: Copper, 26·91; nickel, 14·14; iron, 31·335; sulphur, 26·95; cobalt, ·935. Mr. F. L. Sperry says that platinum exists in quite appreciable quantities, so that the matte contains some ounces per ton of that rare metal, while gold and silver occur in strong traces. The first blast furnace was started on the 24th December, 1888, and with slight interruptions has been running ever since. The second furnace was built in the summer of 1889, and was started on the 4th of September of the same year. On 1st October, 1890, there was about 6,500 tons of matte, and the ore on the roast beds would produce about 6,000 tons more, containing 922 and 852 tons of nickel respectively, or a total of 1,774 tons of metallic nickel, and 3,362½ tons of metallic copper.

"The average daily output of matte for the month of September, 1890, was 25 tons, but the full capacity of both furnaces would be about 60 tons of matte. If the former average was kept up, the yearly production of matte would reach 9,125 tons, but if the furnaces were run at their full capacity they would average nearly 8½ tons of nickel a day, or nearly 3,066 tons of metallic nickel and 5,913 tons of copper a year. At present the matte is piled in heaps outside of the smelters, and, when wanted to be shipped, is broken up in pieces and placed in old oil barrels, the chinks between the larger pieces being filled with smaller fragments, so that the whole is packed tolerably firm and close. It is then sent to the various refiners in Europe or the United States according to their respective bids. So far no refining works have been built at Sudbury, but the vast quantity of material to treat, the tedious and costly process for the further refining of the ore, consisting as it does of alternate roastings and smeltings, in addition to the great expense incurred at present in shipping the matte to such long distances, seem great incentives to the early erection of refining works, so that the ore could be fully treated on the spot. The proposition to build nickel steel

works was lately submitted to the Government by the Canadian Copper Company, and it is to be hoped that some satisfactory arrangement will be arrived at to give a further impetus to our present mining activity in this region.

"Nickel is a comparatively new metal for it was not recognized as an element till 1751, when Cronstedt, the Swedish mineralogist, in examining the ores of certain veins in the German copper mines made the discovery of the two new metals, nickel and cobalt, which names he retained as they were in use amongst the miners. Nickel in its pure state is silver white in colour, hard, tough, fusible with difficulty, and is susceptible to magnetism, although not to the same extent as iron. Its use in the industrial arts has rapidly increased since it has been produced in a pure state, as it formerly existed only as an impure alloy, and so could not be so suitable for the purposes for which it is now used. The demand has only grown at a moderate rate as compared with the growth and demand for other useful metals, and a decrease in price from $2.60 per pound in 1876 to the present price, which varies from 50 to 60 cents per pound, seems to have had no very important influence in increasing that demand. The supply of late years has been more than sufficient for the demand and new deposits have always been found in advance of any necessity for their product. The first chief demand for this metal was for making nickel or German silver as a substitute for the more precious metal in making spoons and forks and other ware in general for which silver had been previously used, and its whiteness and the facility with which it received and held the silver, after the process of what is known as electro-plating was introduced, cause it to be still more widely used. It is also made use of to plate iron, zinc, etc., and also in alloy with copper for the manufacture of small coins, which are used so extensively in the United States, Germany, Belgium and other countries. The proposition to use rolled nickel plate as an advance over ordinary tin plate, is one which is receiving attention at present. It has also been recommended for making nickel crucibles to replace those of silver used in chemical manipulations as they would cost less and have the great advantage of melting at a higher temperature. Markets and uses.

"Nickel plated kitchen utensils are coming into general use as in Germany, and as it is well known that acids have a more or less solvent action on nickel, an investigation was undertaken which showed that 7½ grains of nickel could be taken into the stomach and repeated for a long time without any noticeably bad effects. There is thus no ground for uneasiness in the use of such utensils, especially if the same precautions are used as in the case of copper vessels, namely, thoroughly cleaning them and avoiding the storing of food in them. The proposi-

Markets and uses.

tion to use nickel in alloy with steel to increase the strength and quality of the latter, will, if carried out, increase the consumption very materially, and all have been eager to know the result of the recent experiments undertaken at the instigation of the United States Government. A French invention has effected the means of regulating the composition of such an alloy, and subsequent experiments in Glasgow revealed the fact that this alloy could be made in any good open hearth furnace working at a fairly high temperature as wel las in the crucible. In obtaining a correct idea of the value or usefulness of alloys of nickel with iron or steel it should be borne in mind that the composition is complicated by manganese, carbon, silicon, sulphur and phosphorus whose influence must be carefully watched, requiring a long series of experiments. A comparison of steel alloyed with 4·7 per cent nickel raised the elastic limit from 16 up to 28 tons, and the breaking strain from 30 up to 40 tons, without impairing the elongation or contraction of area to any noticeable extent. A further gradual increase of hardness was noticed until 20 per cent is reached, when a change takes place, and successive additions of nickel tend to make the steel softer and more ductile. The alloys polish well, and the colour of the steel is lightened as the proportion of nickel increases. They do not corrode as readily as other steel. The 1 per cent nickel steels welds fairly well, but this property lessens with each addition of nickel. It can, therefore, be seen that considerable advantage may be expected from these alloys, especially where the percentage of nickel is less than five.

"The consumption of nickel and nickel alloy in the United States has increased from 294,000 pounds in 1880 to 421,000 pounds in 1888, while the total consumption of the world was estimated not to exceed 700 or 800 tons of the pure metal. The chief supply at present comes from New Caledonia, a penal colony of France (long. 165° E., S. lat. 22°). M. du Peloux states that the cost of production at this place could be so reduced that the company could sell at from 37 to 46 cents per pound, and yet have a good profit. Dr. Peters in his evidence before the Ontario Mining Commission states that the Canadian Copper Company could sell it from 25 to 30 cents per pound with a handsome profit. A commission appointed by the United States Government to examine the probable quantity of nickel in the Sudbury district has given a very glowing report to their government. It is highly probable, however, as can be seen from the above figures that our mines could supply the whole demand, even if the other sources of supply did not produce anything. It has been decided by the United States Government to make use of nickel steel armour plates, and already the contract has been awarded so that there is every prospect of a brilliant future for this

mining industry around Sudbury. In view of our immense deposits it will be necessary to increase its consumption in every possible direction."

Plant at Messrs. H. H. Vivian & Co's mine.

The plant at the works of Messrs. Vivian & Co. differs somewhat from the rest. The cupola blast furnace is water-jacketed below, but the upper part is of brick and the matte and slag flow out into a fixed forehearth built also of brick, instead of into a movable "well" as at the two other mines. A further difference lies in the fact that in order to minimise the loss of nickel in the slag the production of a much lower grade matte is aimed at, whose percentage is subsequently raised by a sort of Bessemerizing process. For this purpose the matte is run into barrel shaped Manhé converters mounted on wheels. These are run on tracks from the furnance, under a hood connected with a stack. Air is blown through the molten matte by means of tuyeres penetrating the lower part of the converter and a further proportion of the sulphur and iron is removed by oxidation, the latter by combining with the silicious material present forming slag. The converters are lined with fire-clay and fine quartz mixed. After the matte is sufficiently Bessemerized most of the slag is run off and the last of it is chipped off the surface of the concentrated matte produced.*

Exploration and discovery.

Besides those of the Sudbury district, reports of discoveries from numerous other points have been rife. Many of these reports have been ill-founded or unimportant, but two deserve special notice.

One of these is situated about two miles east of Schrieber Station on the Canadian Pacific Railway, where Messrs. Marks, of Port Arthur, have located what is said to be a large deposit similar to those at Sudbury.

New Brunswick.

The other is situated about three miles from the town of St. Stephen, in Charlotte county, New Brunswick. It is said to contain 3 to 4 per cent of nickel. A correspondent in that district writes us that it is a very large deposit and describes the enclosing rocks as highly altered sandstones, argillites and fine conglomerates, cut in all directions by dykes of trap, in which felspar and black mica are the prominent minerals. This locality is underlain by rock marked as of Cambro-Silurian age on the published maps of the survey, but which, it is believed, may contain areas of older rocks.

---

*Mr. A. Merry, jr., who was for many years on the technical staff of Messrs. H. H. Vivian's Smelting Works at Swansea, England, and who was manager for the firm at Sudbury during the erection of the plant and inauguration of the works, makes the following comments, comparing the cupolas in use by the different companies:—

"There are two such cupolas, the one has a fixed 'forehearth' or 'well,' and the other is on wheels, though there is not much advantage in the latter as the former seldom requires more than slight repairs necessitating no greater delay than the time spent in blowing down to change the movable well on wheels. We have worked both systems for many years and this is the opinion on their comparison. The wells are built to suit the requirements of the converter which is not the case with the wells of the other companies who hitherto only smelted to cupola matte."

New Brunswick.

Mr. W. F. Best, of St. John, N.B., who is local Dominion Analyst, furnishes the following data. He says :—

"Samples were taken at about 17 feet from surface, and a New York chemist finds—

Sulphur	32·93
Iron	56·00
Copper	1·03
Nickel	2·04
Gold	Trace.
Silver	"
Insoluble residue	8·00
	100·00

"I have found as high as 2·48 per cent of nickel at nineteen feet from surface in pit No. 2." *

British Columbia.

The report of the Minister of Mines of British Columbia alludes to the existence of a deposit of nickel ore on the west bank of the Kootenay River in the Toad Mountain district. It is said a crosscut eight feet long failed to reach the wall of the deposit, thus proving it to have at least that thickness.

Outside of the Sudbury district the developments made on the deposits of ores of this metal have been slight, simply consisting of preliminary testing of the same.

Nickel City.

At Nickel City, near Whitefish Station on the Algoma branch, works are being erected, which it is hoped will be operating next year, where it is proposed to grind and then treat the ore by a special method, of which particulars could not be obtained, but which is said to be some sort of wet process, gold and silver ores being also dealt with.

Production.

There were shipped from this district, by rail, the following quantities of nickeliferous material :—

Matte	3,693 tons.
Ore	1,351 "

The amount of fine nickel in the matte, etc., produced and shipped during the year, by direct returns, came to 1,435,742 pounds, which, taken at the average market value of 65 cents per pound, is worth $933,232. As the above basis of valuation has been commented upon, it may be well to explain that it has been thought best to adopt it owing

* A sample subsequently collected from the deposit weighing about 75 pounds and consisting almost altogether of pyrrhotite, chalcopyrite being practically absent, has since been subjected to analysis in the Laboratory of the Geological Survey and found to contain nickel, 1·718, cobalt, 0·165 per cent, with 5·43 per cent of gangue matter. For further details regarding which see forthcoming Chemical Contributions to the Geology of Canada, Vol. V, Report of Geological Survey Department.

to its being in keeping with the practice commonly followed for the metals. It also recommends itself as the only method of attaining a common basis of valuation, when, as in the case of the metals, the material is shipped in such various stages of concentration or preparation. Of course, owing to the expense of the subsequent stages of extraction, the price obtainable for the metal in the matte would be much below the market price as given above for fine nickel, only counting about 13 cents per pound for the nickel and 6 cents per pound for the copper. Where no allowance is made by the buyers, the price given for the nickel would range from 22 to 24 cents per pound. Assuming then an average price of 23 cents, this would make the total value of all the matte shipped $330,220, or at 13 cents per pound, $186,646.

Imports into U.S.A. and prices.

We are indebted to the kindness of the Engineering and Mining Journal of New York for the following figures relating to prices, imports, etc., by the United States, the result of enquiries made by them. They point out with regard to price that as the nickel trade is conducted, the bulk of transactions are made for long periods and the spot business is small, so that it is impossible to show the actual condition of the markets at short intervals. However, during 1890 it ranged between 60 and 80 cents per pound. At the beginning of the year it was 60 cents and some large contracts were made at even slightly lower figures. The price reached 80 cents about the middle of the year and remained at that point until the financial troubles in November, after which it fell to 60 cents.

NICKEL.

TABLE 1.

IMPORTS BY THE UNITED STATES.

Imports of Nickel by the United States—Calendar Year 1890.

	Lbs.	
In ore and matte....	78,685	$ 20,683
Nickel, nickel in alloys, and nickel oxide.....	611,898	300,231
	690,583	320,914

NICKEL.

TABLE 2.

IMPORTS BY THE UNITED STATES.

Imports of Nickel by the United States—Fiscal Year ending 30th June, 1890.

			Lbs.	
In ore, matte and other crude forms, all from Canada.....			111,201	$ 11,687
Nickel, nickel in alloys and nickel oxide, from England.....			208,309	105,572
do	do	France.....	85,410	33,485
do	do	Germany..... ...	127,771	52,256
			532,691	203,000

Uses.

Besides the already mentioned uses a large demand should eventually arise for nickel steel, apart from its application to armour plate, in the general construction of ships and in many other directions, so that a market should grow up for this metal at fairly remunerative prices. It is hardly likely, however, that the price will keep very high, as apart from all the foreign deposits at present known to exist, there is every likelihood of the discovery of other important districts in Canada itself. The known areas of similar Huronian rocks are quite numerous and extensive, especially in the great Archæan region extending all the way from the coast of Labrador, along the northern side of the St. Lawrence and Ottawa River valleys and the north shores of Lakes Huron and Superior, to the edge of the younger rocks underlying the prairie sections of the west at Lake Manitoba, whilst the belt of Huronian rocks of the Sudbury district itself is known to extend a long way to the north-east. Whilst many of these areas are too far away to be sufficiently accessible for a long time, yet there are many which are well within reach of, or actually traversed by, the Canadian Pacific Railway. Whether the geological conditions favourable to the existence of nickeliferous pyrrhotite bodies, other than the existence of Huronian rocks, are there to be found, remains yet to be proved.

Probable supply.

We cannot say either that nickel-bearing ores are confined to this formation, so that many of the large bodies of pyrrhotite already known to exist in various places may on examination be found to carry the metal in workable quantities.

Considerable interest has been taken in this industry during the past year, owing to the prominence given to it in the newspapers, following on the successful trials of nickel steel for armour plate. This led to

renewed activity in prospecting, the subject being brought into further prominence by the visits of the allied societies of the British Iron and Steel Institute and the American Institute of Mining Engineers, on two successive occasions, to the Sudbury mines, which has led to a certain amount of acquisition of properties by outside capital.

The temporary withdrawal of the mineral lands from sale by the Ontario Government, and the proposed imposition of a royalty, has, however, toward the end of the year, caused somewhat of a lull in the activities of the Sudbury district.

PETROLEUM.

The only oil-producing territories in Canada during 1890 were as in previous years the Petrolia and Oil Springs fields, in the township of Enniskillen, Lambton county. Ontario.

No new developments are reported from this township, nor has the field been extended, though drilling operations are constantly being carried on, new wells being "brought in" to replace those abandoned. For a description of this field see report of the Division of Mineral Statistics and Mines for 1889, part S, Vol. IV, 1888-89.

In no other part of Ontario were drilling operations undertaken in search of oil, though it is said that in boring for gas at Comber, in Essex county, oil was obtained, though not in sufficient quantity to be of commercial value.

In Quebec operations were being carried on in the vicinity of Gaspé Basin though with what success was not ascertained. Quebec.

It is proposed to further investigate this district during the present year.

Oil has several times been reported as occurring in commercial quantities near Pointe aux Trembles. That there is no truth in the reports may be readily understood by the following words of Mr. A. P. Low, who during his investigations in that district, visited and thus reports upon the locality:—

"The indications of petroleum at Pointe aux Trembles were investigated; the Utica shales were there found to be highly impregnated with oil, but as the shale and limestone appear to form a synclinal basin in the Archæan valley, with only a few low, narrow anticlinal ridges, the possibility of a large collecting area for oil under the shales is doubtful."

An important discovery was made during the year in the South Kootenay Pass in Alberta and British Columbia, where oil was found occurring in natural springs, but in what quantity is not yet known. It is of a pale greenish yellow and appears to be of very light gravity, similar to the British Columbia.

celebrated Washington county crude oil of Pennsylvania. Very little is as yet known of this occurrence, though in all probability investigations will shortly be made.

North-West Territories.

Regarding the occurrence of tar sands and maltha deposits in the Athabasca region, Mr. R. G. McConnell, who carried on investigations in that district, in his summary report to the Director of the Survey, says:—

Athabasca, Tar-sands.

"The valley of the Athabasca for a hundred miles above Lake Athabasca shows only alluvial sands, and the boulder-clays associated with stratified sands and gravels. Beds of rolled tar-sand pebbles occur in the latter in a number of places. A coarse gravel bed which immediately underlies the surface, and overlies the boulder-clay was found to be completely saturated with soft tar. Ten miles below Calumet River the Devonian limestone rises to the surface of the valley from beneath the glacial beds and almost immediately afterwards is overlaid by the tar-bearing sands of the Cretaceous. From this point the Devonian limestones undulating at low angles, and accompanied by the tar-sands, are exposed at frequent intervals as far as Crooked Rapid, a distance of about eighty miles. At Crooked Rapid they become affected by a slight south-westerly dip and sink below the surface of the valley, and eight miles farther on, at Boiler Rapid, the tar-sands also disappear, and are replaced by higher divisions of the Cretaceous.

"The tar-sands mentioned above belong to the Dakota formation and constitute in this region the basal member of the Cretaceous system. They rest unconformably on the Devonian limestones. Lithologically they may be described as soft sandstone, the cementing material of which is a bitumen or inspissated petroleum derived from the underlying limestones. The sands are siliceous and usually rather fine-grained, but also grade occasionally into a coherent grit. The eastern boundry of the tar-sands was not precisely defined, but their outcrop was estimated to have a minimum distribution of fully 1,000 square miles. In thickness they vary from 150 to 225 feet. The tar is unequally distributed through the sands, in some places merely staining the grains, but in most of the sections examined it is present in sufficient quantity to render the whole mass more or less plastic. An analysis by Mr. Hoffmann of a specimen collected some years ago by Dr. Bell gave by weight:—

Bitumen	12·42
Water (mechanically mixed)	5·85
Siliceous sands	81·73

A cubic foot of the bituminous sand rock weighs, according to Mr. Hoffmann, 117·5 lbs. This figure multiplied by the percentage of bitumen, 12·42, gives 14·59 lbs. as the amount of bitumen present in a cubic foot,

or $\frac{14}{68}\cdot\frac{59}{7} = 22{\cdot}9$ per cent in bulk. At the minimum thickness of 150 feet, and assuming the distribution as given above at 1,000 square miles, the bituminous sand rock in sight amounts to 28·40 cubic miles. Of this mass, if the preceding analysis is taken as an average, although this is probably rather high, 22·9 per cent in bulk or 6·50 cubic miles is bitumen. This calculation can, of course, only be ragarded as an approximation, but will serve to give some idea of the enormous outpouring of bituminous substances which has taken place in this region. The amount of petroleum which must have issued from the underlying limestones required to produce 6·50 cubic miles of bitumen cannot be estimated, as the conditions of oxidation and the original composition of the oil are unknown. It must, however, have been much greater than the amount of bitumen. Athabasca tar-sands.

"A few miles west of the Athabasca the sand rock, still saturated with tar, passes below the higher divisions of the Cretaceous, and its extension in this direction can only be ascertained by boring. It was not recognized on Peace River nor on the lower part of Red River, and must disappear somewhere in the intervening region.

"In ascending the Athabasca the tar-sands, after an exposure of over twenty miles, pass below the surface at Boiler Rapid and are not seen again. Above this the upper divisions of the Cretaceous, influenced by a light south-westerly dip, and also by the grade of the stream descend gradually in the banks of the valley and disappear in succession. The Cretaceous section is as follows in descending order:—

		Feet.
Cretaceous.	Pierre shales	700
	Niobrara sand and sandstone	35
	Niobrara shales	90
	Niobrara sand and sandstone	300
	Benton shales	275
	Dakota tar-sands	175
		1,575
	Devonian limestone	

"The commercial value of the tar-sands themselves, as exposed at the surface, is at present uncertain. But the abundance of the material and the high percentage of bitumen which it contains makes it probable that it might, in the future, be profitably utilized for various purposes. It proves a flow of petroleum to the surface unequalled elsewhere in the world, but its more volatile constituents have long since disappeared, and the rocks from which it issued are probably exhausted. In their extension under cover, however, the case is different, and it is here that oils of economic value must be sought. Above Boiler Rapid the tar-sands

Athabasca tar-sands.

are overlaid by a cover of shales, sufficient to prevent the oil from rising to the surface, and as we ascend the river this cover gradually thickens. The geological attitude of the cover is not the most favourable, as the beds dip away from the outcrop at the rate of about six feet to the mile, and it is possible that part or even the whole of the oil may have flowed northwards and eastwards through the Dakota sands and escaped where these come to the surface. It is unlikely, however, that all the oil has escaped in this manner, as small anticlinals in the covering beds are almost certain to exist, and a differential hardening of the sands themselves may serve to enclose reservoirs or pools of large capacity. It is also possible that the sands at their outcrop, may, by the deposition of tarry substances, be plugged tightly enough to prevent further egress.

"Favourable indications of the presence of oil are afforded by the existence of several natural gas springs in the valley of the Athabasca above Boiler Rapid. One of these occurs at the mouth of Little Buffalo River and is twenty miles distant in a straight line from the outcrop of the tar-sands. The gas here forces its way from the sands up through a covering of 250 feet of Benton shales and issues from the surface in numerous small jets distributed over an area fifty feet or more in diameter. Some of the jets when lighted burn steadily until extinguished by heavy rains or strong wind, and afford sufficient heat to cook a camp meal. A second spring was noticed thirteen miles below the mouth of Pelican River, or forty miles in a straight line from the outcrop of the tar-sands at Boiler Rapid. The volume of gas escaping here is less than at the mouth of Little Buffalo River, and in order to reach the surface it is obliged to penetrate 570 feet of shales and sand. Escaping jets of gas were also noticed at several points further up the river, but these were mostly small and may possibly be due to decaying vegetable matter.

"The question of the continuity of the tar-sands, and their petroliferous character under cover, can only be settled in a decided manner by boring, and it is highly desirable that drilling operations should be undertaken for this purpose. The indications seem amply sufficient to warrant the small expenditure involved, and the advantages which would accrue from a successful issue of the search to this portion of the North-West are almost incalculable. The southern limit of the field cannot, without present knowledge or without boring, be defined; it may possibly extend to the Saskatchewan or beyond, as even as far as Manitoba the rocks are more or less petroliferous.

"Two bore holes, one at the mouth of Lac la Biche River, and the other at the mouth of the Pelican, would add largely to our knowledge of the underground geology of this region, and would either settle posi-

tively the question as to the presence or absence of petroleum in paying quantities, or at least afford valuable data for future action. At the mouth of the Pelican River, a bore hole, in order to reach the tar-sands, would require to be sunk 700 feet, and at the mouth of Lac la Biche River about 1,200 feet. The former locality is 50 miles distant in a straight line from the outcrop of tar-sand at Boiler Rapid. The latter is 106 miles distant from the same point, and is only 110 miles from Edmonton."

Statistics.—During 1890 there were twelve refineries in operation, eight of which are located in Petrolia, two in London, one in Sarnia and one in Hamilton, as follows :— Producers.

Imperial Oil Co	Petrolia.
M. J. Woodward & Co	do
John McDonald	do
Petrolia Oil Co	do
Consumers' Oil Co	do
McMillan, Kittridge & Co	do
Premier Oil Co	do
Jno. McMillan	do
Jno. R. Minhinnick	London.
W. Spencer & Co	do
Sarnia Oil Co	Sarnia.
Canadian Oil Co	Hamilton.

These refineries employ about 250 men in and about the works, and throughout the oil-producing territory there are about 2,000 men employed either directly or indirectly in the production of crude and refined oil. The wages paid for skilled labour in the production of refined oil are from $2.00 to $2.50 per day, while ordinary labour, in and around the refineries, is paid for at the rate of from $7.00 to $10.00 per week.

Apart from those engaged in the refining of oil there is quite a staff of drillers busily engaged throughout the year in sinking wells, of which about 400 are annually drilled, to replace a nearly similar number that are annually abandoned.

From returns made direct to this office there were 28,412,341 gallons, or 811,781 barrels, of crude oil received at the refineries, of which 28,267,746 gallons were consumed in the manufacture of the various products of petroleum, deducting from this a decrease in stocks of the tanking companies, amounting to 117,089 barrels, there is found to have been an approximate production of crude oil of 695,000 barrels, an Production.

increase, when compared with the figures of the year previous, obtained in the same manner, of 54,701 barrels.

These figures are, of a necessity, only approximate, as the change in stocks at the refineries, if any, was not obtained. At the average price of oil for the year, $1.18, the value of the above quantity of oil would be $820,100.

As in previous years, however, the production and value of oil as shown in the summary table of production is obtained by computation from the inspection returns of the Inland Revenue Department.

Tanking companies.

The tanking companies operating as such were:—

The Petrolia Crude Oil and Tanking Co., Petrolia; The Crown Warehousing Co., Petrolia; The Producers Tanking Co., Petrolia, all of whom have kindly furnished us with returns of the year's operations, of which the following is a résumé:—

Stocks, 1st January, 1890	213,772 $\frac{32}{35}$
Quantity of oil received	480,963 $\frac{8}{35}$
do delivered	598,052 $\frac{7}{35}$
Stocks, 1st January, 1891	96,683 $\frac{33}{35}$
Decrease of stocks during year	117,088 $\frac{34}{35}$

The returns of the several refineries above referred to give the following results:—

PETROLEUM.

TABLE 1.

PRODUCTION OF CANADIAN OIL REFINERIES.

Products.	1889.		1890.	
	Quantity.	Value.	Quantity.	Value.
Illuminating oils galls.	9,479,917	$1,084,829	11,129,277	$1,264,677
Benzine and naphtha "	409,135	34,861	636,247	37,026
Paraffine oils "	703,025	87,936	446,888	64,713
Gas oil "	2,917,346	65,954	4,246,447	84,752
Lubricating oils and tar "	2,191,881	96,407	2,877,388	130,349
Paraffine wax lbs.	561,820	44,197	913,730	56,903
Totals		$1,414,184		$1,638,420

PETROLEUM.

TABLE 2.

CONSUMPTION OF CRUDE OIL AND CHEMICALS.

Articles.	1889.	1890.
Crude petroleum..... ....galls.	25,066,275	28,267,746
Sulphuric acid.... . .....lbs.	3,638,704	4,284,826
Soda..... ... . "	380,487	336,758
Litharge .. .. "	477,969	443,922
Sulphur ..... "	76,325	85,729

Inspection returns.

The following figures and tables, 3 and 4, are taken from the books of the Inland Revenue Department, and show the number of packages of Canadian oil inspected during the calendar year 1890, as well as the total quantity of refined oil, imported and domestic, inspected during the *fiscal* years from 1881 to 1890, inclusive.

During 1890 the packages of Canadian oil inspected were:—

236,997 . ... @ 10 cents inspection fee
9..... @ 5 do do
44,186..... .... @ 2½ do do

Assuming that these packages contain 42, 10 and 5 gallons respectively, there is found to be an approximate inspection of

9,953,874 gallons in packages of 42 gallons each.
90 do do 10 do
220,930 do do 5 do

or a total inspection of 10,174,894 gallons.

This amount computed at an average percentage of the crude oil of 38 would be equivalent to a consumption of crude of 26,776,037 gallons, or 795,029$\frac{22}{35}$ barrels, which at the average price of crude oil during the year, $1.18 per barrel, would be valued at $902,734.

PETROLEUM.

TABLE 3.

CANADIAN OILS AND NAPHTHA INSPECTED AND CORRESPONDING QUANTITIES OF CRUDE OIL.

Fiscal Year.	Refined Oils Inspected.	Crude Equivalent Calculated.	Ratio of Crude to Refined.
	Galls.	Galls.	
1881	6,406,783	12,813,566	100 : 50
1882	5,910,787	13,134,993	100 : 45
1883	6,970,550	15,490,111	100 : 45
1884	7,656,011	19,140,027	100 : 40
1885	7,661,617	19,154,042	100 : 40
1886	8,149,472	21,445,979	100 : 38
1887	8,243,962	21,694,637	100 : 38
1888	9,545,895	25,120,776	100 : 38
1889	9,462,834	24,902,195	100 : 38
1890	10,121,210	26,634,763	100 : 38

In the following table (4) is given the total amount of illuminating oil, both domestic and imported, inspected during the fiscal years from 1881 to 1890, and represents the market for that product in Canada :—

PETROLEUM.

TABLE 4.

TOTAL AMOUNT OF OIL, IMPORTED AND CANADIAN, INSPECTED.

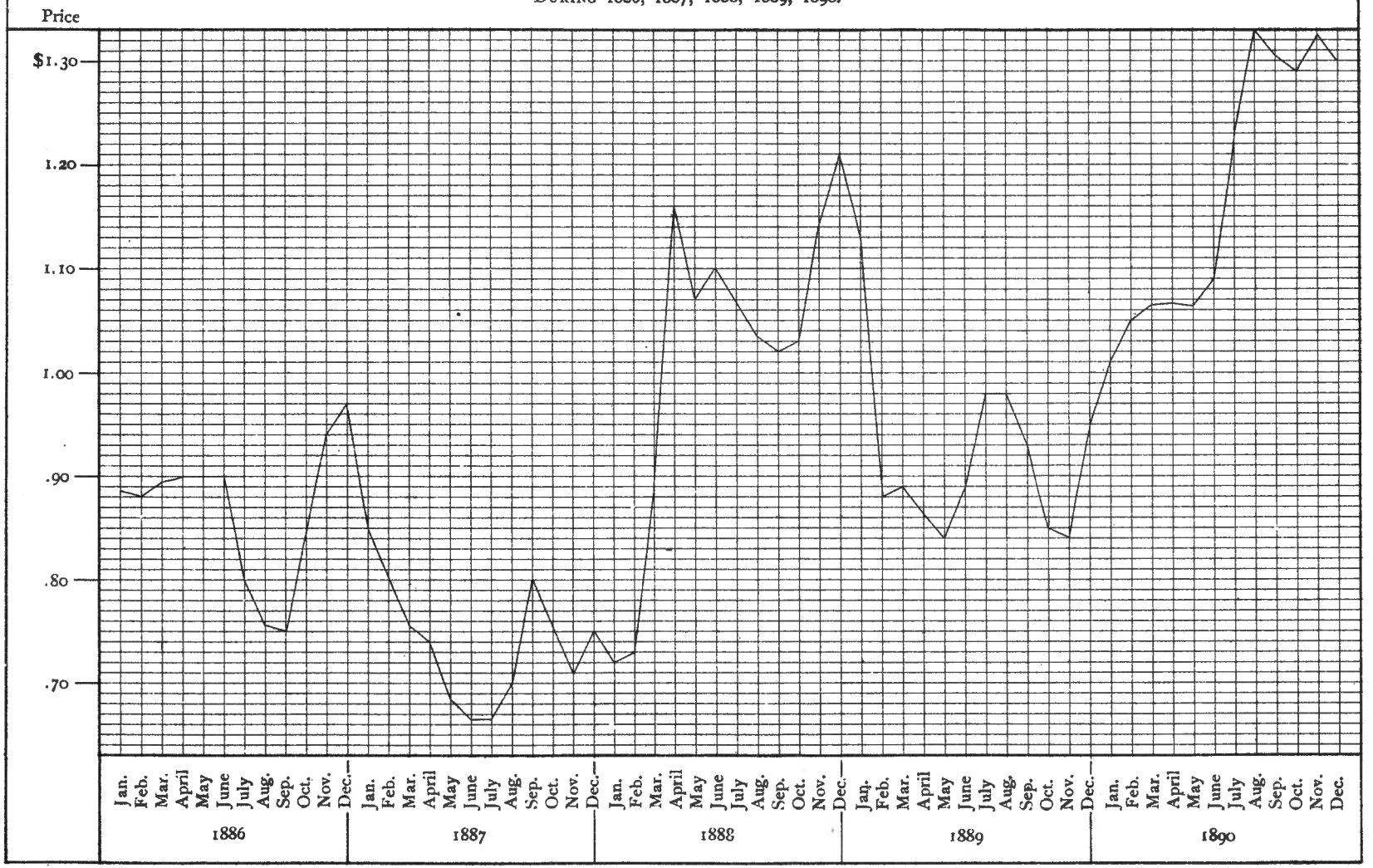
Fiscal Year.	Imported.	Canadian.	Total.
	Galls.	Galls.	Galls.
1881	476,784	6,406,783	6,883,567
1882	1,351,412	5,910,747	7,262,159
1883	1,190,828	6,970,550	8,161,378
1884	1,142,575	7,656,011	8,798,586
1885	1,278,115	7,661,617	8,939,732
1886	1,327,616	8,149,472	9,477,088
1887	1,665,604	8,243,962	9,909,566
1888	1,821,342	9,545,895	11,367,237
1889	1,767,812	9,462,834	11,230,646
1890	2,020,742	10,121,210	12,141,952

Prices. The following information regarding prices of crude oil has very kindly been furnished by Mr. James Kerr, and indicates the prices of crude oil as quoted on the Petrolia Oil Exchange :—

PETROLEUM

TABLE A

RANGE OF PRICE (AVERAGE CLOSING PRICE) OF CRUDE OIL
DURING 1886, 1887, 1888, 1889, 1890.



PETROLEUM.

TABLE 5.

PETROLIA OIL EXCHANGE, CRUDE PETROLEUM BUSINESS FOR THE YEAR 1890.

1890.	Opening Price.	Highest Price.	Lowest Price.	Closing Price.	Average Closing Price.	Sales. (Barrels.)
January	$1 01½	$1 03	$1 01¼	$1 02¼	$1 02	41,417
February	1 02¼	1 11	1 02	1 08½	1 06	43,872
March	1 08½	1 09½	1 05½	1 05½	1 07¼	31,494
April	1 07¾	1 10	1 06¼	1 08½	1 08	19,551
May	1 08	1 08	1 07	1 07½	1 07½	28,284
June	1 07¾	1 16	1 07¾	1 16	1 10¼	40,063
July	1 16	1 37	1 16	1 37	1 23	33,679
August	1 35½	1 35½	1 31	1 32	1 32¾	27,271
September	1 31⅝	1 31⅝	1 27¾	1 30¾	1 30½	32,047
October	1 31	1 32	1 28	1 28	1 29	36,822
November	1 28½	1 36¼	1 28½	1 35	1 32¾	27,600
December	1 35	1 35	1 27	1 30	1 30	32,824
Year 1890	1 01½	1 37	1 01¼	1 30	1 18	394,924
do 1889	1 21	1 21	80	1 01	92¾	400,932
do 1888	75½	1 23½	71	1 23	1 02¾	516,007

The following tables of exports and imports of oil are compiled from information obtained from the Customs Department and explain themselves:— Exports and imports.

PETROLEUM.

TABLE 6.

EXPORTS OF CANADIAN CRUDE AND REFINED PETROLEUM FROM 1873 TO 1890.

Calendar Year.	Gallons.	Value.
1873	5,869,579	$1,287,576
1874	28,946	2,509
1875	11,836	2,214
1876	2,533,772	583,550
1877	1,431,883	323,013
1878	609,171	85,571
1879	235,171	17,032
1880	3,085	751
1881	501	99
1882	1,119	286
1883	13,283	710
1884	1,098,090	30,168
1885	337,967	10,562
1886	241,716	9,855
1887	473,559	13,831
1888	196,602	74,542
1889	235,855	10,777
1890	420,492	18,154

PETROLEUM.

TABLE 7.

IMPORTS OF CRUDE AND REFINED PETROLEUM.

Fiscal Year.	Gallons.	Value.
1880	687,641	$131,359
1881	1,437,475	262,168
1882	3,007,702	398,031
1883	3,086,316	358,546
1884	3,160,282	380,082
1885	3,767,441	415,195
1886	3,819,146	421,836
1887	4,290,003	467,003
1888	4,523,056	408,025
1889	4,650,274	484,462
1890	5,075,650	515,852

Subtracting the quantities of imported oils inspected (table 4) from those shown in table 7, there is found to have been an annual importation of oil, crude, and other than illuminating, as is shown in the following table 8:—

PETROLEUM.

TABLE 8.

IMPORTS OF CRUDE AND MANUFACTURED OILS OTHER THAN ILLUMINATING.

Fiscal Year.	Gallons.
1881	960,691
1882	1,656,290
1883	1,895,488
1884	2,017,707
1885	2,489,326
1886	2,491,530
1887	2,624,399
1888	2,701,714
1889	2,882,462
1890	3,054,908

The imports of paraffine wax and paraffine wax candles are given in the following tables 9 and 10:— Paraffine wax.

PETROLEUM.

TABLE 9.

IMPORTS OF PARAFFINE WAX.

Fiscal Year.	Pounds.	Value.
1883.	43,716	$ 5,166
1884.	39,010	6,079
1885.	59,967	8,123
1886.	62,035	7,953
1887.	61,132	6,796
1888.	53,862	4,930
1889.	63,229	5,250
1890.	239,229	15,844

PETROLEUM. Paraffine wax candles.

TABLE 10.

IMPORTS OF PARAFFINE WAX CANDLES.

Fiscal Year.	Pounds.	Value.
1880.	10,445	$2,269
1881.	7,494	1,683
1882.	5,818	1,428
1883.	7,149	1,734
1884.	8,755	2,229
1885.	9,247	2,449
1886.	12,242	2,587
1887.	21,364	3,611
1888.	22,054	2,829
1889.	8,038	1,337
1890.	7,233	1,186

PHOSPHATE.

The production of this mineral for 1890, as shown by direct returns to this office, amounted to 31,753 tons, having a spot value of $361,045. These figures show an increase of 765 tons and $44,383 as compared with the figures of production for last year. Production

The yield of the two districts to the grand total is as follows:—

	No. of tons.	No. of Producers.
Quebec district	27,172	11
Ontario do	4,581	15

Exports.

The following tables, Nos. 1 and 2, explain themselves, graphic table A giving the total exports for the whole Dominion for this and past years:—

PHOSPHATE.

TABLE 1.

EXPORTS OF PHOSPHATE.

Year.	Ontario.		Quebec.	
	Tons.	Value.	Tons.	Value.
1878. ...	824	$12,278	9,919	$195,831
1879.....	1,842	20,565	6,6(4	101,470
1880.....	1,387	14,422	11.673	175,664
1881.....	2,471	36,117	9,497	182,339
1882.....	568	6,338	16,585	302,019
1883.	50	500	19,666	427,168
1884.....	763	8,890	20,946	415,350
1885..	434	5,962	28,535	490,331
1886.....	644	5,816	19,796	337,191
1887.	705	8,277	22,447	424,940
1888.....	2,643	30,247	16,133	268,362
1889....	3,547	38,833	26,440	355,935
1890..... . .	1,866	21,329	26,591	478,040

PHOSPHATE.

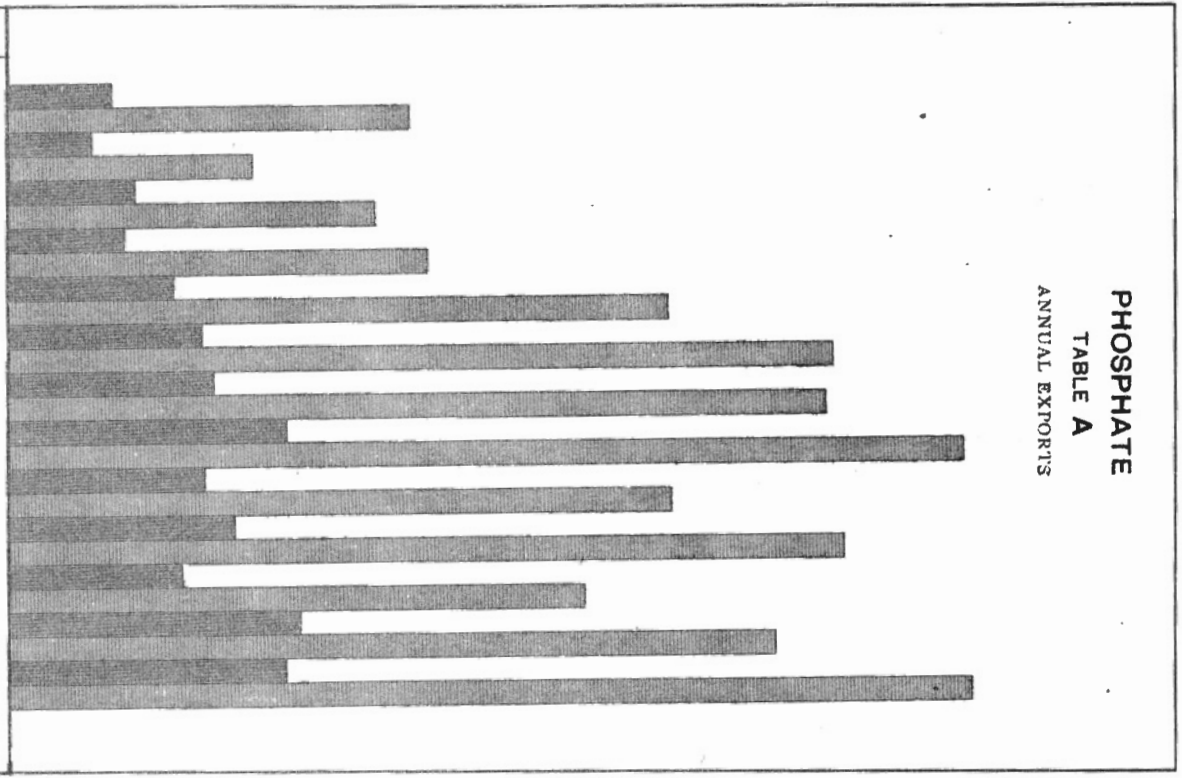
TABLE 2.

G. B. imports

GREAT BRITAIN: IMPORTS OF CANADIAN APATITE COMPARED WITH TOTAL IMPORTS OF PHOSPHATES IN THAT COUNTRY.

Year.	Canadian Apatite.		Total Phosphates.		Per cent of Value of Canadian Apatite to total Value.
	Long Tons	£ stg.	Long Tons	£ stg.	
1882.....	8,187	39,851	199,428	613,198	6·5 per cent.
1883.....	16,531	66,714	246,945	813,825	8·2 do
1884.....	15,716	52,370	219,225	643,851	8·1 do
1885.....	21,484	76,179	238,572	628,027	12·1 do
1886..	18,069	63,490	223,111	526,885	12·0 do
1887..... ...	19,194	65,974	283,415	614,088	10·7 do
1888.	12,423	42,291	257,886	544,919	7·7 do
1889..	23,123	71,037	304,953	703,704	10·1 do
1890.....	21,089	65,420	343,501	849,452	7·8 do

Year	Quantity	Value
	Tons	$
1878	10,743	208,109
1879	8,446	122,035
1880	13,060	190,086
1881	11,968	218,456
1882	17,153	338,357
1883	19,716	427,668
1884	21,709	424.240
1885	28,969	496,293
1886	20,440	343,007
1887	23,152	433,217
1888	18,776	298,609
1889	29,987	394,768
1890	28,457	499,369



PHOSPHATE
TABLE A
ANNUAL EXPORTS

The industry continues to be prosecuted as formerly in the two districts of Ottawa county, Quebec, and in that of Eastern Ontario. In these two districts the phosphate deposits are found in rocks of Laurentian age. Occurrence of deposits.

In the Ottawa county district these consist largely of gneisses, granitic gneisses with pyroxenite belts and considerable areas of crystalline limestone. The pyroxenite rocks are apparently intrusive in the gneissic rocks and all the phosphate deposits of importance occur in them. The gneissic rocks form the greater proportion of the area in which the working mines of this district are included and often merge into rocks having a similar mineralogical composition, but a granitic structure, the parallel arrangement of the minerals being entirely absent. Quebec.

The belts of pyroxenite run parallel with the general strike of the surrounding rocks, but at their contact show evidences of their intrusive nature and throughout them at places there are developments of a rock consisting almost altogether of somewhat coarsely crystallized felspar which frequently shows a peculiar violet or blue colour on the cleavage faces.

The phosphate bodies are distributed through these belts in the most irregular manner. Each one varying from the other in the details of its characteristics, showing in common, however, the feature of extreme irregularity. In a few instances they show a general extension of the phosphate in a plane which gives the openings made on them the appearance of having followed a vein, but there are no walls nor sharp planes of division which persist for any distance between the phosphate and enclosing rock. Most of the excavations made show the bodies of mineral to have been of extremely irregular shape; merging into the enclosing rock and holding a very varying proportion of intermixed rock. At places very large bodies of almost pure phosphate have been encountered, yielding many thousand tons.

The intermixed material consists, almost without exception, of pyroxenite, although some pits show considerable developments of pink calcite and at places a good proportion of pyrite distributed through the phosphate.

A survey of the group of mines belonging to the Phosphate of Lime Company and the Canadian Phosphate Company, all of which are on one belt, shows a long string of pits and openings and strippings of very varying dimensions, numbering probably 200 and covering a length of nearly two miles, the width of the strip being about ten chains. This pyroxene belt has a general strike of N. 50° W. passing through the Crown Hill mine, at its southern end and on to the High Rock and Star Hill mines. Further north, about a mile, are the openings known as the Central Lake

mine which also seems to be on an extension of this belt; it must therefore take a more northerly course, coming round to a strike of N. 25° W. Here, also, there are a number of openings extending on the belt for about three-quarters of a mile. Some work has also been prosecuted on the same belt south of the Crown Hill mine on the Ross Mountain, so that with these five mines we have a proved length of the belt of some four miles and a half with a possible continuation a mile further north to the High Falls mine of the General Phosphate Company, Limited.

The above constitute the largest connected group of mines of the district tributary to the River du Lièvre, on the west side of which they are situated, at a distance of about twenty miles above Buckingham village.

The other chief mines of this district are as follows:—

The North Star mine on the east side of the river near Tamo Lake and opposite the lower end of the High Rock belt, the output of which is carted a distance of about four miles to the river bank, to be shipped. The works at this place are concentrated within a length of about twenty chains on a narrow belt of pyroxenite about 120 feet wide striking N. 20° W. Here there are some fifteen or twenty openings of various dimensions, one shaft having attained a depth of about 600 feet. The surrounding rocks consist of distinctly banded gneisses with quartzite bands.

Passing down the river towards Buckingham we come to the group of mines in the vicinity of Little Rapids. Of these there were six working during the year. Five are on the east bank of the river, viz., the London and Little Rapids mines, near the Little Rapids locks, and the Emerald, Squaw Hill and Ætna mines, two miles and a half further down. The fourth, known as the Sprucé Lake mine, is about opposite the Emerald on the other side of the river, about four miles in from the same. The strike of the pyroxene belts here was not so fully worked out as those further up the river, but they range about N.E. and S.W. or roughly at right angles with the others. The London and Little Rapids mines seem to be on two parallel and adjacent belts, or what may on further study turn out to be one belt divided at this point by a "horse" of barren rock. The Emerald and Squaw Hill workings are close together, comprised within a radius of about five chains whilst the Ætna mine is about half a mile further inland, and would seem to be on the extension of the same belt.

The mode of occurrence of the phosphate at these places shows no features very strikingly different from those above enumerated, except at the Emerald Mine where for the amount of mineral yielded during

the working of the mine it has been concentrated in a very small compass, the hill in which it occurs being fairly honey-combed with extensive excavations.

All these mines bring their product to the River du Lièvre where it is loaded on large scows and towed down the river to Buckingham village. Here it is transhipped into railroad cars and taken thence over the Canadian Pacific Railway to Montreal.

The Templeton sub-district is adjacent to that of the River du Lièvre, but being the other side of the watershed of that river all its product is taken out to the Canadian Pacific Railway at East Templeton station.

Here there is a large area of pyroxenite, throughout which deposits of apatite seem to be plentifully distributed. The most extensively worked mine is that known formerly as the McLaurin and Blackburn property, now owned and operated by the Templeton District Phosphate Mining Syndicate, Limited, who are also opening up deposits at several other points in the vicinity. Here is the famous "Big Pit" out of which such large quantities of the mineral have been taken since the commencement of operations several years ago. Around it, within a radius of a mile, a number of other properties have been worked at various times during past years.

Chief amongst those in operation during 1890 are the following, viz.:— S. ½ lot 9, range XII. worked by Mr. Lewis McLaren, of Templeton; the E. ½ of lot 9, range X, worked by Mr. Falardeau; lot 9 in range IX, worked by Messrs. Courselles & Belcourt, of Ottawa, and lot 14, in range X, or the Pearson property, worked under the direction of Mr. Charles Lionais. The operations at most of these are of a preliminary nature, designed to open up and develop the properties.

In this locality the mode of occurrence of the phosphate is very similar to that of the district first described, although at the last named, Pearson property, the mineral occurs in a number of well-defined veins cutting the containing pyroxene rock. On a visit to the property there were seen several veins running north-east and south-west, which seemed persistent and regular, and were crossed by others striking W. N. W. These veins, as far as exposed, showed a filling of calcite, in which the apatite occurred being in the form of crystals where vugs had been uncovered.

In the Gatineau River district, to the west of the last named, a number of properties have been proved to carry phosphate deposits on which during former years a fair amount of work was done, but of late there is very little to report from there in the way of development.

The working mines in the Ontario district are situated mainly in that part of the county of Frontenac south of the Canadian Pacific line from Ontario.

Montreal to Toronto and tributary to the Kingston and Pembroke Railway, comprising the townships of Oso, Hinchinbrooke, Bedford, Loughboro' and Storrington. Some few places were also worked in the townships of North Burgess and South Sherbrooke, Lanark county and in North Crosby township, Leeds county. This district will be all comprised within the triangular area bounded on the south and east by the Rideau canal, on the north by the Canadian Pacific Railway and on the west by the Kingston and Pembroke Railway.

The geological conditions are in general similar to those already described for the Ottawa county district, similar Laurentian rocks being found to occur. The phosphate deposits, however, take more the shape of regular veins and much of it is extracted from the crystalline limestones.

Some activity in the matter of developing phosphate deposits is reported from near Carp village, in Carleton county, and from Sebastopol township, in Renfrew county.

Characteristics of Canadian apatite.

Canadian apatite is generally of a green colour of varying shades, although more rarely red. Its texture varies much, even in the same pocket or deposit from the crystalline or "rock phosphate" to the finely granular aggregates aptly called "sugar phosphate." The former has the advantage that in process of extraction it can be obtained clean, forming the best grade of "lump phosphate." The latter kind in blasting out gets broken up finely and is apt, on account of the intimate intermixture of foreign material, to be classed and shipped as "seconds."

The mineral both of the Ontario and Quebec districts belongs to the variety fluor apatite. A series of eight analyses made by the chemical branch of the Survey in 1878* gave the following proportions:—tribasic phosphate of lime, 88·138 per cent. to 89.810 per cent. One exceptional specimen, however, ranging as low as 74·295 per cent—fluorine from 3·311 per cent to 3·863 per cent with a little chlorine, carbonate of lime and other things. These specimens were selected so as to be as free as possible from mechanically intermixed impurities that they might represent the composition of the pure mineral itself.

Mining methods.

The mining methods adopted are quite simple, viz.: Opening up pits wherever phosphate is found outcropping on surface either of sufficient purity and extent to pay or where it is believed development may prove a sufficiently extensive body. If such does not prove to be the case, the working is of course abandoned, otherwise the pit is extended in every direction, following the body of mineral until exhausted or until

*See Report of Progress, Geological Survey of Canada, 1877-78.

the policy of the management points to the advisability of suspension of work in order to concentrate on some more profitable body. Mining methods.

Thus a phosphate "mine" presents the appearance of a number of pits of all sizes and shapes, mostly abandoned either permanently or temporarily and full of water, dotted irregularly all over the area of the phosphate-bearing belt comprised within the property of the company, amongst which at a few points active operations will be seen to be progressing. Owing to these facts mining operations must always be very irregular in their nature, nor can the economies due to a far-seeing arrangement of the work on a defined plan be secured, because the centre of operations is ever changing, and it is impossible to predict from month to month where it will be.

The larger operators use machine drills almost altogether, some few having large permanent air compressor plants supplying power over the whole property, by means of a system of pipes supplementing this at outlying points with machine drills worked from small portable boilers. Hoisting is done almost altogether by means of derricks erected and moved about as required, small portable steam or horse power hoists being used.

The material to be handled is considerable in comparison with the yield of pure phosphate, for whilst work may be carried on for short periods in almost solid mineral the average of a good pit will run nearer five of rock hoisted to one of phosphate and oftener near ten to one at the less profitable points. As the pits are generally working downwards the waste rock has all to be hoisted, forming the extensive "dumps" which are so noticeable a feature dotted all over a worked area.

The phosphate is cobbed and hand picked to free it from intermixed foreign matter and graded into "firsts" and "seconds." The "firsts" consist of the clean phosphate that can be picked out by hand, the "seconds" of the more finely divided material in which a certain amount of intermixed rock, etc., must be left, which it would not pay to pick out. The "firsts" will range from 75 to 85 per cent, and the "seconds" from 60 to 75 per cent of tribasic phosphate of lime. The cobbing is either done at the pit's mouth or in temporary sheds at convenient places in the vicinity, or, as with some of the larger mines, where the works are more concentrated and systematised, they have one or two central cobbing sheds, stove heated for winter work, to which the material is brought by tramways. The interior of one of these will show a large square table on to which the mineral is dumped from the car coming in above and around, which may be seen about 40 or 50 small boys busily hammering and sorting. Screening is used to a certain

extent in separating the more easily pulverized phosphate of the "seconds" from the associated rocky portion, which on account of their greater hardness or toughness form the larger particles.

Owing to the often intimate admixture of phosphate through the rock the waste from the cobbing sheds and the dumps at the pits still shows a considerable amount of the mineral, which, however, it would not pay to extract.

In the River du Lièvre district the larger mines have tramways of considerable length for bringing their product to the shipping point on the river bank, where they have complete wharfage arrangements for either the direct placing of the mineral in the scows or for its temporary storage. The subsequent methods of shipment have been already described.

The operators of the Templeton sub-district suffer from having to haul their product some eleven miles out to the railway, waggons being the only available means. This adds from $2 to $3 per ton to the cost of laying down at the shipping point.

In the Ontario district the material will be brought out to the Canadian Pacific and Kingston and Pembroke railways, or the Rideau canal by waggon and shipped, most of it going to Montreal to join that from the other districts.

Markets and uses.

Nearly all the phosphate shipped from Canada finds a market in continental Europe and Great Britain, where it is used by the manufacturers of superphosphate. Some little, however, is similarly used in Canada, at the works of Messrs. Brodie, at Smith's Falls, and Messrs. Nichols & Co., at Capelton, P.Q. The latter firm continues to manufacture chemical manures of various grades, using Canadian phosphate and acid from their own sulphuric acid works at that place. The home consumption would not, however, amount to more than 600 or 700 tons.

A small quantity which is exported to the United States consists mostly of the lower grade mineral which is ground at the mills at Buckingham station.

With regard to the general course of the industry outside of the change of ownership of some of the older mines, the main feature has been the formation of a large company in London, England, known as the General Phosphate Corporation, Limited, with the purpose of making extensive purchases of phosphate lands. Although disappointed in raising the whole of the capital asked for, several properties were acquired and operations commenced late in the fall at the Ross Mountain and High Falls mines in the River du Lièvre district, where, also, two other new companies operated during the year, viz., the Dominion

Mining Company, at the London mine, and the Anglo-Continental Guano Company, at the Squaw Hill and Ætna mines.

Outside the operations in the old districts there is little to report regarding discovery and development of phosphatic materials elsewhere, except to allude to an interesting occurrence mentioned in the Summary Report of the Director of the Geological Survey for 1890, which speaks as follows:—"A specimen of phosphatic shale collected by him (Mr. Tyrrell) from the Niobrara formation on Wilson River, on the Lake Dauphin Plain, in Manitoba, was given for analysis to Mr. Hoffmann, who reports that it contains 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. A very small outcropping of this shale which is largely composed of fragments of fish remains was seen in the bank of the river, but if the bed proves to be an extensive one it will furnish a very valuable source of supply of phosphate of lime for the benefit of Manitoba and the country further west, being very similar in character to the coprolite beds of England and France."

PYRITES.

Production.

The Canadian sulphur ore produced and used during the year amounted to 49,227 tons, which, taken at the current price of such ore for the year, *i. e.*, $2.50 per ton, would have a value of $12,067.50.

As in former years this production resulted from mining operations at the group of copper mines near Sherbrooke, P.Q., which have been fully described in the article on copper in this report.

A small proportion is used locally in the manufacture of acid at the works of Messrs. Nichols & Co., at Capelton, the rest all being shipped to the United States, where it is used for a similar purpose.

The amount of pyrites imported into that country during 1890, as given by the *Engineering and Mining Journal* of New York, was 115,000 tons, with an average of 43 per cent of sulphur.

The ore carries sulphur to the extent of 35 to 40 per cent, which is burnt off in the process of use, leaving only from 2 to 3 per cent in the residue.

In calculating from the returns received, only that portion of the ore shipped from these mines which was actually used in sulphuric acid manufacture, was included in the above total.

The ores of nickel and copper mined at Sudbury represent of course a very considerable amount of sulphur, but none of it becomes available for any useful purpose, being all dissipated into the surrounding atmosphere in the process of heap-roasting adopted, it having been decided after consideration of the subject by some of the companies that their

ends would be better served than by erecting the very extensive and costly plant, which would be necessary to handle such large quantities of ore and utilize their sulphur contents, the profitable result of such a proceeding being also open to considerable doubt.

Imports. The following table (No. 1) gives the imports of brimstone and crude sulphur, and illustrates the Canadian market for the same, which it is hoped may eventually be supplied, at all events partially, by pyrites of home production :—

PYRITES.

TABLE 1.

IMPORTS: BRIMSTONE OR CRUDE SULPHUR.

Fiscal Year.	Pounds.	Value.
1880....	1,775,489	$27,401
1881.....	2,118,720	33,956
1882.	2,375,821	40,329
1883....	2,336,085	36,737
1884.....	2,195,735	37,463
1885.....	2,248,986	35,043
1886....	2,922,043	43,651
1887	3,103,644	38,750
1888.	2,048,812	25,318
1889.	2,427,510	34,006
1890.....	4,440,799	44,276

SALT.

Returns of the production of salt are, as in previous years, made from Ontario and New Brunswick, and show a marked increase over the figures given for the year 1889. Outside of these two provinces no salt is made except in Manitoba and the North-West Territories where it is produced in small quantities by the Indians.

Ontario. In Ontario the salt is obtained from beds at or near the base of the Onondaga formation, where it occurs inter-stratified with marls, dolomites and shales.

The following record of a boring made by Mr. H. Attrill, at Goderich, in 1876* may be taken as an index to the general character of the wells, which are sunk to various depths, ranging from 1,000 to 1,500 feet :—

	Feet.	Inches.
Surface deposits.....	78	9
Dolomite with thin limestone layers.....	278	3
Limestone, with corals, chert and beds of dolomite.....	276	0
Dolomite with seams of gypsum.....	243	0

*See Report of Progress, Geological Survey of Canada, 1876-77, pp. 226 227.

	Feet.	Inches.
Variegated marls with beds of dolomite...	121	0
Rock salt, first bed.....	30	11
Dolomite with marls towards the base.....	32	1
Rock salt, second bed.....	25	4
Dolomite.....	6	10
Rock salt, third bed.....	34	10
Marls with dolomite and anhydrite.....	80	7
Rock salt, fourth bed.	15	5
Dolomite and anhydrite.....	7	0
Rock salt, fifth bed.....	13	6
Marls, soft, with anhydrite.....	135	6
Rock salt, sixth bed.....	6	0
Marls, soft, with dolomite and anhydrite...	132	0
Total depth.....	1,517	0

It will be seen on reference to the above section that there is in a distance of 520 feet a total thickness of 126 feet of rock salt.

The salt is obtained in the form of brine, in most cases of full saturation, the natural waters of the well acting as a solvent upon the salt beds.

The brine so formed is pumped into settling tanks, from whence there is a constant stream feeding the evaporating pans. By reason of the gradual dissolving away of the salt at the base of the well large cavities are formed into which the rocks constituting the roof of the cavity are continually falling, where owing to their marly and clayey composition they are in a measure taken into mechanical suspension and pumped into the evaporating pans causing a slight falling off in the purity of the salt.

Analysis of Goderich salt.

Regarding the quality of salt obtainable in Ontario, the following analysis conducted by Dr. T. Sterry Hunt, may not prove uninteresting.

The salt chosen for examination was from the second bed in Mr. Attrill's well and gave the following results:—

Sodium chloride.....	99·687
Calcium do	0·032
Magnesium do	0·095
Sulphate of lime.....	0·090
Insoluble in water.....	0·017
Moisture.....	0·079
	100·000

Analysis of Cheshire salt.

Dr. Hunt in the report of the Geological Survey, 1876–77, compares this analysis with one made of the famous Cheshire rock salt in 1872, the salt chosen for comparison being "crushed Marston rock salt" manufactured by Messrs. Fletcher & Rigby.

The analysis shows a proportion of foreign matter equivalent to 2·67 per cent, as follows:—

Sodium chloride	96·70
Calcium do	0·68
Magnesium do	Trace
Potassium do	——
Sulphate of lime	0·25
Insoluble matter	1·74
Moisture	0·63
	100·00

Comparison of various salts.

Again in the same report Dr. Hunt gives the following list of salts containing impurities, with the amount of foreign matter found in each respectively:—

Cheshire salt (analysis above)	2·67	per cent.
Cordova, Spain, salt	1·45	do
Turk's Island salt	2·34	do
Saginaw salt	2·00	do
Syracuse solar salt	1·15	do
do boiled salt	1·50	do
Goderich coarse salt (analysis made in 1871)	1·09	do
Goderich medium salt	1·28	do
do fine salt	1·62	do

It will be seen, therefore, that the salt produced in Ontario is of superior quality, ranging in amount of contained foreign matter from 1·09 per cent to 1·62 per cent, or an average of about 1·36 per cent.

No boring operations in search of salt were made during the past year, the only new feature in the trade being the erection of a block at Parkhill by Messrs. Hutchins & Co.

It is intended to make use of a well sunk some years ago by the Parkhill Salt Company, which, owing to the low price of salt prevailing at the time, was never put into service.

Producers Ontario.

The operators during 1890 were:—

Courtright	Courtright Salt Company.
Parkhill	Hutchins & Company.
Port Franks	Jos. Williams.
Exeter	Exeter Salt Works Company.
Hensall	Geo. McEwen.
Clinton	Henry Ransford.
Goderich	N. A. Chemical Company.
do	Ogilvies & Hutchison.
do	Peter McEwen.
do	Jos. Kidd, jr.
Warwick	Elarton Salt Works Company.
Wingham	Grey, Young & Sparling Co.
Blyth	do do
Kincardine	L. Rightmeyer.
do	Ontario People's Salt Company.
Brussels	T. T. Coleman.

During 1890 the industry was on a better footing than for the past few years, owing to the formation of a trust or combine of the various manufacturers under the title of the "Canada Salt Association." A similar association was in existence from 1882 to 1885, when owing to dissension among the members, it was dissolved in the end of March, 1885. In the interregnum between that date and 1890 the industry fell off greatly, many of the works being closed, if not for the whole period, at least for a very considerable portion of each year.

The industry, notwithstanding the efforts of the producers, suffers greatly from its competition with English salt, which is admitted duty free.

In the report of this Division for 1886, this point is alluded to as follows: "Another thing which militates against the Canadian salt industr is the competition of English salt coming in duty free, and with discriminatory freight rates in its favour. Even were this removed, there would remain the natural disadvantage of the distance of the chief market for salt in the Dominion, *i.e.*, the sea fisheries, from the centre of production, the cost of carrying the salt over such long distances doubling, or more than doubling, its price at the point of consumption. The discrimination mentioned in favour of the competing English salt arises from the fact that both the railways and steamship lines can afford to carry material moving west at a very much lower rate than that moving east. In fact, a large quantity of English salt comes out to Montreal as ballast, paying either none or a mere nominal freight charge."

New Brunswick.

In New Brunswick the salt production is as in previous years the result of the operations of the Messrs. Heinrichs, at Plumweseep, near Sussex, King's county, where a brine is obtained from natural springs that affords a very superior quality of dairy salt; the output being only sold locally and as such.

Production.

The quantity of salt produced during the year 1890 was 43,754 tons, having a net value of $198,897, an increase over last year of 10,922 tons and $69,350.

The production for the past five years is given below:

1886.....	62,359	tons,	valued at.....	$227,195
1887.....	60,173	do	do	166,394
1888.....	59,070	do	do	185,460
1889.....	32,832	do	do	128,547
1890.....	43,754	do	do	198,897

Exports and imports.

In the following tables will be found the exports and imports for the past eleven years:

SALT.

TABLE 1.

EXPORTS.

Year.	Bushels.	Value.
1880.....	467,641	$46,211
1881.....	343,208	44,627
1882.....	181,758	18,350
1883.....	199,733	19,492
1884.....	167,029	15,291
1885.....	246,794	18,756
1886.....	224,943	16,886
1887.....	154,045	11,526
1888.....	15,251	3,987
1889.....	8,557	2,390
1890.....	6,605	1,667

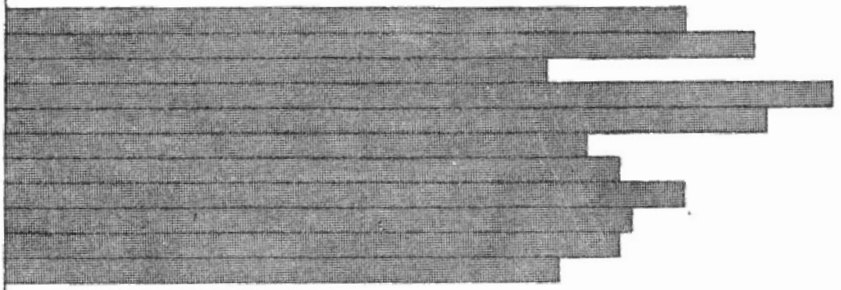
SALT.

TABLE 2.

IMPORTS: SALT PAYING DUTY.

Fiscal Year.	Pounds.	Value.
1880.....	726,640	$ 3,916
1881.....	2,588,465	6,355
1882.....	3,679,415	12,318
1883.....	12,136,968	36,223
1884.....	12,770,950	38,949
1885.....	10,397,761	31,726
1886.....	12,266,021	39,181
1887.....	10,413,258	35,670
1888.....	10,509,799	32,136
1889.....	11,190,088	38,968
1890.....	15,135,109	57,549

Fiscal Year	Tons
1880	106,720
1881	117,115
1882	84,932
1883	129,442
1884	119,081
1885	90,984
1886	96,236
1887	106,728
1888	97,338
1889	96,019
1890	86,813



SALT

TABLE A

IMPORTS OF SALT ALL SORTS.

SALT.

TABLE 3.

IMPORTS: SALT NOT PAYING DUTY.

Fiscal Year.	Pounds.	Value.
1880	212,714,747	$400,167
1881	231,640,610	488,278
1882	166,183,962	311,489
1883	246,747,113	386,144
1884	225,390,121	321,243
1885	171,571,209	255,719
1886	180,205,949	255,359
1887	203,042,332	285,455
1888	184,166,986	220,975
1889	180,847,800	253,009
1890	158,490,075	252,291

In the graphic table "A" opposite is given the total quantity of salt imported for the past eleven years, the quantity being given in tons.

SILVER.

The total production of this metal for 1890 was 400,687 ounces, valued at $420,722, as compared with 383,318 ounces, valued at $343,848 for 1889. This represents an increase of 17,369 ounces and $76,814. Production.

The following table gives the relative contributions of the different provinces to the total for the past four years, as given in previous reports, all showing an increase:—

SILVER.

TABLE 1.

PRODUCTION OF SILVER.

Year.	Ontario.		Quebec.		British Columbia.		Total.	
	Ozs.	Value.	Ozs.	Value.	Ozs.	Value.	Ozs.	Value.
		$		$		$		$
1887	190,495	190,495	146,898	146,898	11,937	11,937	349,330	349,330
1888	208,064	208,064	149,388	149,388	37,925	37,925	395,377	395,377
1889	181,609	162,309	148,517	133,666	53,192	47,873	383,318	343,848
1890	158,715	166,652	171,545	180,122	70,427	73,948	400,687	420,722

The record of the progress and development in the various provinces during the year is given below.

There is nothing much to note with regard to this province. The return given represents, as formerly, the silver contents of the pyritous Quebec.

ores shipped from the mines in the vicinity of Capelton in the Eastern Townships district of Quebec. A gratifying addition was also made in the shipments of argentiferous galena from the Temiscamingue Mine up the Ottawa River. Further particulars regarding these two districts will be found in the articles on Copper and Lead.

Ontario

The silver from this province is, as formerly, the product of the mines in the vicinity of Thunder Bay, Lake Superior. As this district has been fully described in Part H, Vol. 1887-1888, and also alluded to in Parts S., Vols. 1886, 1887 and 1888, there will be no need to give the details of the mode of occurrence of the veins here.

The mines working at present are in two groups situated at distances of 20 and 32 miles from Port Arthur, on a line extending W. S. W. from that place. The chief producing mines of these two groups, known respectively as the Rabbit Mountain and Silver Mountain districts, are the Beaver, Badger and Porcupine mines in the former, and the Shuniah-Weachu and West End mines at Silver Mountain. Prospecting and development work has been prosecuted on a number of properties throughout the district as follows:—In the region north and west of Whitefish Lake preliminary work has been done on a number of properties as far west as Arrow Lake. In the Silver Mountain district work was prosecuted on the Crown Point, Silver Centre (R. 64) and Augusta properties, the latter being immediately west of the West End mine. In the Rabbit Mountain district some half dozen properties were working outside of the three producing mines, whilst further east in the township of Paipoonge, Neebing and McIntyre and east of Port Arthur along the line of the Canadian Pacific Railway, small forces of men have been at work on several properties.

A certain amount of work has also been prosecuted in testing veins at the headwaters of the Pine River, south of Silver Mountain, and at Cloud Lake towards the centre of the area of these silver-bearing rocks. These experiments are specially interesting, as they are in a part of the district which has been comparatively unexplored, owing to its inaccessibility, but where, for geological reasons, any veins found might be expected to have as good a chance of proving rich as in the other parts of the district. In fact, the greater thickness of the favourable black slates, which there is reason to believe will be found to characterise this vicinity would assure the favourable character of one set of the conditions necessary for the existence of payable ore in any fissures that may be discovered there.

The developments on the chief mines begin to assume considerable proportions. The No. 3 shaft at the Shuniah-Weachu mine, Silver Mountain, is said to be down 800 feet, whilst the greatest depth attained,

so far, at the other end of the same vein, is said to be 225 feet in one of the shafts of the West End mine. Of the Rabbit Mountain group the most extensive developments are to be found at the Beaver mine which has attained a depth of 600 feet. These depths are, of course, measured from the tops of the shafts which are at various levels.

British Columbia.

It will be noted that the amount of silver produced and shipped from this province still continues to show an increase which amounts to 17,235 ozs., and $26,075 as compared with last year. These figures do not seem to be very exact, as the Report of the Minister of Mines for British Columbia, from which they were taken, states that they represent 110 tons of ore, valued at $409 per ton for both silver and copper, but that the relative value of each metal has not been made known. Thus this item may represent the value of a certain amount of copper.

The total amount of the silver produced as yet is not, of course, large, but from the promising nature of the districts, as reported by Dr. Selwyn, Dr. G. M. Dawson and other reliable authorities, there can be no doubt but that with the advent of better means of communication they will speedily become large contributors to the silver production of the country.

The districts of East and West Kootenay and Yale, constituting that part of the province bounded on the west and north by the Canadian Pacific Railway, on the east by the interprovincial and on the south by the international boundary, include the chief discoveries of silver, copper and lead bearing veins at present made.

The chief centres of activity at present lie in the Toad Mountain, Hot Springs or Ainsworth and Hendryx camps and the Illecillewaet subdivision of the West Kootenay district and the Cherry Creek and Rock Creek camps of the Yale district.

As mentioned in the articles on gold and copper, these veins so often show an intimate association of the ores of all these metals that it is impossible to definitely classify them under either one head or the other, so that for convenience the information about them is given here.

The silver produced in the province as above given was all the result of operations on the Toad Mountain and Hot Springs groups of veins.

The reports of the progress of mining in the various districts are reproduced below from the report of the Minister of Mines of the province for 1890.

The silver veins of East and West Kootenay are mentioned as follows :—

"*Illecillewaet Subdivision.*—Under the able superintendence of Mr. Jas. Brady, C.E., the tunnel in the Lanark is now over 500 feet long, 300 feet of which was completed this season. The lode in this claim is from

British Columbia.

2½ to 5 feet wide and of a high grade character. Sixteen car loads, shipped some three or four years ago, returned in silver alone 89 oz. to the ton. The company has expended a large amount of money in developing its property and is deserving of the utmost success.

"The Maple Leaf has two shafts sunk, one at the upper end of the claim 35 feet deep, the other at the lower extremity, 45 feet. The vein is 4½ feet wide. Returns from a previous shipment yielded 90 oz. in silver, $\frac{175}{1000}$ oz. gold, and 28 per cent lead. The Crystal adjoins the Maple Leaf on the west. In performing the assessment work on this claim last summer a solid body of good ore was struck, the width of which was not ascertained. A shipment of ore will be made to the sampling works to test its value.

"The Oak Leaf is owned by Messrs. Jowett and Haig, and with more work will probably become a valuable property. The vein is 2 feet wide, composed of galena in a slate formation. Assays range from 45 to 200 oz. of silver to the ton, and from 50 to 60 per cent lead.

"The Cariboo Company have extended their tunnel 100 feet farther this summer. The vein is galena, lying between walls of porphyry, and varies from 6 to 12 feet in width. The assay value is $30 per ton. This claim shows a large body of ore, which can be made very profitable on being provided with cheap transportation to the railway.

"The Gladstone is owned by Messrs. McArthur and Kennedy, of Illecillewaet. A shaft has been sunk 20 feet, and a tunnel run on the vein 30 feet; width of lode from 18 to 30 inches. The ore is of a high grade character. About 20 tons is on the dump ready for transportation by mule train.

"On Gold Hill are located the Cora, Spanish Fly, Crown Point, Vulture and some others. They are situated in a depression, about 12,000 feet long, which extends across the mountain. The vein matter is lead carbonates from 6 to 12 feet wide, possessing an assay value of 20 oz. in silver to the ton. A trail was constructed by the Government last summer, which starts from a point on the Cariboo Creek trail, about two miles east of Illecillewaet, and terminates at the above group of mines, a distance of about 5½ miles. This improvement will prove a great assistance to mining operations in that direction.

"The Goat Cave is located south of the railway track, back of the town of Illecillewaet, on the steep slope of a mountain. A specimen of the ore yielded an assay amounting to 120½ oz. in silver and 63 per cent lead. A tunnel is in about 20 feet on the lode, which is composed of quartz and galena. One half of the claim was sold last fall by the proprietors, Messrs. Scott and Chisholm, to Mr. Sando, of London, England. I did

not learn the amount, but one of the conditions is that the sum of $4,000 be expended by the purchaser in development. British Columbia.

"At Albert Cañon, the Wild Fox, owned by Abrahamson Bros., of Revelstoke, has a tunnel 47 feet long; vein matter is galena, 3 feet wide; assay value 22 oz. silver to the ton, and 47 per cent lead. There are two other locations of the same character upon which insufficient work has been accomplished to determine their value.

"It is a matter of surprise to every one that the Illecillewaet subdivision has not attracted more attention from capitalists and mining men in general. Many of the veins are rich and well defined, exhibiting large bodies of ore, and possessing the great advantage of being situated within easy reach of a railway, and, in some instances, quite close to this means of transportation. It is, therefore, not owing to the absence of any of these features that development has not been more actively prosecuted, but to the fact that here and elsewhere the majority of mine owners cannot afford the heavy expenditure required for that purpose, and they demand too high a price for their property to secure the investment of capital. Some of the richest mining sections in the adjoining States have experienced similar periods of depression, ascribed to the same cause, until the capitalist was offered sufficient inducements to come to their rescue. It is evident that a more liberal course will have to be pursued to attain the benefit of the great wealth lying dormant by this means in the principal mining districts of the province.

"*Fish Creek.*—The Dunvegan mine, which looked so promising last year, has remained idle since spring. The Kootenay Smelting and Trading Syndicate had it bonded for the sum of $60,000 for three months. After the expiration of that time a further extension was demanded but refused, and work was discontinued.

"The Mogul is an extension of the Dunvegan. It has a drift in the ledge 23 feet, exposing a fair body of high grade ore of the same character as that found in the last-mentioned claim.

"*East Arm, Upper Arrow Lake.*—With the exception of assessment work little has been accomplished on the locations, about a dozen in number. The Kootenay Smelting Company have done some drifting on one of their claims without satisfactory results. The ore is rich, but the vein is broken and difficult to trace.

"*Lardeau River Country.*—On the 29th of September J. W. Haskins recorded at the Revelstoke office five mineral claims discovered by him in the Lardeau country. They are situated about six miles east of Trout Lake, and, judging by the assays, indicate the existence of a rich mineral belt in that direction. Specimens from the different claims were assayed

British Columbia.

by Mr. Rosser, the assayer for the Smelting Works, and gave the following returns :—Alice, 1st assay, 10 oz. gold, 50 oz. silver, 72 per cent lead, to the ton; 2nd assay, from different portions of the vein, 20 oz. silver, trace of gold, 40 per cent lead. Homestake, 0·86 oz. gold, 102 oz. silver, to the ton, 16 per cent lead; 2nd assay, from another portion of the lode, 75 oz. silver to the ton. Copper King, 11 oz. silver; no assay made to ascertain percentage of copper. Clara, 31 oz. silver to the ton; traces of gold.

"The discoverer, during an absence of several months, explored Fish Creek and the mountain ranges bordering on that stream, without finding anything worthy of attention. East of the lake mentioned, however, he detected the presence of mineral indications, which he followed, and led to the discovery of these ore deposits. The veins average from 2½ to 3 feet wide, and are about 18 miles from the head of navigation on the East Arm."

"*Toad Mountain Subdivision.*—On the west side of Cottonwood Creek, about three miles south of Nelson, is an important group of locations which will prove profitable to their owners when in a position to make shipments. The vein is between four and five feet wide, possessing an average assay value of $30 to the ton. The ore is capable of being concentrated. A shaft is sunk on the Lizzie Co. 38 feet deep, and one on the Umatilla and Uncle Sam, 40 feet. A drift has also been run on the two latter claims. These mines are well situated for transportation facilities.

"On the Sandy Creek slope of the mountain are some important locations, among which are the Toughnut and Evening. On the former a shaft has been sunk 80 feet, and a tunnel run 127 feet. The vein is from four to eight feet wide, and contains ore of a high grade character. This mine will be an ore producer next summer. A tunnel has been run in the Evening, which is an extension of the Toughnut, a distance of 137 feet, in addition to an incline 65 feet.

"On the Give Out slope are a number of mines, the principal ones being the following:—The Jim Crow, with a shaft 25 feet deep; the Dandy, a shaft 40 feet deep, which will be sunk to a depth of 100 feet this winter. The lode in this claim is changing from galena to grey copper, which returns high assays. The Grizzly Bear is opened up by a shaft 68 feet deep. The Iroquois, a tunnel 90 feet long. The Give Out, a shaft 30 feet. The Newmarket, a shaft 40 feet deep.

"All the foregoing mines show excellent bodies of ore of a high or medium grade character, which will be industriously worked with the advent of cheap transportation.

"The celebrated Hall mines, comprising the Silver King, Kootenay Bonanza, and American Flag, are situated on the summit of Toad Mountain. They would have employed a large number of men last summer had it not been for the litigation in which they were involved. The tunnel in the Silver King is 330 feet long, in which are employed fourteen men. A large quantity of ore is on the dump awaiting the completion of the waggon road for shipment. One hundred and ten tons of ore were forwarded last fall from this mine to Helena, Montana. It was taken from a cross-cut at the bottom of the incline, and sampled from $404 to $414 to the ton in silver and copper. British Columbia.

"On the north side of the Kootenay River, the Alaska, a late discovery, is located on a ledge over 30 feet wide, existing in a granite formation. The vein matter consists of dolomite, carrying galena and copper pyrites. The returns from the assays have not yet been learned.

"Assessment work merely has been done on the Copper Queen and other claims situated on the same side of the river.

"*Hot Springs Subdivision.*—Development in this subdivision has been prosecuted with diligence in the principal mines. The Skyline forwarded last fall 95 tons of ore to the smelter at Anaconda, which sampled 280 ounces of silver to the ton. An engine has been erected for pumping and hoisting purposes, and a shaft-house 70 by 31 feet. A contract for sinking 200 feet has been awarded, besides 200 feet of cross-cutting and drifting. A pack trail has been graded from the waggon road to the mine, a distance of 10 miles. The Union has an engine erected on the ground, and will sink to a depth of 200 feet. The Krao has also pumping and hoisting works about ready for operation. The Number One Company have struck the vein within fifteen feet of the bottom of their old incline. The ore is high grade and averages nearly four feet of solid ore. This claim was formerly considered a failure, but additional work has proved it to be one of the best locations in the camp. The lode will now be tapped and prepared for stoping.

"The Little Donald has changed hands, Mr. Stevens, of Spokane Falls, being the purchaser. This year a deep tunnel will be started provided with the best improved machinery for the purpose.

"The Crescent, Eden, Tenderfoot, Vancouver, Old Timer and Neosha Companies have all within a few weeks struck bodies of rich ore, carrying native silver, and are sacking it for shipment. The Old Timer and Tenderfoot cover the intervening ground between the United and Krao, and demonstrate the permanent character of the ore body that extends through this mineral belt.

British Columbia.

"The Maestro, Spokane, and Libby Companies are to drive their tunnels this winter. These claims are certain to develop into first-class properties. The contract for work on the Gallagher will be given this winter. The following work has been accomplished on the undermentioned mines:—

	Feet.
Skyline, incline and drifts	490
United, shaft	60
Gallagher, shaft and drifts	220
Krao, shaft and drifts	350
Fourth of July, tunnel and drifts	100
Union, shaft	85
Arkansas, shaft	50
Spokane, tunnel and drifts	350
Maestro, tunnel and drifts	260
Lady of the Lake, tunnel	60
Dictator, tunnel and drifts	200
Number One, tunnel and drifts	1,200
Lakeview, shaft	25
Little Donald, shaft and drifts	250
Black Chief, tunnel	30
Pataha, tunnel and drifts	120

Besides many others having shafts and tunnels from 30 to 50 feet.

"The intrusion of a 'horse' in the Union shaft for a time prevented satisfactory results. Since then the vein has assumed its proper position, and now looks as well as ever.

"The amounts of ore on the dump ready for shipment, which will be largely increased during this winter, are as follows:—The Skyline, 1,000 tons that will return 45 ounces to the ton; United, 1,200 tons; Krao, 1,000 tons; Number One, 2,000 tons, besides 50 tons of high grade. The quantity sacked by other companies has not been learned.

"*Hendryx mines.*—Development in the Blue Bell mine has been steadily carried on under the management of Dr. Hendryx. The tunnel and drifts have attained an aggregate length of 1,500 feet. The work accomplished last year has only corroborated the knowledge previously obtained as to the apparently inexhaustible supply of ore in this valuable property. I have been informed that the adjoining extensions, two in number, have been purchased from Mr. Ainsworth for the sum of $100,000. This will necessitate the construction of a smelter to render the large body of mineral wealth controlled by the Hendryx Company available.

British Columbia.

"*Goat River.*—The Goat River mines are situated about eight miles north of the boundary line. They were discovered about the latter end of July, by James King. An Indian happened one day to show him a piece of float he had found, which Mr. King recognized to be rich. The latter at once instituted a strict search, which was rewarded by finding the lode whence it had been detached. The ore is galena, three feet on the surface, and assaying from $30 to $80 in silver to the ton. A tunnel 125 feet long has tapped the vein at a depth of 100 feet, which, at the point of intersection was found to be six feet wide. Twelve locations have been recorded. These mines are situated within four miles of the Kootenay River, and will enjoy the advantages resulting from cheap transportation. They will attract a number of men next summer. Anticipating the importance this camp will attain, the Government has lately appointed a gentleman residing in the vicinity to discharge the duties of a mining recorder.

"*Trail Creek.*—Trail Creek is situated on the west bank of the Columbia river, about 20 miles below Sproat, and 10 miles north of the 49th parallel. The mines are scattered over an extent of country extending back from the river from three to eight miles, including Red Mountain, which contains some of the most promising locations. One hundred and sixteen claims have been recorded, which are divided into two distinct groups, the smaller one, containing about forty locations, possesses veins from two to ten feet wide, assaying as high as $180 in the precious metals, silver predominating; the vein matter also carries lead, zinc and antimony.

"The principal mines in this belt are the Lily May, Zwiloo, Blossom and Homestake. A shaft in the Lily May at the depth of 20 feet shows a vein four feet wide, carrying about 80 ounces of silver to the ton, choice pieces running up to 180 ounces. The Zwiloo also shows up equally as well, and is considered one of the best locations in the camp.

"The larger group commences about two miles north of the first mentioned. Copper and iron are here the most widely disseminated ores. with a little antimony, more or less gold, and a small quantity of silver, A cross-cut in the vein of the Le Roi exposes a solid body of ore 18 feet wide, which will run about 8 per cent copper, 10 ounces in silver, and varies from $3 to $500 in gold to the ton. A part of this mine has been bonded by a Spokane Falls company, who are steadily working it with two shifts of men. There is every probability this will turn out to be a first class mine. Three other locations on this vein exhibit similar favourable indications. The St. Elmo, Mountain View and Spar have been bonded by Portland, Oregon, capitalists. These are the only claims that possess galena veins. Six or seven others are under bond,

British Columbia.

but work will not be actively carried on before the approach of spring. The Josie, owned by R. E. Lemon, which returned large assays, was also bargained for, but I have not learned whether the bargain was effected.

"The ore bodies in this district exist in a syenite formation, and are generally capped with iron rock. Some of them are of great width, varying from four to fifty feet, and cut the stratification of the rock at right angles. Their general course is east and west, with the exception of the Lily May, and its extensions, which runs north-east and south-west. Excellent facilities for shipping are provided by the easy access to the Columbia River, whence freight can be cheaply transported to Revelstoke, or the Dalles, where connection can be made with the Spokane and Northern Railway.

"The belief is entertained that with the attaining of greater depth copper will be found in paying quantities. This has proved to be the case in the Le Roi, the copper having increased from seven per cent on the surface to fifteen per cent at a depth of ten feet; also a perceptible improvement in the quantity of silver. The surrounding country presents an inviting appearance to the eye, consisting of level benches, covered with grass and timber. The latter is open and affords no obstacle to prospectors.

"The climate is mild and agreeable, and the snowfall amounts to only nine or ten inches in depth. About fifty men will winter there this year. A mining record office has been established, which is a great convenience to miners, who, previously, had to undergo the loss of time and expense incurred in travelling to Nelson on business connected with their claims."

East Kootenay.—The particulars of progress, &c., in this district are reported as follows:—

"The mineral of the district, as far as at present ascertained, lies in two main belts. The mineral at Ottertail and Field, in the Rockies, appears to be local, no continuation of large extent having been traced. The first of these belts commences in the Selkirk Range, at the head of the North Fork of the Spillemcheen River, near Mount Sir Donald, and runs thence in a south-easterly direction on the easterly slope of the Selkirks, passing through the McMurdo district, including Cariboo Basin, Carbonate Basin, and cutting McMurdo Creek, Copper Creek, Vermont Creek, Horse Thief Creek, Toby Creek, &c., gradually approaching the Columbia valley and passing into the Rockies to the south of the Columbia lakes.

"The minerals discovered up to the present in this belt are gold in sulphurets (free milling at the surface), silver-bearing galena and grey copper, antimony, bismuth and other minerals occurring casually.

"The minerals of this belt are *high grade*, especially the grey copper and antimonial copper ores, assays as high as 1,024 oz. to the ton having been obtained. Test lots of ore, amounting to about 50 tons, shipped last season from the neighbourhood of Vermont Creek, gave excellent results. British Columbia.

"The second important belt, mentioned above, runs about parallel to the Selkirk mineral belt, generally in the limestones and quartzites at or close to their contact with the slates (Cambrian) of the Selkirk formation, along the valley of the Columbia southwards, crossing the valley and passing into the Rockies near the Columbia lakes. The discoveries in this belt are probably some of the most important of the district, though less continuous than those of the Selkirk belt, viz.: Jubilee Mountain, Spillemcheen Mountain, Steamboat Butte, Windermere Mountain, and various promising discoveries of copper ore in the Hughes Range, east of the Kootenay River. The bulk of the ore so far extracted is of copper and lead, carrying silver. Some high assays in silver and gold have been obtained principally from Jubilee Mountain.

"The Field discoveries, of which the 'Monarch' mine is the most important, also those in the neighbourhood of Ottertail, both quite close to the Canadian Pacific Railway in the Rockies, would appear to be more local in their character, no continuous belts having been traced for any considerable distance.

"The region down the Columbia to Canoe River, north of the railroad, has not yet been prospected for quartz.

"*Field.*—The 'Monarch' mine, situated on Mount Stephen, near the summit of the Rockies, a quarter of a mile from and at an elevation of 850 feet above the Canadian Pacific track, is at present the only fully equipped working mine in the district. The company has resumed work this fall. A force of ten miners is now at work, terms having been arranged to supply the Revelstoke Smelter Company with 200 tons of ore per month. The shipping ore averages about 60 per cent lead with 10" (ozs.?) "of silver to the ton.

"The ore occurs in somewhat irregular chambers, pockets and other deposits in the limestone, with but little gangue, and seems abundant. It is expected that the mineral will lie in more regular form and even greater body when more depth into the mountain has been reached. The mine was discovered in 1884. About 1,500 tons of ore have been extracted and shipped up to the present time. The underground workings amount in the aggregate to about 450 feet of tunnelling, with larger chambers opened out in places where ore was more abundant. A considerable amount of work has also been executed on the outside, consisting of a tramway, galleried out of the face of the mountain, leading to

British Columbia.

the principal ore bins, and a gravity road from thence to the bins on the railroad, together with all the necessary plant for working the mine.

"On the various other claims in the vicinity of Field, little more than prospecting and assessment work has been done, though some of the prospects look as favourable as the 'Monarch' did before it was opened up.

"The ores so far found in the locality have been very pure galena ores, low grade in silver, containing occasionally a small percentage of zinc.

"*Ottertail.*—No work of consequence has been done in this locality for several years.

"*Selkirk Mineral Belt, including McMurdo District.*

"*Cariboo Basin.*—On the north side of the Middle Fork of the Spillemcheen, or McMurdo Creek, on which a number of claims, showing good croppings, have been located, has not received much development work this season beyond assessment work on some of the claims.

"*Carbonate Mountain*—On the south side of McMurdo Creek, has many important claims. Messrs. Rand Bros., of Vancouver, on behalf of English capitalists, purchased a property of ten claims in the fall of 1889, to which they have added other locations. The most important of these prospects, showing on the surface, occur on the 'Monitor,' 'Southern Cross' and 'Polly Brown' claims. The previous development done on these claims was unimportant. The vein can be traced continuously along the whole length of the property, extending from McMurdo Creek along the summit of Carbonate Mountain into Copper Creek. This main lead, like most of the mineral in the belt, runs in a south-easterly and north-westerly direction, lying almost vertically between walls of slate, mica-schist and granitic rock. The width of the vein on the surface is estimated as varying from 2 to 5 feet, fairly well mineralized. The property was examined by Mr. Giffard, the well known English expert, in the summer of 1889, in the interest of Messrs. Rand Bros., prior to their purchase, whose report, of course a private one, was understood to be favourable. Messrs. Rand Bros. have been actively at work since that time prospecting their property, and are at present engaged in driving a tunnel and cross-cut from McMurdo Creek, which is expected to cut the lead at a depth of 2,500 feet from the croppings along the top of the mountain. From the latest reports the tunnel was in 300 feet and the cross-cut commenced. The ore of the croppings is composed of sulphides of lead, iron and antimony, averaging about 50 oz. to the ton of silver.

British Columbia developments.

"About three miles further up McMurdo Creek from the above line of claims, near the summit of the range, a number of claims have been located, amongst the most important of which are the 'Bobby Burns' and 'Chief of the Selkirks,' the original discovery claims of the locality. Little work has been done heretofore on these. The 'Bobby Burns' contains a large vein of gold quartz, free milling on the surface. A 3-stamp mill has been purchased by the owners, and is now at Golden to work on this claim next summer. Gold is visible in some of the surface rock, and assays of 35 oz. of gold have been obtained.

"The 'Chief of the Selkirks' and adjoining claims at the summit contain galena and grey copper ores.

"Continuing south-eastward from the Carbonate Mountain claims, between Copper Creek and the South Fork of the Spillemcheen, several claims have been located on which only assessment work has been done. These are favourably reported on. On the southern slope of this divide, running down into Vermont Creek, occur the 'Dark Horse,' the 'Agnes,' and the 'Syenite Bluff.' A 6-ton sample lot of galena ore was shipped from the Dark Horse claim last summer, also a shipment from the Agnes claim. Both gave very favourable results.

"On the south side of Vermont Creek, near its junction with the South Fork, a block of claims, discovered in the summer of 1889, contain a number of veins of galena and grey copper, about ten in number, varying in width from 2 inches to 20 inches, in the slate formation. It is considered that these veins will in some cases run together. Thirty-five tons of ore were packed out on horses from these veins to the Columbia River, a distance of about 21 miles, thence by steamboat to Golden and by rail to Revelstoke, realizing, under all these difficulties, a handsome profit to the owners. The ore was pronounced to be of excellent quality at Revelstoke.

"Good prospects have been located further south, on Crystal Creek and Bugaboo Creek in the same belt. The country between this point and Horse Thief Creek has been but little prospected. In this latter locality, and on Toby Creek, very promising new discoveries were made last season and a number of claims recorded. The 'Little Fellah' claim, on Horse Thief Creek, is described by a reliable and disinterested person as a magnificent prospect. It is stated to be a well-defined lode in talc slate, about 20 feet in width. Assays from 20 to 50 per cent of copper and 20 to 100 oz. of silver have been made. Several other good copper prospects have been located on this creek.

"New discoveries, stated to be large veins, containing high grade galena, are also reported from about 20 miles up Toby Creek.

"Mineral Locations along the Columbia Valley Belt referred to in General Description" (pp. 176–179).

British Columbia developments.

"*Jubilee Mountain*—situated about 42 miles up the Columbia River from Golden, on the Canadian Pacific Railway, has mineral claims located along its ridge and western slope for a distance of over four miles. About 30 tons of copper glance and carbonates of very fine quality, averaging 55 per cent copper, were shipped from the 'Lancaster' claim, owned by John McRae, during last summer to Swansea, as a sample lot, by C. F. Law, agent for Toronto capitalists. A good body of silver-bearing galena ore has been opened up on the 'Constance' claim this winter, and development work on a large scale is looked forward to in the spring. The claims on which most development work has been done are the 'Constance,' 'Lancaster,' 'Horseshoe' and 'Alice.'

"*Spillemcheen Mountain.*—A considerable amount of work has been done on various claims on this mountain during the past few years. Messrs. Wells and Pollock have been at work this winter driving a tunnel to reach the 'Big Lead,' understood to lie at the contact between the lime quartzite and the slate, at a low depth. They have drifted altogether 260 feet up to date, and expect to cut the lead within 20 feet further. The results of other prospecting work recently done on the mountain have been very favourable; a large quantity of ore has been taken out. The claims showing most development work are the 'Spillemcheen,' 'Homestake,' 'Rothschild,' 'Tiger' and 'Eureka.'

"*Windermere Mountain*—situate about four miles north of Windermere, on the Lower Columbia Lake, has been drawing much attention during last summer. Mr. O. A. Brown, of Spokane, became interested in claims on this mountain in July last, and has been actively developing with excellent results, having exposed a large body of copper glance and carbonates. He has from 75 to 100 tons of ore on the dump at present, and expects to make some shipments in the spring. Two shafts, 40 feet and 20 feet respectively, have been sunk, and a tunnel to tap the lead in depth is contemplated. The ore consists of copper glance, carbonates and red oxides. A large number of assays have been obtained, ranging from 10 to 80 per cent in copper, and from $3 to $130 in silver, to the ton. Two principal ore bodies have been cut through, one 18 feet in width, the other 7 feet. There are fourteen claims taken up in this locality. Some of these promise to prove valuable.

"In the neighbourhood of Wild Horse Creek some development has been done on a galena ledge about three miles above the old camp. It would appear that a large quantity of concentrating ore, carrying silver, has been met with.

"Prospectors have brought in samples of ore from about 25 miles up Wild Horse Creek, which are stated to have assayed $225 in gold, silver and copper. British Columbia developments.

"The discovery of a new mineral district is reported about 11 miles in a south-easterly direction from Fort Steel. A sample from this locality assayed: gold, $96; silver, $300; and copper, 12 per cent."

From Yale district the following items are reported:—

"*Yale Creek.*—The owners of the Queen silver mine, in which extensive tunnelling and sinking has been done, still persevere at heavy outlay to develop their property, from which very rich prospects in silver have been obtained, assaying as high as $500 in silver and $140 per ton in gold.

"*Silver Peak, near Hope.*—The Eureka and Victoria Companies have not been carrying on work of late years, but I am pleased to say the company (composed of wealthy Victorians) has been remodelled in the past year, with a view to resume vigorous operations next season. Rich assays have been obtained from these mines, ranging from $100 to $800 per ton in silver.

"*Stump Lake Mines.*—This locality was fully reported upon last year. During the past twelve months, assessment work has been done on a number of claims, but I regret to say that the Nicola Milling and Mining Company have, for the present, discontinued working their mines. It is expected, however, that they will resume operations early next spring. No new discoveries of quartz have been made during the past season.

Dr. Dawson in his Summary Report to the Director of the Geological Survey for 1890, speaks of these mines thus:—

"The metalliferous deposits in the vicinity of Stump Lake referred to in the Summary Report for 1888 (p. 8) and in the Mineral Wealth of British Columbia (p. 69 B) notwithstanding the favourable conditions for their development and the high assay value of some of the ores, have not yet assumed a position of permanent importance. The Nicola Mining and Milling Company have now sunk in the 'Joshua' shaft to a depth of about 400 feet, and have done considerable drifting, for the purpose of exploration, but with this exception 'assessment work' only has been carried out on the various claims taken up in this vicinity. The general parallelism and the evident connection of the veins of this locality with the outline of the great granitic area to the west rendering it important that this should be done, the remaining part of the line of contact of this granite with the stratified rocks was traced in detail. The vicinity of this line of contact, like that of several other similar contact lines and numerous places not distinctly connected with granitic masses,

is characterized by a great abundance of vein quartz. Many specimens of such veins have been collected for the purpose of assay, the results of which it is hoped will afford some definite information as to the habitus and mode of occurrence of the gold and silver ores."

In the Similkameen sub-division very little was done in quartz mining, the owners of mineral claims having satisfied themselves with merely performing the necessary work to hold their locations.

Prices. The appended graphic table A opposite, shows the prices obtained for the metal during the year. The very considerable fluctuations were due to the legislation, actual, and proposed by the United States Government, looking to the enforced purchase by the Treasury Department of 4,500,000 ozs. of the metal each month, and the consequent operations of speculators.

Exports. The export figures of this metal as found in the books of the Customs Department, are given in Table 2 below:—

SILVER.

TABLE 2.

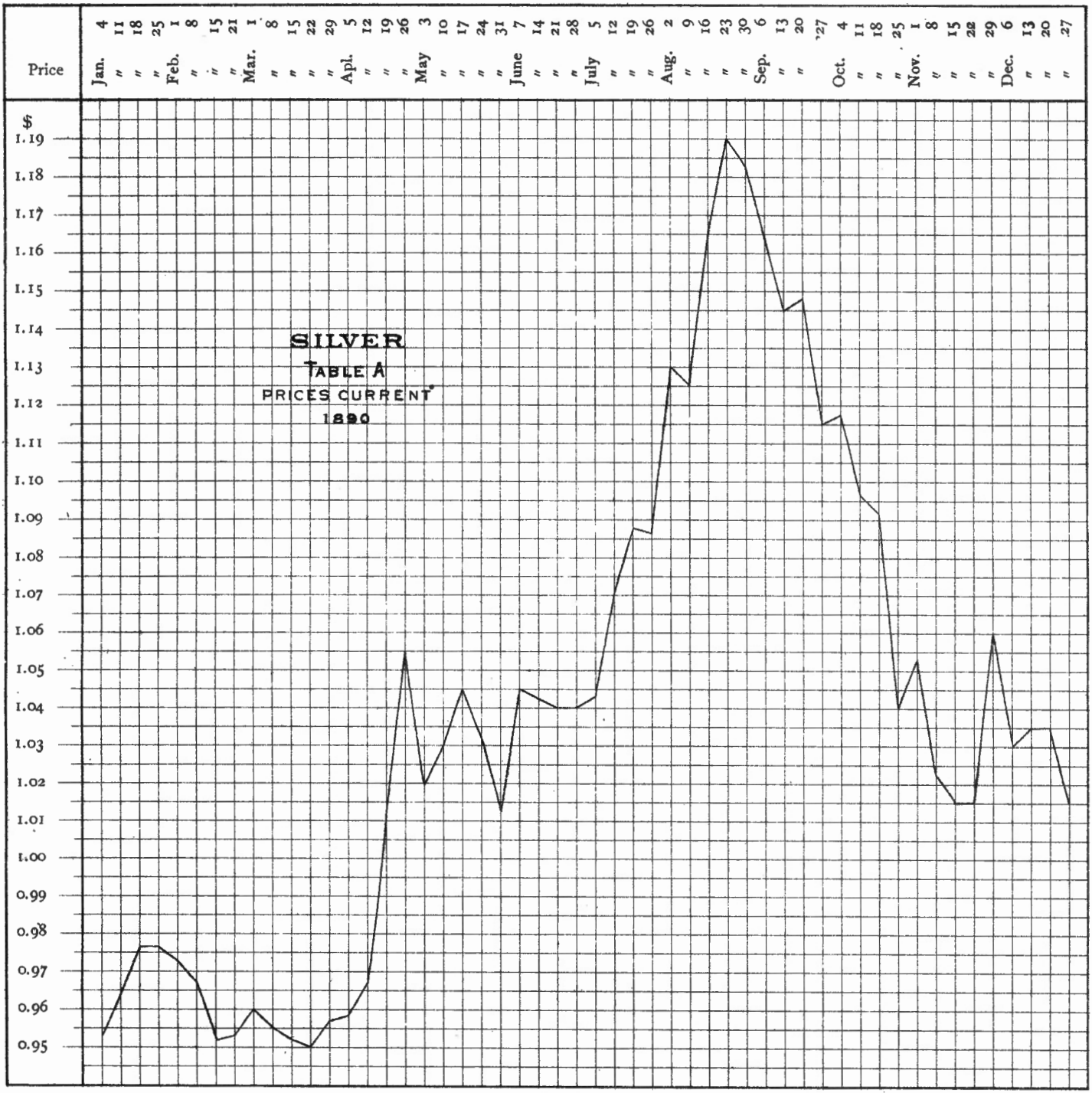
EXPORTS OF SILVER ORE.

Province.	1886.	1887.	1888.	1889.	1890.
Ontario	$16,505	$184,763	$208,064	$203,871	$203,142
Quebec	8,000	450	5	2,500	900
Nova Scotia				50	
Manitoba	1,452	3,741		5	
British Columbia		17,331	10,939	5,737	100
Totals	$25,957	$206,285	$219,008	$212,163	$204,142

STRUCTURAL MATERIALS.

Building stone. *Building stone.*—No new features were noticeable in the trade for the past year, the industry being carried on in the same lines as in years previous, with the exception, possibly, that the various varieties are now shipped to more distant points and not as before used almost altogether locally. For example, a very considerable quantity of New Brunswick sandstone now finds a market in Montreal, Toronto, Hamilton and other western cities, while stone from the quarries near Credit Forks, Peel county is delivered as far east as Montreal.

Ontario. In Ontario the production has been somewhat less than in 1889 owing to the fact that in several of the largest buildings erected during the


Price
Jan. 4 " 11 " 18 " 25
Feb. 1 " 8 " 15 " 21
Mar. 1 " 8 " 15 " 22 " 29
Apl. 5 " 12 " 19 " 26
May 3 " 10 " 17 " 24 " 31
June 7 " 14 " 21 " 28
July 5 " 12 " 19 " 26
Aug. 2 " 9 " 16 " 23 " 30
Sep. 6 " 13 " 20 " 27
Oct. 4 " 11 " 18 " 25
Nov. 1 " 8 " 15 " 22 " 29
Dec. 6 " 13 " 20 " 27
$
1.19
1.18
1.17
1.16
1.15
1.14
1.13
1.12
1.11
1.10
1.09
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
SILVER
TABLE A
PRICES CURRENT
1890

year, New Brunswick or Ohio stone has been used and also that considerable quantities of ornamental terra-cotta and pressed bricks are now used in the erection of large buildings. The points of greatest production were as in years previous in the vicinity of Caledon township, Peel county, the Niagara escarpment between Hamilton and Queenston in Wentworth and Lincoln counties, and Belleville, considerable quantities also being obtained at Owen Sound, St. Marys, Amherstburg, Elora, Kingston, Cornwall, Ottawa and Pembroke.

Quebec. In Quebec large quantities of limestone are quarried in the vicinity of Montreal and between that place and Terrebonne; at Hull, Ottawa county, and at many points on the north side of the St. Lawrence river. Sandstone is obtained in considerable quantity at Chateau Richer.

New Brunswick. In New Brunswick the most important quarry is the "French Fort Quarry" near Newcastle, Northumberland county, the other large quarries being in the south-eastern part of Westmoreland county.

Nova Scotia. In Nova Scotia a considerable quantity of stone is raised throughout Cumberland and Pictou counties, a very large proportion of which is used in the repairing of railway works and in the construction of the Chignecto Ship Railway.

The stone quarried in Prince Edward Island and the Western Provinces amounts to but little, and is almost entirely used locally.

Production. The production for the year, as returned to this office, is given in the following table, which shows an increase over similar returns for 1889 of 41,226 cubic yards and $51,092.

STRUCTURAL MATERIALS.

TABLE 1.

PRODUCTION OF BUILDING STONE.

Province.	No. of Returns	Cub. Yards.	Value.
Ontario	47	113,465	$347,252
Quebec	30	217,595	456,703
Nova Scotia	.....	37,835	92,211
New Brunswick	10	8,934	54,697
Prince Edward Island	1	140	180
Manitoba	2	2,098	5,140
North-West Territories	3	2,496	8,600
Totals	93	382,563	$964,783

As there are many small producers in Canada who cannot be reached, or who have failed to make returns, these figures are not complete, but are supposed to represent about four-fifths of the production; assuming that such be the case, there was a production during 1890 of about 480,000 cubic feet, having an approximate value of about $1,200,000.

Exports and imports.

The following tables show the exports of wrought and unwrought stone and marble, and the imports of building stone and manufactures of stone :—

STRUCTURAL MATERIALS.

TABLE 2.

EXPORTS OF STONE AND MARBLE, WROUGHT AND UNWROUGHT.

Province.	1889.		1890.	
	Wrought.	Unwrought.	Wrought.	Unwrought.
Ontario	$ 3,422	$ 271	$ 7,284	$ 6,474
Quebec	.....	391	53	1,613
Nova Scotia	2,714	1,060	252	16,821
New Brunswick	15,226	26,482	13,649	11,275
Manitoba	.....	.....	.....	9
British Columbia	12	.....	487	7,419
Totals	$21,374	$28,204	$21,725	$43,611

STRUCTURAL MATERIALS.

TABLE 3.

IMPORTS OF BUILDING STONE.

Fiscal Year.	Value.
1880	$ 35,970
1881	58.149
1882	33,623
1883	35,061
1884	51,088
1885	30,491
1886	41,675
1887	54,368
1888	86,373
1889	100,314
1890	132,155

STRUCTURAL MATERIALS.

TABLE 4.

IMPORTS OF MANUFACTURES OF STONE OR GRANITE, N. E. S.

Fiscal Year.	Value.
1880	$29,408
1881	36,877
1882	37,267
1883	45,636
1884	45,290
1885	39,867
1886	41,984
1887	41,829
1888	47,487
1889	61,341
1890	84,396

During the past year Canada afforded a market for building stone of about $1,350,000, as follows:— Canadian market.

Production	$1,200,000	
Imports of building stone	132,155	
Imports of stone and granite	84,396	
		$1,416,551
LESS—Exports, wrought stone	$ 21,725	
Exports, unwrought stone	43,611	
		65,336
		$1,351,215

The production of building stone for the past four years, according to direct returns, and supposed to represent approximately the same proportion to the total output as do the figures for 1890, is as follows:—

1886—165,777 cubic yards	$642,509
1887—262,592 do	552,267
1888—411,570 do	641,712
1889—341,337 do	913,691

Marble.—The production for 1890 amounts to 780 tons, valued at $10,776, and is altogether from Ontario. The output for the past four years has been as follows:— Marble production.

1886—501 tons, valued at	$9,900
1887—242 do	6,224
1888—191 do	3,100
1889— 83 do	980

Notwithstanding the many extensive deposits throughout Canada, more particularly in the pre-Cambrian areas of the Eastern Townships of

Quebec and the Laurentian areas of Hastings, Frontenac and other counties in Ontario, no work to any extent was performed, with the exception of that necessary to extract the above small amount, which was produced at Arnprior and Renfrew, Ont.

During the year operations were begun on a band of Huronian limestone, affording a handsome banded marble, near the Garden River Settlement, about ten miles east of Sault Ste. Marie. Only development work was done and no shipments were made.

Imports.

The following table shows the imports of marble, all sorts, since 1880; there were no exports reported as such :—

STRUCTURAL MATERIALS.

TABLE 5.

IMPORTS OF MARBLE.

Fiscal Year.	Value.
1880	$ 63,015
1881	85,977
1882	109,505
1883	128,520
1884	108,771
1885	102,835
1886	117,752
1887	104,250
1888	94,681
1889	118,421
1890	99,353

Granite production.

Granite.—The production of granite during 1890 amounted to 13,307 tons, valued at $65,985 at the quarry. This shows an increase in quantity over the previous year of 2,152 tons, while the value has decreased to the extent of $13,639.

The following figures show the production for the past four years:—

1886—6,062 tons, valued at..... $ 63,309
1887—21,217 do 142,506
1888—21,352 do 147,305
1889—10,197 do 79,624

Of the production for 1890, the following subdivision may be made to show the production of provinces :—

Nova Scotia, 2,000 tons. ..... $ 9,200
New Brunswick, 5,195 do 33,224
Quebec, 2,870 do 14,200
Ontario, 3,242 do 9,361

It will be seen on reference to the above that the granite raised in Ontario is quoted at less than $3 per ton; subtracting the amount credited to that province the remainder has a value of about $5.60 per ton. This value, although less than that of 1889, is believed to represent more closely the net price *at the quarry*.

Slate.—The production of this material for 1890 is altogether that of the province of Quebec, no slate being quarried elsewhere in the Dominion. Slate

The area from which this production is reported lies in the three townships of Melbourne, Cleveland and Shipton in Richmond county, Quebec, wherein the more important slate bands are found. To the south of Richmond, the production consisted almost altogether of roofing slates, mantels and slabs for sinks, billiard tables, &c., while to the north of that place large quantities of school slates are annually produced, though during 1890 a considerable proportion of the production of that district was in the form of roofing slate.

The following data are furnished by the new Rockland Slate Company, giving the results of tests of their product, and will illustrate the qualities of the slate of this district:—

Analysis made by B. J. Harrington, B. A. Ph. D., Professor of Chemistry, Mineralogy, &c., McGill University.

Silica	65·39
Alumina	15·97
Ferrous oxide	4·66
Manganous oxide	0·39
Lime	0·67
Magnesia	2·99
Potash	3·60
Soda	3·33
Loss by ignition	3·26
	100·26
Specific gravity	2·75

Tests

Made at the Testing Laboratory of the Bridge Company, Lachine, P.Q., on an Emery Testing Machine:

1*st Test. Crushing.*—Strain perpendicular to lamination.

A 2″ cube failed at 108,570 lbs. = 26,574 lbs. per square inch.

2*nd Test. Crushing.*—Strain perpendicular to lamination.

A 2″ cube failed at 129,880 lbs. = 32,069 lbs. per square inch.

3*rd Test. Crushing.*—Strain parallel to lamination, but perpendicular to grain, *i.e.*, edgewise.

A 2″ cube *was not crushed* at 151,000 lbs. = 36,531 lbs. per square inch.

4*th Test. Breaking.*—Strain perpendicular to lamination.

A piece of slate 3′ long 4″ wide and 1″ thick on bearers 30″ apart, failed by splitting at 950 lbs. Modulus of rupture 10,000.

A beam 12″ long 1″ square, supported at both ends and loaded in in the centre, fails at 556 lbs.

5*th Test. Breaking.*—Strain perpendicular to lamination.

A piece of slate 3′ long 4″ wide and 1″ thick, on bearers 30″ apart, failed by splitting at 1,092 lbs. Modulus of rupture 11,667.

A beam 12″ long 1″ square, supported at both ends and loaded in the centre, fails at 558 lbs.

Production.

Deflection with pressure at 690 lbs. was $\frac{7}{10}$ of 1″

The amount produced during the year was 6,368 tons, having a net value of $100,250, showing a decrease from 1889 of 567 tons and $18,910. The production for the past four years is as follows:—

1886—5,345 tons	$ 64,675
1887—7,357 do	89,000
1888—5,314 do	90,689
1889—6,935 do	119,160

Exports and imports.

As may be seen on reference to the following table the market is almost entirely a domestic one, small quantities only being exported:—

STRUCTURAL MATERIALS.

TABLE 6.

EXPORTS OF SLATE.

Year.	Tons.	Value.
1884	539	$6,845
1885	346	5,274
1886	34	495
1887	27	373
1888	22	475
1889	26	3,303
1890	12	153

The following table shows the imports during the past eleven years :—

STRUCTURAL MATERIALS.

TABLE 7.

IMPORTS OF SLATE.

Fiscal Year.	Value.
1880	$21,431
1881	22,184
1882	24,543
1883	24,968
1884	28,816
1885	28,169
1886	27,852
1887	27,845
1888	23,151
1889	41,370
1890	22,871

Flagstones.—The production of flagstones during 1890 was altogether that of Dudswell and Brompton townships in Wolfe and Richmond counties, Quebec, from the various quarries of which a small quantity of a superior quality of stone is shipped for flagging. Returns were not received of any stone produced in Ontario for this purpose, though it is believed that considerable quantities of limestone were sawn to dimension for flagging. Flagstones.

The use of flagtones has been lessened of late years by the introduction of "granolithic" and other artificial pavements, which are being laid in many cities at a much less cost than flagging, and apparently meeting all the requirements of natural stone, so that the market has not increased as much as might be expected.

The production for 1890 was 17,865 square feet, valued at $1,643, which shows when compared with the year previous an increase of 3,865 square feet and $243. The production during the past four years was :— Production

1886—	70,000 (?) feet	$ 7,895
1887—	116,000 do	11,600
1888—	64,800 do	6,580
1889—	14,000 do	1,400

Imports.

The imports are given in the following table ; no export of flagstones, as such, are reported :—

STRUCTURAL MATERIALS.

TABLE 8.

IMPORTS OF FLAGSTONES.

Fiscal Year.	Tons.	Value.
1881	23	$ 241
1882	90	848
1883	10	99
1884	137	1,158
1885	205	1,756
1886	1,602	9,443
1887	1,316	10,966
1888	2,642	21,077
1889	1,669	15,451
1890	5,665	48,995

Cement.

Cement.—There were during 1890 seven makers producing natural cement, as follows :—

T. A. Gauvreau & Co..... Quebec, Que.
C. B. Wright & Co.....Hull do
Napanee Cement Works Co.....Napanee Mills, Ont.
Jas. Marshall .....Rymal do
Toronto Lime Co.....Limehouse do
John Battle .....Thorold do
Isaac Usher & Sons..... do do

These makers all produce a *natural* cement made from rock obtained in the immediate vicinity of their works. One company, The Imperial Portland Cement Co. (Ltd.), produce Portland cement only, and have their works at Pointe Claire, near Montreal, Another company, The English Portland Cement Co. (Ltd.), had under construction an extensive plant for the manufacture of Portland cement at Marlbank, Ontario, where they will during 1891 commence producing on a large scale, marl obtained in the neighbourhood entering largely into the manufacture.

Method of manufacture.

The method employed in the manufacture of *natural* cement is simple, and consists in the calcination of the raw stone or so-called "cement rock," after which it is ground by means of ordinary buhrstones. Before grinding, however, it is generally necessary that it should be broken into comparatively small lumps, which is accomplished by means of an ordinary cracker or crusher. The rock that produces a good natural cement consists essentially of an impure limestone or rather a carbonate of lime and magnesia with a definite proportion of silicate of alumina or clay and it is upon the amount of silica the rock contains that the quality of the finished product depends.

The quantity of cement produced during 1890 was, according to returns received at this office, 102,216 brls., valued at $92,405, showing an increase over that reported for 1889 of 11,742 brls. and $22,615. The production for the past three years was as follows:— Production.

1887—69,843 brls.....$81,909
1888—50,668 do 35,593
1889—90,474 do 69,790

The greater part of this production finds a market in Canada, as may be seen on reference to the table of exports of lime and cement, wherein the amount of cement is known to be inconsiderable. The increase in production since 1888 is understood to be on account of the wider use of granolithic pavements and roadways. Imports.

The imports of cement are given in the following tables:—

STRUCTURAL MATERIALS.

TABLE 9.

IMPORTS OF CEMENT IN BULK OR BAGS.

Fiscal Year.	Bushels.	Value.
1880	65	$ 28
1881	579	298
1882	386	86
1883	1,759	548
1884	4,626	1,236
1885	4,598	1,315
1886	6,808	1,851
1887	5,421	1,419
1888	23,919	5,787
1889	32,818	10,668
1890	21,055	5,443

STRUCTURAL MATERIALS.

TABLE NO. 10.

IMPORTS OF HYDRAULIC CEMENT.

Fiscal Year.	Barrels.	Value.
1880	10,034	$ 10,306
1881	7,812	7,821
1882	11,945	13,410
1883	11,659	13,755
1884	8,606	9,514
1885	5,613	5,396
1886	6,164	6,028
1887	6,160	8,784
1888	5,636	7,522
1889	5,835	7,467
1890	5,440	9,048

Portland cement.

STRUCTURAL MATERIALS.

TABLE 11.

IMPORTS OF PORTLAND CEMENT.

Fiscal Year.	Barrels.	Value.
1880	.....	$ 55,774
1881.....	.. ....	45,646
1882..... ..	....	66,579
1883	. ...	102,537
1884..	. . ....	102,857
1885.....	....	111,521
1886.....	.....	120,398
1887...	102,750	148,054
1888	122,402	177,158
1889	122,273	179,406
1890..... ...	192,322	313,572

Assuming that the imports for the fiscal year represent those for the calendar year, there was, during 1890, a market for cement in Canada amounting to over $400,000.

Roofing cement.

Roofing Cement.—There was during the year a production of cement for roofing purposes of 1,171 tons, valued at $6,502. This is altogether the result of the manufacture of certain refractory minerals mined in Ontario.

Lime.

Lime.—Although the quantity produced is less than that made in 1889 there is a marked increase in total value, attributable almost entirely to the province of Ontario, where the prices ruled higher than during the year previous. In New Brunswick there is an apparent falling off in production of about 19 per cent, due no doubt to the introduction of the McKinley Bill, as the greater part of the production of that province finds a market in Boston and the New England states where it commands a good price on account of its superior quality.

There is nothing worthy of mention regarding the industry during 1890, the production as previously being that of works scattered throughout the various provinces and territories.

Production.

The amount produced during the year was, according to returns made to this office, 2,501,079 bushels, valued at $412,308, a decrease in quantity compared with 1889 of 447,170 bushels, whereas there is shown to be an increase in value of $49,460.

The production by provinces, as well as the totals for the past four years, are given below:—

STRUCTURAL MATERIALS.

TABLE 12.

PRODUCTION OF LIME.

Province.	No. of Returns	Bushels.	Value.
Ontario	60	1,234,975	$ 185,602
Quebec	15	116,593	23,274
Nova Scotia	.....	217,944	44,565
New Brunswick	11	814,662	136,586
Prince Edward Island	3	17,355	3,581
Manitoba	3	69,550	10,700
British Columbia	1	30,000	8,000
Totals	93	2,501,079	$ 412,308

STRUCTURAL MATERIALS.

TABLE 13.

ANNUAL PRODUCTION OF LIME.

Year.	No. of Returns	Bushels.	Value.
1886	87	1,535,950	$ 283,755
1887	133	2,269,087	394,859
1888	93	2,216,764	339,951
1889	106	2,948,249	362,848

Full data cannot of course be obtained, though all the principal makers have made returns, and it is supposed that the production shown above is equivalent to about four-fifths of the total amount, the returns not received being principally those of farmers and small local producers.

In the following tables may be found the exports of lime and cement and imports of lime:— Exports and imports.

STRUCTURAL MATERIALS.

TABLE 14.

EXPORTS OF LIME AND CEMENT.

Province.	1887.	1888.	1889.	1890.
Ontario	$4,269	$12,262	$12,877	$17,341
Quebec	83	398	71	.....
Nova Scotia	142	278	11,017	17,137
New Brunswick	77,518	97,318	135,222	130,180
Prince Edward Island	4	....	2	5
Manitoba	241	.....	.....	.....
British Columbia	4	.....	2,060	4,141
Totals	$82,261	$110,256	$161,249	$168,804

STRUCTURAL MATERIALS.

TABLE 15.

IMPORTS OF LIME.

Fiscal Year.	Barrels.	Value.
1880	6,100	$6,013
1881	5,796	4,177
1882	5,064	5,365
1883	7,623	9,224
1884	10,804	11,200
1885	12,072	11,503
1886	11,021	9,347
1887	10,835	8,524
1888	10,142	7,537
1889	13,079	9,363
1890	8,149	5,360

Bricks.

Bricks.—There is very little to report in this industry during 1890, the production and distribution of operators being about the same as in past years. A feature worthy of mention is the fact that there are much larger quantities of pressed and fancy bricks made than heretofore, such works as those in the vicinity of Milton, Ont., and Ormstown, Que., turning out large quantities of fancy and more particularly pressed fancy bricks.

Production.

The production according to returns received at this office amounted during 1890 to 211,727 thousands, valued at $1,266,982. These returns are not considered complete, but are supposed to represent about four-fifths of the total, thus making the actual production about 260,000 thousand. The production by provinces is as follows:—

STRUCTURAL MATERIALS.

TABLE 16.

PRODUCTION OF BRICKS DURING 1890.

Province.	No. of Returns.	Thousands.	Value.
Ontario	221	138,491	$807,389
Quebec	27	44,331	238,572
Nova Scotia	.....	8,400	55,360
New Brunswick	10	9,335	68,885
Prince Edward Island	5	1,150	8,775
Manitoba	2	1,200	10,800
North-West Territories	3	900	10,000
British Columbia	9	7,920	67,201
Totals	277	211,727	$1,266,982

The total production per annum for the previous four years as returned to this office is as follows:—

1886—139,345	thousand,	valued at	$ 873,600
1887—181,581	do	do	986,689
1888—165,818	do	do	1,036,746
1889—200,561	do	do	1,273,884

These figures may be taken as are those for 1890, as representing about four-fifths of the total output.

A small quantity of bricks were exported during the year, principally from Ontario, as may be seen on reference to the following figures:— Exports and imports.

Ontario	715 M	$3,449
Nova Scotia	19 M	156
Prince Edward Island	15 M	157
Total	749 M	$3,762

Of the imports (table 17) a great proportion is of fancy bricks imported into Ontario from Ohio, Pennsylvania and New Jersey. That the amount is small is attributed to the fact that the market for them is largely supplied by domestic manufacturers:—

STRUCTURAL MATERIALS.

TABLE 17.

IMPORTS OF BUILDING BRICK.

Fiscal Year.	Value.
1880	$ 2,067
1881	4,281
1882	24,572
1883	14,234
1884	20,258
1885	14,632
1886	5,929
1887	2,440
1888	20,720
1889	24,585
1890	12,500

Terra-Cotta.—The terra-cotta industry, although comparatively new in Canada, has sprung into a state of no insignificance, the production for the year 1890 amounting to about $90,000. Terra-Cotta.

The producers operating during the year were:—

The Hynes Terra-cotta and Brick Company, Toronto, Ont.

The Ontario Terra-cotta Brick and Sewer Company, Toronto, Ont.

The Toronto Pressed Brick and Terra-cotta Company, Toronto, Ont.

The Rathbun Company, Deseronto, Ont.

The Ormstown Brick and Terra-cotta Company, Ormstown, Que.

The works of the Hyne's Terra-cotta and Brick Company are in Toronto. Those of the Toronto and Ontario Companies between Milton and Campbellville, Ont., while the two last company's works are at Deseronto, Ont., and Ormstown, Que., respectively. Besides producing a considerable quantity of pressed fancy bricks, these companies (with the exception of the Rathbun Company) produce large quantities of ornamental terra-cotta work, such as tiles, panels, string courses, roofing and ridge tiles, finials, chimney pots and garden vases and pedestals. Clay, eminently suitable for the manufacture of terra-cotta, occurs in many parts of the Dominion, though more especially in the Province of Ontario. Throughout the area underlain by the Medina and Clinton formations, this is particularly so, as the shales of these formations on decomposing, afford a good clay, containing a sufficient amount of iron oxide for colouring. The more important localities are of course those at present being operated, viz.:—Streetsville, Campbellville, Milton and Napanee Mills. Other localities are Freeman and Hamilton, in Wentworth county, and Limehouse, in Halton county.

Porous terra cotta.

At Deseronto the Rathbun Company are making a terra-cotta suitable for the fire-proofing of buildings. This material is made from a mixture of clay and sawdust in about equal proportions, when on firing in kilns the sawdust is burnt out, leaving a vesicular product known to the trade as "porous terra-cotta."

An experiment was made in the presence of the writer, where, in a small building 6x6x10 feet, built of 1-inch lumber and lined with 1½ inch terra-cotta furring, about one quarter of a cord of slabs and edgings, thoroughly saturated with kerosene, was ignited and allowed to burn for half an hour. Notwithstanding the intense heat in the interior, the sides and ends of the building were practically cool, while the roof (a flat one) was only warm. The fire was, at the end of half an hour, extinguished quickly with water, after which the walls were intact and had apparently suffered no injury. This company also manufacture porous terra-cotta in shapes suitable for the protection of wooden and iron beams and joists, as well as for arches for flooring, which have the advantage that, besides their fire-proof qualities, they add very materially to the strength of the flooring.

Test made at Toronto.

The following extract from the Toronto *Globe* of the 20th of May, 1890, gives an account of a test made at the Board of Trade building at that time in course of construction in Toronto :—

"An interesting test was made at the new Board of Trade buildings yesterday and is still in progress. The Rathbun Company, of Dese-

ronto, manufacturers of terra-cotta fire proof flooring, made a test in the presence of Mr. E. A. Kent, Buffalo, architect of the building; Mr. W. Phillips, superintendent of the works; Mr. Wills, secretary; Mr. J. I. Davidson, president of the Board of Trade; and Mr. E. D. Morris, representing the Rathbun Company. An arch which was thought to be defective was selected for the test. The arch, composed only of terra-cotta fire proof, is held between iron beams. A slab of iron about a foot square was placed in the centre of the arch, the span being 4 feet x 3 feet. Over 5,000 lbs. of iron was piled on the piece of iron. More iron was piled on the arch in the afternoon, so as to ascertain the breaking weight of the arch. It finally broke under a pressure of 6,981 pounds, or 5,800 pounds to the square foot."

In commenting on this account of the test the Rathbun Company make the following remarks:—

"The test was made on the level floor of arch (no concrete) and commenced at 11 a.m. when 5,800 lbs. was placed on the arch; the weight was left in position until 4:15 in the afternoon when 1,181 lbs. were added, making in all 6,981 lbs., the last 116 lbs. causing the breakage.

"This test proves that the arch withstood 6,865 lbs. on 1 foot by 1 foot 2 inches superficial area, or 5,721 lbs. to the square foot, the material being 8 inches thick in hollow blocks forming a flat arch."

No statistics regarding terra-cotta are available beyond those of production already given, nor is it possible to give figures of production for previous years.

Drain Tiles.—The manufacture of ordinary drain tiles is carried on at many of the brick yards throughout the Dominion, though there are many yards which produce tiles alone. The state of the industry is very similar to that of the year previous, no new features having been developed. Drain tiles

According to returns made direct to this office, and supposed to represent about two-thirds of the total output, the production for the year 1890 was 10,521 thousands, valued at $140,877, which, compared with 1889, shows a decrease in quantity of 5 thousands and an increase in value of $6,612. The production by provinces is shown as follows:— Production.

STRUCTURAL MATERIALS.

TABLE 18.

PRODUCTION OF TILES DURING 1890.

Province.	No. of Returns.	Thousands.	Value.
Ontario	84	10,372	$138,647
Quebec	1	35	525
Nova Scotia		11	160
New Brunswick	2	103	1,545
Totals	87	10,521	$140,877

Returns of the production of tiles have been published by this office for the past four years, as follows :—

1886	12,416 M	valued at	$142,617
1887	14,658 M	do	230,068
1888	7,518 M	do	114,057
1889	10,526 M	do	134,265

The imports are included with those of sewer pipes in table 19. No exports are reported.

Sewer pipes.

Sewer Pipes.—During 1890 there were produced $348,000 worth of sewer pipes, which were made altogether from domestic clay and salt glazed. Statistics of imports only are available, and it is presumed that there were no exports. The following table shows the imports of sewer pipes and drain tiles :—

Imports.

STRUCTURAL MATERIALS.

TABLE 19.

IMPORTS OF DRAIN TILES AND SEWER PIPES.

Fiscal Year.	Value.
1880	$ 33,796
1881	37,368
1882	70,065
1883	70,699
1884	71,755
1885	69,589
1886	57,953
1887	71,203
1888	101,257
1889	83,215
1890	77,434

Pottery.—Returns were received from 21 producers of pottery, aggregating $195,242. This amount is supposed to represent about four-fifths of the total output, as returns were not received from several operators known to have been producing during the year. The articles principally manufactured are flower pots, chimney pots, jars, crocks and all varieties of Rockingham and cane ware and earthenware. As may be seen on reference to the following table the production is largely that of the province of Quebec, where the larger and more important potteries are situated. Pottery.

Ontario	$ 76,242
Quebec	106,500
Nova Scotia	5,000
Prince Edward Island	3,000
Manitoba	4,500

The following table shows the imports during the past eleven years, of which the greater part is made up of stoneware demijohns and jugs, Rockingham and other heavy stoneware:— Earthenware imports.

STRUCTURAL MATERIALS.

TABLE 20.

IMPORTS OF EARTHENWARE.

Fiscal Year.	Value.
1880	$322,333
1881	439,029
1882	646,734
1883	657,886
1884	544,586
1885	511,853
1886	599,269
1887	750,691
1888	697,082
1889	697,949
1890	695,206

Sands and Gravels.—No returns of production of sands and gravels have been received nor asked for, as it would be impossible to arrive, even approximately, at the amount produced. The following table, however, represents the amounts exported during the past two years by provinces:— Sands and gravels.

STRUCTURAL MATERIALS.

TABLE 21.

EXPORTS OF SAND AND GRAVEL.

Province.	1889.		1890.	
	Tons.	Value.	Tons.	Value.
Ontario	282,774	$51,830	341,656	$64,398
Nova Scotia	172	690	170	750
New Brunswick	80	80	210	290
Manitoba			122	80
British Columbia	18	47		
Totals	283,044	$52,647	342,158	$65,518

The exports for the past fourteen years are as follows :—

STRUCTURAL MATERIALS.

TABLE 22.

EXPORTS OF SAND AND GRAVEL.

Year.	Tons.	Value.	Year.	Tons.	Value.
1877	11,998	$ 2,151	1884	73,741	$19,978
1878	50,140	8,381	1885	110,661	22,878
1879	46,999	9,438	1886	124,865	24,226
1880	53,951	11,177	1887	180,860	30,307
1881	58,693	15,129	1888	260,929	38,398
1882	60,158	16,218	1889	283,044	52,647
1883	55,346	14,065	1890	342,158	65,518

INDEX.

	PAGE
Abrasive materials	9
Amber	14
Antimony	16
Apatite	153
Arsenic	17
Asbestus	19
Baryta	105
Blacklead	75
Bricks	194
Buhrstones	11
Building stone	182
Cement	190
" Portland	192
" Roofing	192
Chalk	114
Coal	31
"Coal oil"	143
Coke	50
Copper	51
Drain tiles	197
Emery	10
Exports, table of	7
" " destination of	8
Felspar	111
Flagstones	189
Fossil resin	14
Gas, natural	117
Glass and glassware	111
Gold	54
Granite	186
Graphite	72
Grindstones	11
Hones	14
Imports, table of	8
Iron ore	81
Iron and steel manufactures	88
Land plaster	79
Lead	90
Letter of Transmittal	3
Lime	192
Litharge	107
Manganese	92
Marble	185
Mercury	114
Mica	101
Mineral pigments	105
" water	108
Miscellaneous	111
Moulding sand	112
Natural gas	117
Nickel	121
Notes	2
Ochres	106
Paraffine wax	153
Peat	50
Petroleum	143
Phosphate	153
Phosphatic shale	161
Pig, iron	87
Pigments, mineral	105
Plaster, land	79
" of Paris	79
Platinum	112
Plumbago	76
Portland cement	192
Pottery	199
Production of minerals, summary of	6
Pumice	10
Pyrites	161
Quicksilver	114
Roofing cement	192
Salt	162
Sand, moulding	112
Sands and gravels	199
Sewer pipe	198
Shale, phosphatic	161
Silver	167
Slate	187
Soapstone	113
Spelter	116
Steel manufactures, iron and	88
Stone, building	182
Structural materials	182
Sulphur	161
Summary of mineral production	6
Table of exports	7
" " destination of	8
" imports	8
Terra-cotta	195
Tiles, drain	197
Tin	115
Tripoli	9
Water, mineral	108
Wax, paraffine	153
Whetstones	14
Whiting	113
Zinc	115

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

DIVISION OF

MINERAL STATISTICS AND MINES

ANNUAL REPORT

FOR

1891

ELFRIC DREW INGALL
Associate of the Royal School of Mines, England,
Mining Engineer to the Geological Survey of Canada
In charge

H. P. H. BRUMELL, F.G.S.A.
Assistant to the Division

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1893

NOTE

Except for the figures of imports, which refer to the fiscal year, beginning 1st July, the year used throughout this report is the calendar year, and the ton, that of 2,000 pounds, unless otherwise stated.

The figures given throughout the report referring to exports and imports are compiled from data obtained from the books of the Customs Department, and will occasionally show discrepancies, which, however, there are no means of correcting.

The exports and imports, under the heading of each province, do not necessarily represent the production and consumption of the province, *e. g.*, material produced in Ontario is often shipped from Montreal and entered there for export, so falling under the heading, Quebec.

The values of the metallic minerals produced, as per returns to this Department, are calculated on the basis of their metallic contents at the average market price of the metal for 1891. Spot values have been adopted for the figures of production of the non-metallic minerals.

N.E.S.= Not elsewhere specified.

To Dr. A. R. C. SELWYN, C.M.G., F.R.S., &c.,
Director and Deputy Head,
Geological Survey Department.

SIR,—I beg herewith to hand you the report of this Division on Mining and Mineral Production throughout the Dominion during 1891.

As in past years, it will be found to represent as complete a review of the mineral activities of the country and of their commercial results as it is possible to obtain with the means at command. These include the personal investigations of the officers of the Division, supplemented by the issue of circulars asking the production direct from the operators themselves, as well as information selected from official provincial reports and various other sources.

The labour of collecting, comparing and collating this very varied material so as to ensure accurate results and secure a complete and uniform presentment of them is very great, but it is hoped that the result will prove satisfactory.

As in the past, care is still taken to avoid injury to private interests in the manner of publishing results. The confidence of the mining community thus gained has resulted in an increasingly hearty response to our circulars, although, to complete our data, personal application is yet necessitated with a small number of people.

My own absence on sick leave and other exceptional causes explain the unusual delay in the presentation of this report, which it is hoped will not recur, whilst a yet more prompt response on the part of all applied to will help still further towards an earlier publication of the material.

Apart from the preparation of the annual report, the other functions of the Division have been performed as heretofore.

Numerous inquiries have been received and answered respecting the mining and mineral resources of the country, often involving considerable research to give the details asked for.

The preliminary summary of the mineral production in 1891, was issued the end of April, 1892, a revision of which will be found in the folder following p. 4 ss.

The reproduction herewith of the revised general summary statements for past years in tabular form speaks for itself.

During the summer season the field-work of the officers of the Division was as follows :—The writer was engaged in the study of a number of points in the phosphate districts of Ottawa county, Que., relating to the nature and mode of occurrence of the deposits of that mineral, begun in previous years. This investigation was incomplete when the new duties of my present office were undertaken. Mr. Brumell visited the various mining districts throughout New Brunswick and Ontario to collect information regarding the results of discovery and development work there. Mr. Jas. White continued the mining surveys in the phosphate, mica and iron district traversed by the Kingston and Pembroke Railway.

It is desired to gratefully acknowledge the aid received from various sources. Thanks are due to those who, although too numerous to specify here, have, by answering our circulars or letters, provided much valuable material for the compilation of this report. Thanks are also due for aid received from the field officers of the Survey in making inquiries for us. Special mention must be made of the services rendered by my colleague, Mr. H. P. Brumell, assistant to the division, for his very important and efficient aid in every branch of the work. He has further contributed a separate report on Natural Gas and Petroleum (vol. V., part Q.) which will be a valuable addition to our knowledge of these mineral resources in Canada.

Our acknowledgments are also due the Provincial Departments of Mines of Nova Scotia and British Columbia and to the Dominion Customs Department for aid received.

I have the honour to be, sir,

Your obedient servant,

ELFRIC DREW INGALL.

Division of Mineral Statistics and Mines,

4th May, 1893.

Mineral Products of Canada, Calendar Years 1886 to 1891.

PRODUCTS.	1886.		1887.		1888.		1889.		1890.		1891.		PRODUCT.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
METALLIC.													
Copper, (c) lbs.	3,505,000	$ 354,000	3,260,424	$ 342,345	5,562,864	$ 667,543	6,809,752	$885,424	6,013,671	$902,050	8,928,921	$1,160,760	Copper.
Gold, (d) ozs.	76,879	1,330,442	66,270	1,178,637	61,310	1,098,610	72,328	1,295,159	64,046	1,149,776	51,303	930,614	Gold.
Iron Ore (a) tons.	69,708	126,982	76,330	146,197	78,587	152,068	84,181	151,640	76,511	155,380	68,979	142,005	Iron Ore.
Iron Ore, Chromic (a) "	60	945	38	570	.....	.....	.....	.....	.....	.....	.....	.....	Iron Ore, Chromic
Lead (e) lbs.	.....	.....	204,800	9,216	674,500	27,472	165,100	6,604	113,000	5,085	588,665	25.607	Lead.
Nickel (f) "	.....	.....	.....	.....	.....	.....	.....	.....	1,435,742	933,232	4,626,627	2,775,976	Nickel.
Platinum ozs.	.....	.....	1,400	5,600	1,500	6,000	1,000	3,500	.....	4,500	.....	10,000	Platinum.
Silver ozs.	.....	209,090	.....	349,330	.....	395,377	383,318	343,848	400,687	420,662	414,523	406,233	Silver.
Total value, Metallic	.....	$2,021,459	.....	$2,031,895	.....	$2,347,070	.....	$2,686,175	.....	$3,570,685	.....	$5,451,195	
NON-METALLIC.		(a)		(a)		(a)		(a)		(a)		(a)	
Antimony ore tons.	665	$31,490	584	$10,860	345	$3,696	55	$ 1,100	26	$ 625	10	$ 60	Antimony ore.
Arsenic "	120	5,460	30	1,200	30	1,200	.....	.....	25	1,500	20	1,000	Arsenic.
Asbestus "	3,458	206,251	4,619	226,976	4,404	255,007	6,113	426,554	9,860	1,260,240	9,279	999,878	Asbestus.
Coal "	2,091,976	5,017,225	2,368,891	4,758,590	2,658,134	5,259,832	2 719,478	5,584,182	3,117,661	6,496,110	3,623,076	8,144,247	Coal.
Coke, (g) "	35,396	101,940	40,428	135,951	45,373	134,181	54,539	155,043	56,450	166,298	57,084	175,592	Coke.
Felspar "	.....	.....	.....	.....	.....	.....	.....	.....	700	3,500	685	3,425	Felspar.
Fire Clay "	.....	(b)	.....	(b)	.....	(b)	400	4,800	.....	(b)	250	750	Fire Clay.
Graphite "	500	4,000	300	2,400	150	1,200	242	3,160	175	5,200	260	1,560	Graphite.
Grindstones "	4,020	46,545	5,292	64,008	5,764	51,129	3,404	30,363	4,884	42,340	4,479	42,587	Grindstones.
Gypsum "	166,000	202,742	154,008	157,277	175,887	179,393	213,273	205,108	226,509	194,033	203,605	206,251	Gypsum.
Limestone (flux) "	.....	(b)	17,171	17,500	16,857	16,533	22,122	21,909	18,478	18,361	11,376	11,547	Limestone (flux).
Manganese ore "	1,789	41,499	1,245	43,658	1,801	47,944	1,455	32,737	1,328	32,550	255	6,694	Manganese ore.
Mica lbs.	20,361	29,008	22,083	29,816	29,025	30,207	36,529	28,718	770,959	68,074	.....	71,510	Mica.
Mineral Pigments.													
Baryta Tons.	3,864	19,270	400	2,400	397	7,900	.....	.....	1,842	7,543	.....	.....	Baryta.
Ochres "	350	2,350	485	3,733	1,100	3,850	794	15,280	275	5,125	900	17,750	Ochres.
Mineral Water galls.	.....	(b)	.....	(b)	124,850	11,456	424,600	37,360	561,165	66,031	427,485	54,268	Mineral Water.
Molybdenite lbs.	150	156	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Molybdenite.
Moulding sand tons.	.....	(b)	160	800	169	845	170	.....	320	1,410	230	1,000	Moulding sand.
Petroleum (h) bbls.	486,441	437,797	763,933	595,868	733,564	755,571	639,991	.....	765,029	902,734	755,298	1,004,546	Petroleum.
Phosphate tons.	20,495	304,338	23,690	319,815	22,485	242,28	30,988	316,662	31,753	361,045	23,588	241,603	Phosphate.
Precious stones	.....	.....	.....	.....	.....	.....	.....	.....	.....	700	.....	1,000	Precious Stones.
Pyrites tons.	42,906	193,077	38,043	171,194	63,479	285,6	72,225	307,292	49,227	123,068	67,731	203,193	Pyrites.
Quartz "	.....	.....	.....	.....	.....	.....	.....	.....	200	1,000	.....	.....	Quartz.
Salt "	62,359	227,195	60,173	166,394	59,070	185,460	32,832	129,547	43,754	198,897	45,021	161,179	Salt.
Soapstone "	50	400	100	800	140	280	195	1,170	917	1,239	.....	.....	Soapstone.
Structural Materials.													
Bricks m.	139,345	873,600	181,581	986,689	165,818	1,036,746	200,561	1,273,884	211,727	1,266,982	176,533	1,061,536	Bricks.
Building stone c. yds.	165,777	642,509	262,592	552,267	411,570	641,712	341,337	913,691	382,563	964,783	187,685	708,736	Building stone.
Cement bbls.	.....	(b)	69,843	81,909	50,668	35,593	90,474	69,790	102,216	92,405	93,473	108,561	Cement.
Flagstones sq. ft.	70,000	7,875	116,000	11,600	64,800	6,580	14,000	1,400	17,865	1,643	27,300	2,721	Flagstones.
Granite tons.	6,062	63,309	21,217	142,506	21,352	147,305	10,197	79,624	13,307	65,985	13,637	70,056	Granite.
Lime bush.	1,535,950	283,755	2,269,087	394,859	2,216,764	339,951	2,948,249	362,848	2,501,079	412,308	1,829,894	251,215	Lime.
Marble tons.	501	9,900	242	6,224	191	3,100	83	980	780	10,776	240	1,752	Marble.
Miscellaneous clay products (i)	.....	112,910	.....	182,150	.....	.....	.....	239,385	.....	.....	.....	.....	Misc. clay products.
Pottery	.....	(j)	.....	(j)	.....	27,750	.....	(j)	.....	195,242	.....	258,844	Pottery.
Roofing cement tons.	.....	(b)	.....	(b)	.....	(b)	.....	(b)	1,171	6,502	1,020	4,810	Roofing Cement.
Sands and Gravels (k) "	124,865	24,226	180,860	30,307	260,929	38,398	283,044	52,647	342,158	65,518	243,724	59,501	Sands and Gravels.
Sewer pipe	.....	(j)	.....	(j)	.....	266,320	.....	(j)	.....	348,000	.....	227,300	Sewer Pipe.
Slate tons.	5,345	64,675	7,357	89,000	5,314	90,689	6,935	119,160	6,368	100,250	.....	(l)	Slate.
Terra cotta	.....	(j)	.....	(j)	.....	49,800	.....	(j)	.....	90,000	.....	113,103	Terra Cotta.
Tiles m.	12,416	142,617	14,658	230,068	7,518	114,057	10,526	134,265	10,521	140,877	11,839	141,399	Tiles.
Whiting bbls.	400	600	400	600	30	240	.....	.....	500	500	.....	.....	Whiting.
Total value, non-metallic	.....	$9,096,719	.....	$9,417,419	.....	$10,271,866	.....	$11,162,110	.....	$13,719,394	.....	$14,359,174	
" metallic	.....	2,021,459	.....	2,031,895	.....	2,347,070	.....	2,686,175	.....	3,570,685	.....	5,451,195	
Estimated value of products unspecified or not reported (m)	.....	881,822	.....	800,686	.....	881,064	.....	651,715	.....	709,921	.....	689,631	
Grand Total	.....	$12,000,000	.....	$12,250,000	.....	$13,500,000	.....	$14,500,000	.....	$18,000,000	.....	$20,500,000	

(a)—Value at mine, quarry or works.
(b)—Not reported.
(c)—Copper contents of ore, matte, etc., at the average market price for the year.
(d)—Nova Scotia gold at $19.50 per oz., British Columbia at $17.00.
(e)—Lead contents of ore, matte, etc., at average market price for year.
(f)—Nickel " " " "
(g)—Oven coke, the production of Nova Scotia.
(h)—Calculated from official inspection return and computed at average yearly price per barrel of 35 imp. gallons.
(i)—Includes (for the years given) terra-cotta, pottery, sewer-pipe and earthenware.
(j)—Included in miscellaneous clay products.
(k)—Exports only.
(l)—Confidential returns, cannot be quoted.
(m)—Mostly structural materials.

NOTE.—The above figures represent the summary statements incorporated in the annually issued reports of the Division, those for back years being revised to make the method of statement conform with that adopted for recent years.

EXPORTS. Exports.

MINERALS AND MINERAL PRODUCTS MINED OR MANUFACTURED IN CANADA DURING 1891.

Product.	Value.	Product.	Value.
Asbestus, first class	$ 338,072	Oil, refined	$ 104
" second class	209,833	Ore, antimony	60
" third class	13,636	" iron	11,573
Bricks	1,163	" lead	5,000
Cement	2,881	" manganese	6,694
Clay, manufactures of	158	" silver	225,312
Coal	3,393,773	Phosphate	384,661
Copper	348,109	Plumbago, crude	72
Gold	344,692	" manufactured	163
Grindstones	28,433	Salt	1,277
Gypsum, crude	181,795	Sand and gravel	59,501
" ground	588	Slate	195
Iron and steel, about	300,000	Stone, unwrought	46,162
Lime	119,853	" wrought	13,398
Mica, crude and cut	35,252	Other articles	12,194
" ground	2,338		
Nickel	667,280	Total	$6,772,693
Oil, crude	18,471		

EXPORTS

OF PRODUCTS OF THE MINE, WITH DESTINATIONS, DURING FISCAL YEAR 1891.

Exported to.	Value.	Exported to.	Value.
United States	$4,600.800	Spanish West Indies	$ 11,454
Great Britain	851,794	Hong Kong	9,640
Newfoundland	141,692	Australia	8,418
Sandwich Islands	49,064	British Guiana	5,114
France	31,217	Japan	4,664
Germany	22,774	China	150
Mexico	16,188		
British West Indies	16,023	Total	$5,784,143
St. Pierre	15,151		

Imports.

IMPORTS.

MINERALS AND MINERAL PRODUCTS FOR FISCAL YEAR 1891.

Product.	Value.	Product.	Value.
Alum and aluminous cake..	$ 22,411	Iron and steel	$ 10,354,073
Antimony	17,483	Lead and manufactures of.	315,146
Arsenic	4,027	Lime	4,273
Asbestus and mfrs. of	13,298	Litharge	27,613
Ashes, pot, pearl and soda.	2,757	Lithographic stone	5,724
Asphaltum	50,728	Manganese, oxide of	3,743
Borax	22,602	Marble	107,661
Brass and manufactures of.	603,078	Mercury	20,223
Bricks	9,744	Mineral water	41,797
" bath	2,299	Nickel	62
" and tiles, fire	116,390	Ochres	20,550
Buhrstones	2,089	Paraffine wax	52,391
Building stone	170,890	Petroleum and mfrs. of	513,966
Cement	9,061	Plaster of Paris	8,412
" Portland	304,648	Platinum	4,055
Chalk	8,193	Potash salts	10,185
Clay, china	24,429	Precious stones	77,988
" fire	24,878	Salt	380,550
" all other, N.E.S.	6,827	Sand and gravel	23,620
Coal, anthracite	5,224,452	Silex	1,929
" bituminous	4,060,896	Slate	46,104
" dust, &c	36,130	Soda salts	402,332
" tar and pitch	35,721	Stone and granite, N.E.S.	61,051
Coke	179,539	Spelter	31,459
Copper and mfrs. of	573,974	Sulphate of copper	43,614
Copperas	6,310	Sulphur	46,351
Earthenware	634,907	Sulphuric acid	2,466
Emery and pumice	19,875	Tiles, sewer pipes, &c	87,195
Fertilizers	45,375	Tin and manufactures of	1,206,918
Flagstones	36,348	Whiting	27,504
Fuller's earth	4,511	Yellow metal	125,605
Glass and glassware	1,247,692	Zinc and manufactures of	112,201
Graphite and mfrs. of	41,710		
Grindstones	16,991	Total	27,747,879
Gypsum	855		

ABRASIVE MATERIALS.

ABRASIVE MATERIALS.

There is nothing new to add to what was said in last year's report on this subject. The only production coming under this head of which any figures are available is that mentioned as under, relating to grindstones.

Grindstones.

Grindstones.—The total production of this commodity for the year was as follows:—

New Brunswick	2,499 tons,	valued at	$22,787
Nova Scotia	1,980	"	19,800
	4,479		$42,587

From New Brunswick returns are received direct from the producers, whilst the only figures furnished by the Provincial Department of Mines for Nova Scotia are those of exports.

As shown by the following figures the extent of this industry has remained practically constant for several years past:—

1886—4,000 tons,	valued at	$46,545
1887—5,292	"	64,008
1888—5,764	"	51,129
1889—3,404	"	30,863
1890—4,884	"	42,340
1891—4,479	"	42,587

As in former years, a number of operators with quarries situated in New Brunswick and Nova Scotia have contributed to the total production, those of the former province being chiefly situated in Westmoreland, Northumberland and Gloucester counties, and in the latter in Pictou and Cumberland counties.

Referring to his visit to the quarries at Rockport, N.B., during the course of his summer's field work Mr. Brumell furnishes the following notes:—

"Along the shores of Cumberland Basin at many places between Cape Maringouin and Wood Point large quantities of grindstones are made. The stone, which is gray in colour and very free from 'mud spots' or 'bulls,' is obtained under tide-water and floated into the shallower parts where it is 'scabbled' and shipped principally to Boston and points in the New England States. Only large stones are shipped, the average weight being about two tons."

Tripoli.

Tripoli.—Although deposits of infusorial earth of greater or less extent are plentiful in the bottoms of many lakes in Nova Scotia and New Brunswick there are no available records of production. It is known, however, that if any has been produced during the year the amount must be insignificant.

Pumice, Emery, Buhrstone.

Pumice, Emery, Buhrstone.—None of these materials have been mined in Canada during the year.

The subjoined tables of exports and imports of abrasive materials explain themselves.

ABRASIVE MATERIALS.

Exports and Imports.

ABRASIVE MATERIALS.

TABLE 1.

EXPORTS OF GRINDSTONES.

Year.	Value.
1884	$28,186
1885	22,606
1886	24,185
1887	28,769
1888	28,176
1889	29,982
1890	18,564
1891	28,433

ABRASIVE MATERIALS.

TABLE 2.

EXPORTS OF GRINDSTONES.

Provinces.	1889.	1890.	1891.
Ontario			
Quebec	$ 1,387	$ 12	
Nova Scotia	7,150	8,536	$12,387
New Brunswick	21,437	10,016	16,046
Manitoba	8		
Totals	$29,982	$18,564	28,433

ABRASIVE MATERIALS.

TABLE 3.

IMPORTS OF GRINDSTONES.

Fiscal Year.	Tons.	Value.
1880	1,044	$11,714
1881	1,359	16,895
1882	2,098	30,654
1883	2,108	31,456
1884	2,074	30,471
1885	1,148	16,065
1886	964	12,803
1887	1,309	14,815
1888	1,721	18,263
1889	2,116	25,564
1890	1,567	20,569
1891	1,381	16,991

ABRASIVE MATERIALS.

ABRASIVE MATERIALS.

TABLE 4.

IMPORTS OF "SILEX."*

Imports.

Fiscal Year.	Cwts.	Value.
1880	5,252	$2,290
1881	3,251	1,659
1882	3,283	1,678
1883	3,543	2,058
1884	3,259	1,709
1885	3,527	1,443
1886	2,520	1,313
1887	14,533	5,073
1888	4,808	2,385
1889	5,130	1,211
1890	1,768	2,617
1891	3,674	1,929

* The material thus classified by the Customs Department as "Silex" probably represents tripoli or manufactures of the same.

ABRASIVE MATERIALS.

TABLE 5.

IMPORTS OF PUMICE STONE AND EMERY.

Fiscal Year.	Value.
1880	$ 7,854
1881	11,179
1882	15,762
1883	17,823
1884	16,518
1885	14,450
1886	14,458
1887	15,617
1888	18,564
1889	16,888
1890	19,925
1891	19,875

ABRASIVE MATERIALS.

Imports.

ABRASIVE MATERIALS.

TABLE 6.

IMPORTS OF BUHRSTONES.

Fiscal Year.	Value.
1880	$12,049
1881	6,637
1882	15,143
1883	13,242
1884	5,365
1885	4,517
1886	4,062
1887	3,545
1888	4,753
1889	5,465
1890	2,506
1891	2,089

ANTIMONY.

ANTIMONY.

Production.

Small as has been the production of the ores of this metal in Canada of late years, the amount reported for this year is still less, viz., 10 tons, valued at $60.

The production since 1887 is as follows:—

1887	584	tons, valued at	$10,860
1888	345	"	3,696
1889	55	"	1,100
1890	26½	"	625
1891	10	"	60

This is all the production of the province of Nova Scotia, the Department of Mines of which province furnishes the above data, but gives no further information, neither was it found possible for a visit to be made to the vicinity by any of our own officers.

The following table, No. 1, gives the exports of antimony ore:—

Exports.

ANTIMONY.

TABLE 1.

EXPORTS.

Year.	Tons.	Value.	Year.	Tons.	Value.
1880	40	$ 1,948	1886	665	$ 31,490
1881	34	3,308	1887	229	9,720
1882	323	11,673	1888	352½	6,894
1883	165	4,200	1989	30	695
1884	483	17,875	1890	38	1,000
1885	758	36,250	1891	3½	60

The figures of imports as given in Table No. 2 will represent Canada's consumption of the metal, as no ores are imported. ANTIMONY.

ANTIMONY.

TABLE 2.

IMPORTS. Imports.

Fiscal Year.	Pounds.	Value.
1880	42,247	$ 5,903
1881		7,060
1882	183,597	15,044
1883	105,346	10,355
1884	445,600	15,564
1885	82,012	8,182
1886	89,787	6,951
1887	87,827	7,122
1888	120,125	12,242
1889	119,034	11,206
1890	117,066	17,439
1891	114,084	17,483

ARSENIC. ARSENIC.

In regard to this mineral product there is nothing different to report. The already small record of past years was slightly lowered again in 1891, to which year we can only credit 20 tons, valued at $1,000. These amounts as compared with former years are as follows:— Production.

1885	*440	tons, valued at	$17,600	spot.
1886	120	" "	5,460	do
1887	30	" "	1,200	do
1888	30	" "	1,200	do
1889	Nil	" "	Nil	do
1890	25	" "	1,500	do
1891	20	" "	1,000	do

As in previous years, the arsenious oxide above mentioned is manufactured by resubliming the crude arsenious oxide found in the condensation chambers of the mines which were working in 1885 on the arsenical gold ores of Deloro in the Madoc region of Ontario. Small quantities of this crude material, resulting from the roasting of these ores, have been refined from year to year to meet a limited demand. This work employed three men for two months.

* Imports into United States from the Deloro mine, according to Report on the Mineral Resources of the United States, 1885.

ARSENIC.

ARSENIC.

TABLE 1.

Imports.

IMPORTS.

Fiscal Year.	Pounds.	Value.
1880	18,197	$ 576
1881	31,417	1,070
1882	138,920	3,962
1883	51,953	1,812
1884	19,337	773
1885	49,080	1,566
1886	30,181	961
1887	32,436	1,116
1888	27,510	1,016
1889	69,269	2,434
1890	138,509	4,474
1891	115,248	4,027

ASBESTUS.

ASBESTUS.*

Production.

During 1891 the production of asbestus fell off considerably as compared with the output of the year previous, that for 1891 being only 9,279 tons, valued at $999,878, against 9,860 tons, valued at $1,260,240, which was the quantity extracted in 1890. For past years reference must be made to the accompanying graphic table, wherein may be traced the growth of the industry from 1880, when but 380 tons were produced.

Of the total amount shipped from the mines the greater part was exported, largely to the United States, small quantities only going to the various European markets.

By the kind permission of the author, we have incorporated the following exhaustive paper, read on the 14th June, 1892, before the General Mining Association of Quebec by Mr. L. A. Klein, manager of the American Asbestus Co. at Black Lake, Que. :—

Present condition, etc., of the industry.

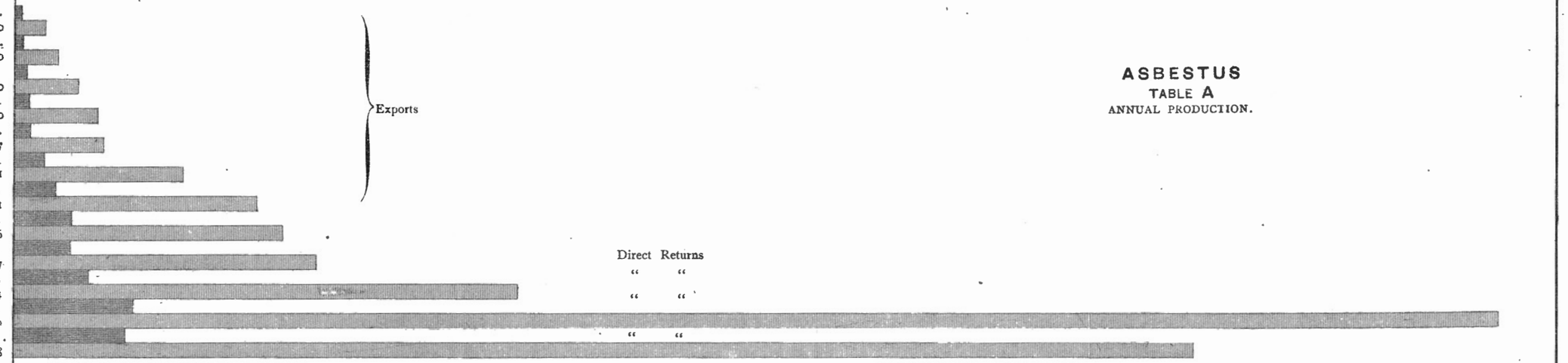
THE CANADIAN ASBESTUS INDUSTRY.

By L. A. Klein, M.E., Black Lake, Que.

"The asbestus industry of Canada has assumed a rank which makes it well worth while to study how to further develop the same, and many have turned their eyes towards our province and its serpentine regions: Governments, capitalists, mining men, speculators, prospec-

*See Foot note p. 14 ss.

Year.	Tons.	Value.
1880	380	$24,700
1881	540	35,100
1882	810	52,650
1883	955	68,750
1884	1,141	75,097
1885	2,440	142,441
1886	3,458	206,251
1887	4,619	226,976
1888	4,404	255,007
1889	6,113	426,554
1890	9,860	1,260,240
1891	9,279	999,878



ASBESTUS

TABLE A

ANNUAL PRODUCTION.

tors, and so on—all have contributed in their own way to this purpose. ASBESTUS.

"Many things have been said and written on asbestus, asbestus formation, asbestus industry, asbestus uses and markets, and it is certainly not the lack of talk on the subject which has induced me to take it up for this paper. I have been led to do so in consideration of the facts that by former writers on the subject a good many practical points have not been touched—points which must be of special interest to those who are about to interest themselves in the industry, be it with money, be it with actual work—but also in consideration of the fact that amongst those not intimately connected with the industry, opinions of an altogether erroneous nature as to the value and character of the industry are spread about, which may occasionally lead to a very inconvenient disappointment. There are even a good many things amongst us mining men out here on which the difference of opinion has not as yet reached a settlement, as it is naturally with an industry in such a young state as ours. Present condition, etc., of the industry.

"I have tried to get the co-operation of all my fellow miners in the industry to make my statements as complete as possible, and I tender my heartiest thanks to those who have complied with my request. I must, however, add that the opinions expressed in this paper are individual, and under no other authority than that of my own observations and my own judgment.

"I had still another object in delivering this paper, and that is to show the asbestus industry in Canada from a national and economic point of view, or, in other words, to look at it as a whole, and a resource for our province and the Dominion of Canada respectively.

"You have to-day looked over the asbestus mines in Thetford and Black Lake, and, while the time was very limited and no chance whatever could be given to follow up a special line of the business in which we are engaged, you have, however, had an opportunity to see in general the mode of occurrence and production of asbestus. While you have done so you have seen the area which, I may safely say, produces about 85 per cent of all the asbestus used in the world.

"Serpentine covers quite a large area in Canada, and especially in the eastern townships of Quebec. It is not my object to-day to describe its extent, which has been done in an exhaustive way as well by members of the Geological Survey as by the authorities of our Provincial Government, but I will confine myself to those districts which have as yet received prominency and which practically supply the demand of the world. These are in the districts of Thetford and Black Lake, with some more or less encouraging developments to the Mode of occurrence.

ASBESTUS. Mode of occurrence.

north and south; the district of Danville, with, so far, one prominent mine in the production of asbestus; and the Templeton district, in which, however, the industry has not yet assumed more than an exploratory character.

"If you compare these very limited areas, representing the region of the big serpentine belt which produces asbestus in a quantity and quality which will, economically worked, yield a profit to the investor, with the comparatively enormous extent of serpentine rock, you will readily come to the conclusion that it takes more than the finding of the serpentine to have a paying asbestus mine, and that is one point I would like to pick out and submit to your consideration.

"While the undoubted success of some of the existing mines, in combination with erroneous ideas on the formation, occurrence and of production and so on, nursed by speculators, lead many to believe that they struck a fortune when a locality was shown to them which contained serpentine of a very good or just the right colour, with occasionally a small asbestus seam in it; and while many have been induced to spend a considerable amount of money under these false impressions, I may state that not one enterprise has proved successful in this industry which has not had anything else to look on than serpentine of a good colour. All those successful mines had as surface indications asbestus in good and large veins of real commercial value, and I do not hesitate to say in some cases larger veins than they can get to-day. We may be able to declare a locality worthless as an asbestus mine, judging from colour and sections of serpentine, but I am certain that neither I, nor any of my confrères who have devoted some of their time to the study of the subject, would commit ourselves in recommending a locality as an asbestus mine from the good look of the serpentine, without having seen besides really valuable and marketable asbestus veins in sufficient quantity, and this notwithstanding the expression of one of our scientific authorities that the rock likely to prove asbestus-producing can be determined by certain peculiarities of texture, colour or weathering.

Characteristics.

"I will not take up your time with a detailed description of the mineral, but merely make a very few general remarks.

"Asbestus is a fibrous variety of serpentine,* and is, chemically speaking, a hydrous silicate of magnesia. From several analyses of a number of specimens all over the world, which I had at my disposal, the percentage of silica is from a little over 40 to 40½ per cent, while

* Whilst the term "asbestus" now includes commercially the fibrous variety of serpentine, chrysotile, which is the mineral mined in Quebec if applied primarily and still applies mineralogically only to the fibrous varieties of hornblende.

magnesia is from 41½ to 43 per cent; other more prominent admixtures were ferrous-oxide and alumina in quantities of from one to three per cent, and further, traces of lime, potash, soda, chlorine and sulphuric acid. This composition is completed by water, to which we have to attach the most importance from a business point of view. This, of course is not water in the form of a moisture, but water intimately" (chemically) "associated with the silicate of magnesia. The importance of this water has been shown by the fact that good and fine asbestus fibre, may it be from the Italian variety, or from the Cambrian rocks of the EasternTownships, or the Laurentians from the north of the St. Lawrence, contains from 13½ to 14 per cent of this water, while some very harsh and brittle specimens of asbestus have shown considerably below 12 per cent. Experiments have further shown that it is comparatively easy to dissociate a part of this water from a fine and silky specimen of asbestus fibre and to render the same hard and brittle by heating it to a certain extent. This peculiarity leaves us to conclude why we find such considerable differences in the qualities of asbestus in comparatively close proximity, as, for instance, the larger percentage of "thirds" in Black Lake than in Thetford; and then even at the best mines, qualities of no, or very little, commercial value. The asbestus in these localities has been rendered harder by the influence of heat through the intrusion of heated matter, following the original formation of it, and this heated matter has been the masses of granulite which we find throughout our serpentine region, with the exception of a small knoll of serpentine in Thetford, where granulite appears only in very small dykes. And here is another point where I differ from some of our fraternity who hold that the presence of these masses of granulite are a good indication of asbestus—a theory which I think can scarcely be maintained, at least, however, as to asbestus of commercial value, in the close neighbourhood of these masses of granulite. ASBESTUS. Characteristics.

"Thirteen incorporated companies with an authorized capital of about three and one-half million dollars, of which a part, however, is employed in the manufacturing business in England, with a number of very prominent private concerns, occupy themselves to-day with the production of asbestus and asbestus mining, and I believe that my estimate that about two and one-quarter millions of dollars are invested in the industry in Canada comes very close to the reality. Companies working.

"While until about four or five years ago, with one single exception, hand work, occasionally connected with horse power hoisting, was exclusively used in asbestus mining, the leading mines are now equipped with more or less extensive plants of machinery to carry on the work. Mining.

ASBESTUS. Mining.

"This work consists,

"Firstly—Of the proper mining operations, such as the drilling, blasting, removing of the broken rock out of the pits to the dumps, hand in hand with the gathering up of the asbestus veins and transport of same to the dressing establishments or cobbing sheds.

"Secondly—The dressing or cobbing, that is, the separating of the asbestus fibre from the adhering rock and the grading of the former in different qualities, followed by packing, transport to railroad, loading, shipping and marketing. It may not be unwise to review these different operations shortly, as the circumstances under which asbestus is produced are entirely different from nearly any other mineral or ore, and we find nearly every item which we were used to consider as a thoroughly established rule greatly changed by these circumstances.

"This is readier understood when we consider the large amount of rock which has to be handled in comparison to the ore, the peculiar nature of this rock, the character of the ore, which is a fine silky fibre, and must be carefully protected from injury, and so on.

"As to the drilling, hand drilling is still in exercise in all the newly opened mines for prospecting work, and even in one or the other of these mines which have already reached considerable prominency. It is further nearly exclusively used for block-holing—only very recently one of the mines has introduced a small size machine drill for the purpose. It is done by three men with 1 inch octagon steel, and 6 to 7 pound hammers. The average capacity is about 15 to 16 feet a day of 10 hours, and the cost about 20 cents per foot. The depth of holes is thus seldom exceeding 4 feet. Some of the mines have not long ago adopted a plan of block-holing with one man only, using a three-quarter inch steel, and 3 to 4 pounds short-handled hammer. The capacity is thus about 8 feet for 10 hours' work and the cost only about 14 cents.

"Most of the mines do their drilling, however, with steam or compressed air, 45 feet per day of 10 hours in the former case, and from 50 to 55 feet in the latter being considered a fair day's work. The expense per foot may be set, considering the present prices for fuel, at from 7 to 8 cents per foot, not including wear and tear on machinery and interest for capital involved in the buying of the necessary machinery. There are in all 7 compressors with a total of 44 drills capacity in use, four of them being built by the Rand Drill Company, two by the Ingersoll Rock Drill Company, and one by the Norwalk people. At present also, 44 steam" (machine) "drills are employed in the industry, of which, however, 11 are run by steam. About one-half of all drills in use are Rand's Little Giant No. 3, 3 Rand sluggers, 5 Ingersoll 3-inch, and 12 Sergeant's—a couple or so being

of other manufacture. The steel in use is $1\frac{1}{4}$ octagon and costs in the neighbourhood of 10 cents a pound. As a rule the drills are worked under 80 pounds pressure to square inch. We may consider an expense of $3\frac{1}{2}$ cents to the ton of broken rock as the average cost at present. ASBESTUS. Mining.

"The blasting is now generally done with dualin, which contains 35 per cent of nitro-glycerine, of which the cost is at present 20 cents per pound, but which prices will be very likely further reduced through the competition of a newly erected powder factory in the district. With all of the larger mines the blasting is done by electricity; still there are some which hold to the system of one hole blasts, claiming that by this system less of the asbestus veins are smashed to small particles and scattered all over the place, therefore involving more expense to pick them up. The expense for explosives is about 3 cents to the ton of rock broken.

"The next operation is the removing of the broken rock from the pits to the dumps with which the picking up of all the asbestus veins goes hand in hand. If the bottom of the pits are on the same level with the top of the dumps, the operation is simply to load the refuse rock on trucks, stone-boards, wheelbarrows, etc., and bring it by one or the other of these means to the dumps; where this is not the case, as in most of the more extensively worked mines, where pits vary in depth from about 30 to 150 feet, the rock has to be hoisted up by means of derricks. At the disposal of this industry there are at this time about 75 derricks, of which, in two cases hand, and in twelve or thirteen cases horse-power is applied as motor, the rest being steam derricks. Hand and horse derricks have of course only a right to exist where there is a comparatively small amount of rock to be handled and where the works are of a more or less exploring character only, and the first expenses of putting in steam plant seems unadvisable. The steam derricks are to be distinguished in two classes, boom and cable derricks; from the latter class only two being so far in use. Boom derricks consist of a mast held by means of guys in a vertical position and turnable on its own axle, while to the foot of the mast a boom or arm is attached and suspended in a more or less horizontal position by means of ropes stretching from end of mast to end of boom. The length of the latter is generally from 40 to 50 feet, and it is clear that the working space of such a boom is limited by its length and can, economically, hardly be extended to more than say 50 feet.

"The cable derricks have a mast somewhat similar to the former, but instead of a boom, a cable with a traveller on it, which cable is stretched from top of mast to some point across the pit, allowing by

ASBESTUS. Mining.

means of the traveller, to hoist from any point of the cable. As this may be stretched to a length of 400 and more feet the enormous advantage over boom derricks seems clear, and I have no doubt that its general introduction is only a question of time. The ropes used for hoisting are $\frac{5}{8}$ to $\frac{3}{4}$ in. crucible cast steel, the guy ropes generally $\frac{7}{8}$ of an inch; the cables $1\frac{1}{2}$ or 2 in. steel ropes.

"There are 18 double and 24 single drum hoistings and winding engines employed in the industry, or a total of 60 drums. The so hoisted refuse rock is placed on lorries and wheeled out on the dumps either by hand, or, where the dumps are somewhat long, by horses, and there discharged. In some of the mines, to a great advantage, self-dumping cars of a very simple construction are being used. While now nearly all the larger mines use iron or steel rails, and lately, specially of the lighter sort (19 lbs. Canadian make, at a price of $40 per ton delivered) there are still some wooden rails with band iron top in use, which practice, however, with the growth of the industry, will have to be soon abandoned.

"The transport of the crude asbestus to the dressing or cobbing sheds is in most cases done by the simple means of a cart and a horse, or where sheds of a more or less provisional character are placed right on the edge of the pits, carried in by hand. Where the cobbing is more concentrated in a special and permanent establishment we find rail connection for the purpose. Two of the mines, however, have a more or less systematic handling of the stuff in this state—consisting of iron self-dumping skips, which are loaded directly from the pits, hence they proceed down an inclined railroad and discharge their loads directly in the cobbing establishment. The skips are brought back by means of winding engines. The cost of the above-described operations, viz., removing of refuse rock, hoisting, picking of asbestus and its transport to sheds, are of course somewhat influenced by the size of the veins in the respective bed rock, the heights and accessibility of the pit's face, lengths of dumps, and so on, but may with fair certainty be set at 22 cents per ton of rock handled in summer time, which figures unfortunately increase in winter time, in some cases to 35 cents, and may be accepted with 25 cents for all year round work.

Dressing.

"The second part of the operation at the asbestus mine is the dressing, or commonly called cobbing, which comprises the freeing of the asbestus veins from rock as much as possible (the crude asbestus in the market still contains from 15 to 40 per cent of rock, some manufacturers even claim more than that while they are negotiating new contracts), and the grading in two, three or four different grades. This operation is as a rule done by hand by little boys, with the aid of

a hammer weighing about 1½ lbs. Some of the mines, however, have partially or entirely adopted the aid of machinery, and this more particularly for the transformation of the so-called cobbing stones—*i.e.*, larger pieces of rock with a more or less valuable asbestus vein in it, a vein, however, which did not give away from the blast, and which requires the breaking away of the adhering rock by means of powerful blows (sledge hammers), or compression (crushers). The first to try and solve the problem was the Scottish Canadian Asbestus Co. Unfortunately the development of the process sustained a sudden interruption by the closing of the mines in the autumn of 1888. Their plant consists of a 50 horse-power engine, Blake rock breaker, travelling picking tables, set of Cornish rolls, revolving screens, elevators, shakers, two large blowers, and so forth. Next the American Asbestus Co. started in to experiment in the winter of 1890–91. The main object then was to do away with the somewhat indistinguishable grade of No. 2, an object, however, which was difficult to reach, unless the fibre could have been thoroughly loosened and freed from stone. Their plant consisted in the main of a Blake crusher, to which the crude asbestus is conveyed by an inclined railway, and automatically dumped in front of the crusher. The jaws of the crusher are set at 1½ inches, the crushed stuff drops on an inclined sieve in shaking motion, which separates all the loose fibre and the dust from the larger pieces of rock and asbestus veins, the former going directly to the cleaning or grading machines, the latter dropping on a revolving picking table, where the barren rock is removed by hand to one side of the table, the asbestus veins being left on the other. At the end of the table is a receiving chute which is divided into two compartments, and into which rock and asbestus are discharged respectively. The rock drops from the chute directly into a lorry and is wheeled to the dumps, while the asbestus is conveyed either to the dry kilns, as necessary in winter time or rainy weather, or to the fine crushers for further manipulation. These latter are of unique construction, of which the object is to allow particles of a certain size and loosened fibre to go through, without being further crushed, as thereby the asbestus fibre is likely to be injured. This so reduced stuff is brought to the cleaning and grading machines, consisting mainly of a set of inclined sieves in rapid shaking motion in connection with blowers, fans, etc.—remaining unbroken stone and unloosened fibre going back to a set of still finer crushers to undergo the process again. The plant at King Bros.' mines in Thetford, which was principally erected for the extraction of asbestus out of large pieces of rocks on the old dumps works—which some years ago did not warrant the expenses for block-holing

ASBESTUS. Dressing.

ASBESTUS. Dressing.

and further handling—consists of a Blake crusher, from which the stuff is conveyed on a set of Cornish rolls with the intention of having all stone reduced to powder—from there to a revolving screen of which the object was to screen out all the dust and leave the clean fibre. This object, however, has not been fully realized, owing to the failure of the rolls to break up the rocks entirely, and an additional blowing and screening plant has been put in, which produces now a very clean product of one grade. The Anglo-Canadian also runs a crusher and a set of sieves, and the Johnson's Co. has recently put in a couple of crushers to overwork the old dumps. None of the processes at their present state, however, may as yet be considered complete, the main difficulties being two :—

"1. That, if asbestus is crushed with a considerable amount of stone together until the latter is reduced to powder—the long and most valuable asbestus fibre is partially destroyed.

"2. If the stone is not entirely reduced before grading it is nearly impossible to free the fibre from the stone, and a large amount of waste is the result.

"Besides, development of this part of the industry has to stand other very trying circumstances, as the objections of a good many of the manufacturers to buy prepared fibre; the trouble with the customs, which is rather inclined to classify the so prepared asbestus as manufactured, and to levy a duty of 25 per cent value on same, and the considerable amount of low grade waste which is found very hard to dispose of.

"The cost of cobbing varies, of course, considerably, according to the quality of material. While some stuff will break from the stone very easy, other requires considerable labour; then larger veins will sooner be gathered than small ones, and while some stuff occasionally may be contracted at $3 per ton (this, however, never includes the manipulation of cobbing stones), others may cost as high as $15 or $18 and more dollars per ton. I believe that, including the breaking of the cobbing stones, $7 is the average cost of cobbing of asbestus for a ton at the leading mines of this section.

"The stuff, after being graded, which is, however, in the entire discretion of every particular mine, (prices of some No. 2 and No. 3 last year differed about 400 per cent), is put in bags of 100 pounds each. Cost of bags are from 5 to 6 cents each, cost of bagging, 20 to 25 cents per ton. The cost for transport to cars and loading on this section, vary from 10 to 60 cents a ton, according to distance from railroad.

"To complete this part of my statement I may add that in this industry there are 40 boilers with a capacity of 1,825 horse power, and about 2,000 men employed, The value of plant, that is, machinery, buildings for stores and dwelling purposes, water reservoirs, roads, etc., is estimated at $355,000. ASBESTUS.

"If I try to give now, in the following, an idea about the cost of asbestus mining, it must be understood that it cannot be applied to any individual mine. The cost of every one will naturally depend in first line upon the quality of the ground the mine is on, and upon how near the respective mine comes to the average with regard to purchase price, invested capital or plant, expenses of management, and s on. As to the quality of ground, I have, therefore, chosen to calculate the expenses on the ton of rock, and the cost of asbestus production will depend upon how many tons of rock, in a certain mine, have to be removed in order to produce one ton of asbestus. On this subject the opinions of the asbestus miners are considerably different, and while some claim to mine only on 50 or so tons of rock to the ton of asbestus, others go as high as 150. I am of the opinion that, as a rule, the quantity of rock mined to the ton of asbestus, is greatly underestimated. Basing, on the capacity and actual work of our machinery appliances, the known quantity of lorry loads removed from a mine during a year, and the known average weight of each load, in relation to the total of asbestus produced, I hold that 1 ton of asbestus to 100 tons of rock is a fair average. If we accept this, the cost of production of asbestus may be set down as follows: drilling, 3½ cents; blasting, 3 cents; labour for removing rock and gathering asbestus in the pits, 25 cents, making a total of 31½ cents to the ton of rock, or $31.50 to the ton of asbestus; $7 for cobbing; $1.50 for bags and bagging; 50 cents for loading; $5.50 for supplies that includes fuel, tools, iron, steel, timber, other materials and repairs; $6 for general business expenses, such as management, insurance, offices, marketing and others; $3.75, 10 per cent wear and tear, calculated on a total of $355,000 in plant and 9,000 tons production, making a total of $55.75 to produce one ton of asbestus. If we calculate now that we have to pay interest on a total invested capital of about two and one-quarter millions of dollars, for which at least 10 per cent must be expected, we have in our sales to average a price of at least $80 per ton of asbestus. Relating to the totals of production for the last eleven years, the figures at my disposal show for 1891 an output of nearly 9,000 tons, with a value of about $1,000,000, thereby ranking third or fourth as far as value of mineral production in the Dominion of Canada goes, being exceeded only by the coal production, valued at about seven and three-quarter Cost of mining, etc.

ASBESTUS.

million dollars, and on about even terms with copper, petroleum and brick.

Growth of industry.

The output of asbestus in 1880 (eleven years ago) has been about 380 tons, amounting to $24,700. Since then the industry has steadily increased, with the only exception of 188-, and has reached in 1890, 9,860 tons, with a value of $1,260,240, taking the official figures as given by the Geological Survey, which, however, seem to me rather high, especially as far as the value is concerned. During the period between 1880 and 1890, the increase has been nearly 2,600 per cent in tonnage, and 5,100 per cent in value.

Prices and market.

"It may be interesting to see what the average value per ton for these last ten years has been, as this is the only measure by which we can judge the industry from a national and economic as well as a business point of view. The years 1880, 1881 and 188-2 brought to the asbestus miners a price of $65 in average, while the price per ton in 1883 reached $72. From here we find the average price steadily decreasing, owing to the large proportions of No. 3 asbestus, until it reached the lowest point, in 1887, of $49. The respective figures are a trifle over $65 for 1884, $58 for 1885, $59.75 for 1886, and, as stated before, $49 for 1887; 1888 yielded an average of $60; 1889, $69.75, until 1890 brought the large figure of over $127 as an average price for every ton of asbestus, if the statements made by the Geological Survey are correct. This enormous increase in prices was due to several circumstances, chiefly relating to the state of the European market, and, in particular, that at the time a number of speculators had bought and kept from the market considerable amounts of stock in expectation of a further rise, while manufacturers as well were anxious to lay in as much stock as possible, under the impression that the mines had nearly reached the top of their capacity, and that prices would be driven to the utmost if stocks should run short. The real state of affairs transpired when the speculators tried to unload. Here a reaction set in, and while manufacturers before were very anxious to buy, they then decided to first await a settlement of the affairs. This, however, was promptly answered with the slacking down in the working of the mines last summer, and led in consequence and in consideration of other obnoxious circumstances—such as the Quebec Mining Act—to the entire shutting down of nearly all the mines in November last. Since then things have somewhat changed.

"It is clear that a mineral which has been successfully exposed to a heat of 4,500 to 5,000 degrees F., which is a non-conductor of electricity, and which may be spun like cotton and flax, has its merits in itself and will stand on those merits. The uses of asbestus are steadily increasing. I cannot, however, dwell on this point, and have to refer those

who are especially interested in the subject to an excellent paper read before the Asbestus Club in September last by Mr. Ed. Wertheim. One thing, though, I would like to mention with regard to the market for crude asbestus, and that is that it seems as if the American market is now rather inclined to buy as good grades as the European, while *vice versa*, manufacturers on the other side of the water are taking up lower grades along with first qualities—circumstances which never prevailed before. So it seems that those two main buyers of our products—America and Europe—are coming on more even terms than ever before. Asbestus. Markets.

"There is no doubt that the industry is still on a steady and very healthy increase, and while we may have temporarily to stand a slight reaction, things will brighten up before long. The sound judgment of those men interested in our industry will soon restore the balance between demand and production and will continue to develop the asbestus industry as wonderfully as they have done so far."

Regarding the exports and imports of asbestus during 1891 and previous years, the following tables are self-explanatory. Exports and Imports.

ASBESTUS.

TABLE 1.

EXPORTS.

Quality.	1888.		1889.		1890.		1891.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1st class.....	3,625	$262,552	4,579	$319,461	5,453	$453,704	4,530	$338,072
2nd "	110	5,306	593	27,308	1,172	58,973	3,186	209,833
3rd "	201	9,884	416	13,375	373	15,853	298	13,636
Totals.....	3,936	$277,742	5,588	$360,144	6,998	$528,530	8,014	$561,541

ASBESTUS.

TABLE 2.

IMPORTS.

Fiscal Year.	Value.
1885.....	$ 674
1886.....	6,831
1887...	7,836
1888.....	8,793
1889...	9,943
1890...	13,250
1891.....	13,298

Coal.

COAL.

Production.

The production of this mineral for the whole Dominion is given in the accompanying graphic Table A, in Plate II., from which it will be seen that there is again a very encouraging increase in the figures of production over those of the previous year.

The 3,127,661 tons, valued at $6,496,110, returned for 1890, compared with the 3,623,076 tons, valued at $8,144,247, produced during 1891, show the amount of this increase to have been 505,415 tons and $1,648,137. This result must be credited almost wholly to British Columbia. The greater proportionate increase in the figures of value is also due to the greater proportion of this higher priced coal, included in the total.

From Table B, showing the proportion contributed to the grand total of tonnage by the several provinces, it will be seen that Nova Scotia still retains the chief place; British Columbia comes next in the amount of its production, whilst the North-west Territories and New Brunswick contribute but a relatively small proportion.

Table C speaks for itself.

The following Table No. 1 illustrative of coal mining in New Brunswick and the North-west Territories, explains itself:—

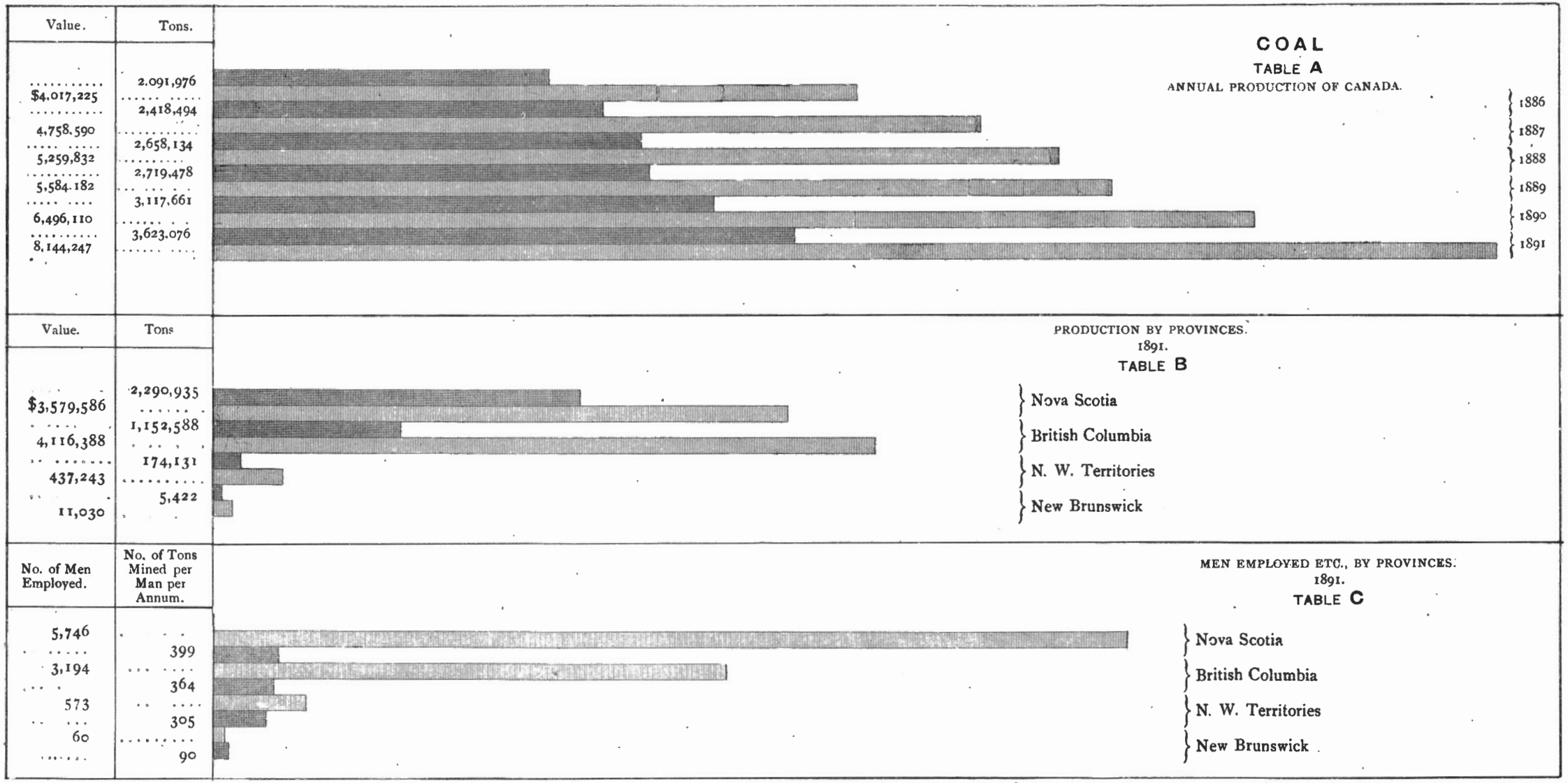
Coal.

Table 1.

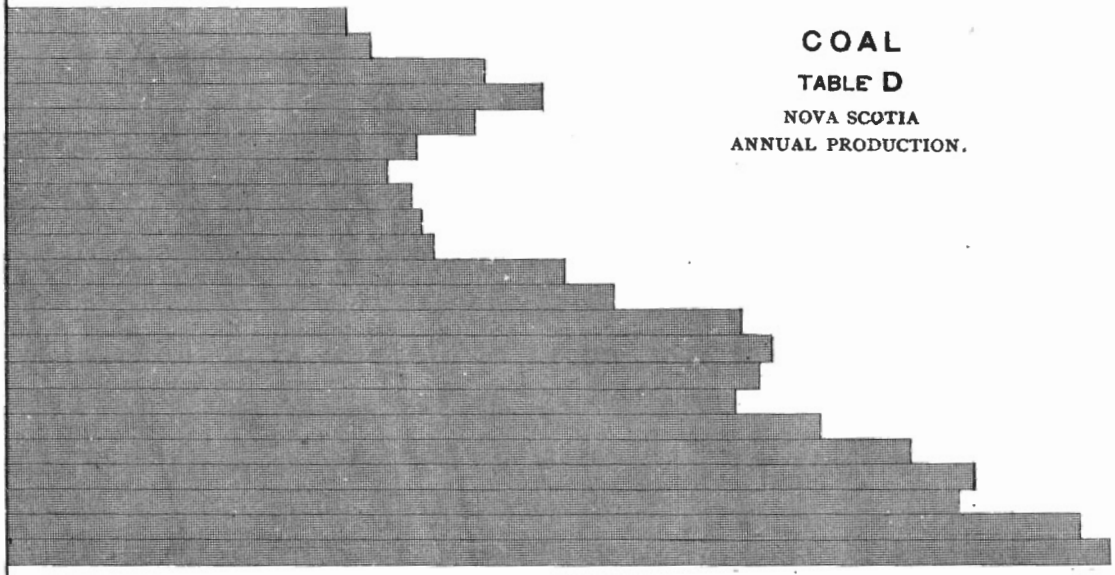
Production in New Brunswick and North-west Territories.

Year.	New Brunswick.		North-west Territories.	
	Tons.	Value.	Tons.	Value.
1887	10,040	$ 23,607	74,152	$ 157,577
1888	5,730	11,050	115,124	183,354
1889	5,673	11,133	97,364	179,640
1890	7,110	13,850	128,953	198,498
1891	5,422	11,030	174,131	437,243

The amount and value of the coal exported from the country are given in Tables Nos. 2, 3 and 4 following, and in graphic Tables F and G.


Value.
Tons.
2,091,976
$4,017,225
2,418,494
4,758,590
2,658,134
5,259,832
2,719,478
5,584,182
3,117,661
6,496,110
3,623,076
8,144,247
COAL
TABLE A
ANNUAL PRODUCTION OF CANADA.
1886
1887
1888
1889
1890
1891
Value.
Tons
2,290,935
$3,579,586
1,152,588
4,116,388
174,131
437,243
5,422
11,030
PRODUCTION BY PROVINCES.
1891.
TABLE B
Nova Scotia
British Columbia
N. W. Territories
New Brunswick
No. of Men Employed.
No. of Tons Mined per Man per Annum.
5,746
399
3,194
364
573
305
60
90
MEN EMPLOYED ETC., BY PROVINCES.
1891.
TABLE C
Nova Scotia
British Columbia
N. W. Territories
New Brunswick

Year	Tons
1870	700,861
1871	754,031
1872	984,664
1873	1,117,643
1874	977,446
1875	848,395
1876	794,803
1877	848,395
1878	863,081
1879	882,863
1880	1,156,635
1881	1,259,182
1882	1,529,708
1883	1,593,259
1884	1,556,010
1885	1,514,470
1886	1,682,924
1887	1,871,338
1888	1,989,263
1889	1,967,032
1890	2,222,081
1891	2,290,935

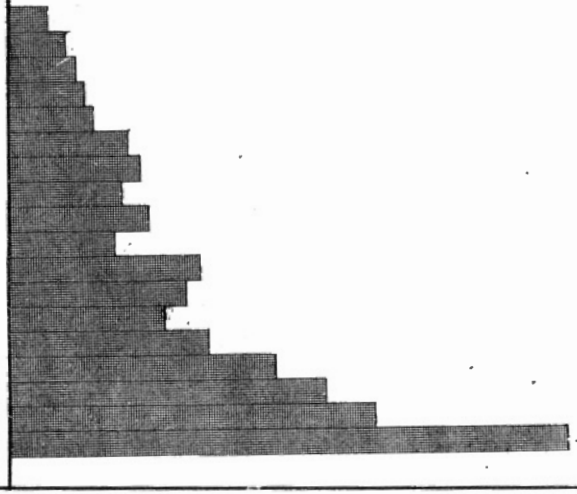


COAL

TABLE D

NOVA SCOTIA
ANNUAL PRODUCTION.

Year	Tons
1874	81,574
1875	110,145
1876	131,192
1877	154,052
1878	170,846
1879	241,301
1880	267,595
1881	228,357
1882	282,139
1883	213,299
1884	394,070
1885	365,596
1886	326,636
1887	413,360
1888	548,017
1889	649,409
1890	759,517
1891	1,152,588



COAL

TABLE E

BRITISH COLUMBIA
ANNUAL PRODUCTION.

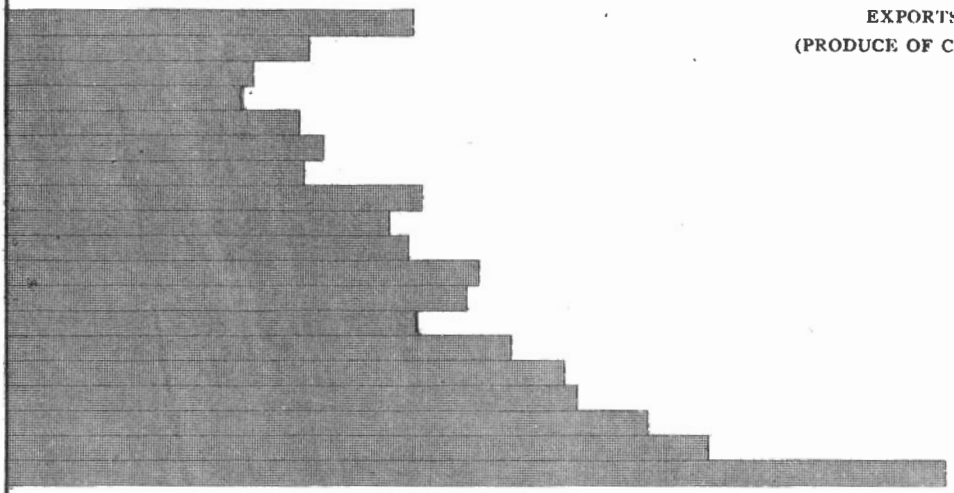
COAL

TABLE F

EXPORTS

(PRODUCE OF CANADA)

Year	Tons
1873	420,683
1874	310,988
1875	250,348
1876	248,638
1877	301,317
1878	327,959
1879	306,648
1880	432,188
1881	395,382
1882	412,682
1883	486,811
1884	474,405
1885	427,937
1886	520,703
1887	580,965
1888	588,627
1889	665,315
1890	724,486
1891	971,259



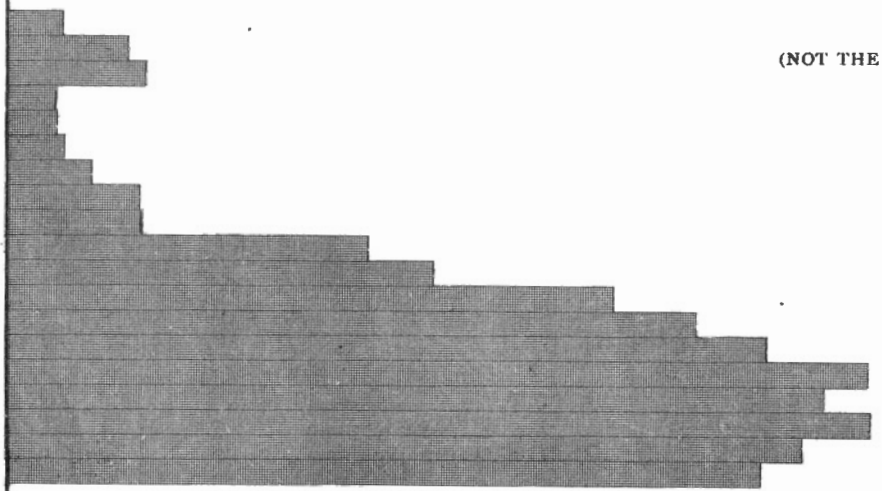
COAL

TABLE G

EXPORTS

(NOT THE PRODUCE OF CANADA)

ar	Tons
1873	5,403
1874	12,859
1875	14,026
1876	4,995
1877	4,829
1878	5,468
1879	8,468
1880	14,217
1881	14,245
1882	37,576
1883	44,388
1884	62,665
1885	71,003
1886	78,443
1887	89,098
1888	84,316
1889	89,294
1890	82,534
1891	77,827



COAL. COAL.

TABLE 2.

EXPORTS: THE PRODUCE OF CANADA. Exports.

Province.	1890.		1891.	
	Tons.	Value.	Tons.	Value.
Ontario	368	$ 559	.....	.....
Quebec	12,599	32,233	4,644	$ 7,304
Nova Scotia	202,387	426,070	194,867	417,816
New Brunswick	37	161	1,747	5,194
Prince Edward Island	142	478	35	109
Manitoba	71	214	2,232	4,655
British Columbia	508,882	1,977,191	767,734	2,958,695
Totals	724,486	$2,436,906	971,259	$3,393,773

COAL.

TABLE 3.

EXPORTS: NOT THE PRODUCE OF CANADA.

Province.	1890.		1891.	
	Tons.	Value.	Tons.	Value.
Ontario	63,251	$150,258	63,777	$158,416
Quebec	13,185	31,042	11,565	25,953
Nova Scotia	5,784	15,055	2,319	6,217
New Brunswick	136	395	165	432
Manitoba	178	801	1	15
Totals	82,534	$197,551	77,827	$191,033

Coal.

Coal.

Table 4.

Exports and Imports.

Exports: Nova Scotia and British Columbia.

Year.	Nova Scotia.		British Columbia.	
	Tons.	Value.	Tons.	Value.
1874	252,124	$647,539	51,001	$278,180
1875	179,626	404,351	65,842	356,018
1876	126,520	263,543	116,910	627,754
1877	173,389	352,453	118,252	590,263
1878	154,114	293,795	165,734	698,870
1879	113,742	203,407	186,094	608,845
1880	199,552	344,148	219,878	775,008
1881	193,081	311,721	187,791	622,965
1882	216,954	390,121	179,552	628,437
1883	192,795	336,088	271,214	946,271
1884	222,709	430,330	245,478	901,440
1885	176,287	349,650	250,191	1,000,764
1886	240,459	441,693	274,466	960,649
1887	207,941	390,738	356,657	1,262,552
1888	165,863	330,115	405,071	1,605,650
1889	186,608	396,830	470,683	1,918,263
1890	202,387	426,070	508,882	1,977,191
1891	194,867	417,816	767,734	2,958,695

The amount and value of Canada's imports of coal for this and past years is given in the tables below, Nos. 5, 6 and 7, which, it must be remembered, are for the fiscal year ending 30th June.

Coal.

Table 5.

Imports of Bituminous Coal.

Fiscal Year.	Tons.	Value.
1880	457,049	$1,220,761
1881	587,024	1,741,568
1882	636,374	1,992,081
1883	911,629	2,996,198
1884	1,118,615	3,613,470
1885	1,011,875	3,197,539
1886	930,949	2,591,554
1887	1,149,792	3,126,225
1888	1,231,234	3,451,661
1889	1,248,540	3,255,171
1890	1,409,282	3,528,959
1891	1,598,855	4,060,896

COAL. COAL.

TABLE 6.

IMPORTS OF ANTHRACITE COAL. Imports.

Fiscal Year.	Tons.	Value.
1880	516,729	$1,509,960
1881	572,092	2,325,937
1882	638,273	2,666,356
1883	754,891	3,344,936
1884	868,000	3,831,283
1885	910,324	3,909,844
1886	995,425	4,028,050
1887	1,100,165	4,423,062
1888	2,138,627	5,291,875
1889	1,291,705	5,199,481
1890	1,201,335	4,595,727
1891	1,399,067	5,224,452

COAL.

TABLE 7.

*IMPORTS OF COAL DUST.

Fiscal Year.	Tons.	Value.
1880	3,565	$ 8,877
1881	337	666
1882	471	900
1883	8,154	10,082
1884	12,782	14,600
1885	20,185	20,412
1886	36,230	36,996
1887	31,401	33,178
1888	28,808	34,730
1889	39,980	47,139
1890	53,104	29,818
1891	60,127	36,130

*NOTE.—This table includes coal dust and all coal other than that specified as anthracite and bituminous.

An idea of the annual consumption of coal in Canada may be gained from the figures below, assuming that the imports, which are for the fiscal year, are about what they would be for the calendar year :— Consumption

	Tons.
Production	3,623,076
Imports	3,058,049
	6,681,125
LESS—Exports	1,049,086
	5,632,039

Coal. Markets.

A reference to Table 11 will show that only about 8 per cent of the coal produced in Nova Scotia is shipped abroad, the sister colony of Newfoundland being our largest buyer, and the United States coming next, whilst the West Indies take a small quantity.

The other great producing district, that of British Columbia, finds a home market for about one-fifth of its production, and the largest proportion of the rest finds a market in California, while smaller consignments are sent to Alaska, China, Japan and the Hawaiian Islands, and a certain amount is utilized by the shipping on the Pacific.

Nova Scotia.

Nova Scotia—In Nova Scotia there were twenty collieries producing, their relative contributions to the output of the province being given in Table No. 8:—

Coal.

Table 8.

Nova Scotia.

Production by Collieries.

1891.

Collieries.	1888.	1889.	1890.	1891.
	Tons.	Tons.	Tons.	Tons.
Cumberland Co.				
Chignecto	16,584	20,801	11,336	1,075
Joggins	54,261	50,870	68,181	67,263
Minudie	1,544	1,456		1,867
Salt Springs			157	
Springhill	454,939	476,167	469,293	513,483
Pictou Co.				
Acadia	325,620	301,960	307,924	319,617
Black Diamond	26,884	38,097	37,270	20,321
East River	879	1,730	1,523	3,276
Holmes		286	65,303	
Intercolonial	177,708	141,072	120,668	157,615
Cape Breton Co.				
Blockhouse	7,625			
Bridgeport	27,134	24,076	31,610	34,605
Caledonia	126,318	128,015	174,915	179,183
Francklyn	9,230	4,531	810	
Gardner				23,820
Glace Bay	89,431	90,630	124,848	131,899
Gowrie	145,018	125,104	158,031	177,032
International	114,429	138,780	160,262	149,161
Ontario	5,166	3,210	10,135	3,484
Reserve	135,650	136,247	174,615	191,345
Sydney	170,224	162,362	203,359	191,174
Victoria	100,619	121,633	101,841	124,361
Inverness Co.				
Broad Cove				175
Rankin				179
Totals	1,989,263	1,967,032	2,222,081	2,290,935

The above table, together with all those here given relating to Nova Scotia, are compiled from material provided by the Government Department of Mines of that province. The details of the coal trade of the province are given in tables Nos. 9, 10 and 11 below :— Coal. Nova Scotia.

Coal.

Table 9.

Nova Scotia.

Production, Sales and Colliery Consumption.

Period.	Production.	Sales.	Colliery Consumption.
	Tons.	Tons.	Tons.
1891—First quarter	404,460	247,306	41,384
" Second "	629,534	542,269	57,965
" Third "	729,531	794,606	51,807
" Fourth "	527,410	487,757	44,825
" Totals	2,290,935	2,071,938	195,981
1890 "	2,222,081	2,000,444	180,589
1889 "	1,967,032	1,741,720	177,106
1888 "	1,989,263	1,765,895	176,336
1887 "	1,871,338	1,702,046	156,550
1886 "	1,682,924	1,538,504	159,512
1885 "	1,514,470	1,405,051	142,939

Coal.

Table 10.

Nova Scotia.

Coal Trade by Counties.

Year 1891.	Cumberland.		Pictou.		Cape Breton.		Inverness.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
First quarter.	137,944	122,160	118,978	95,207	147,363	29,771	175	168
Second "	146,917	130,827	126,309	111,610	356,308	299,832	.....	.....
Third "	141,721	123,872	129,177	129,583	458,633	541,151	.....	.....
Fourth "	157,106	140,880	126,365	117,307	243,760	229,525	179	45
Totals	583,688	517,739	500,829	453,707	1,206,064	1,100,279	354	213
1890	548,966	491,241	532,700	482,170	1,140,415	1,027,033	.....	.....

COAL.
Nova Scotia.

COAL.

TABLE 11.

DISTRIBUTION OF COAL SOLD.

Market.	1890.	1891.
	Tons.	Tons.
Nova Scotia:—		
Transported by land	390,322	404,031
" sea	283,869	312,474
Total	674,191	716,505
New Brunswick	251,749	256,833
Prince Edward Island	62,544	75,570
Quebec	842,163	868,320
Newfoundland	107,557	121,651
West Indies	5,284	4,576
United States	56,956	28,483
Total	2,000,444	2,071,938

Discovery and development in Nova Scotia.

The details of discovery and development in this province, as gleaned from the report of the Department of Mines* of Nova Scotia, are as follows:—

"The returns show a sale during the past year of 1,849,945 tons against 1,786,111 tons during the preceding year. The increase was not as large as anticipated in the spring, and the explosion at the Springhill collieries, reported on in the report for the year 1890, reduced the output of Cumberland county by about 30,000 tons.

"As compared with the sales of the year 1890 the most noticeable points are:—

"The home sales were 639,737 tons compared with 601,956 tons in 1890.

"The province of Quebec took 775,286 tons against 751,931 tons in 1890.

"The sales to the United States were 2,585 tons of round, 58 tons of run of mine, and 22,788 tons of slack coal, in all 25,431 tons, as compared with 50,854 tons in 1890.

Cumberland County.

"The sales to Newfoundland and New Brunswick, Prince Edward Island and other points show little difference.

"The sales of the county were 462,267 tons against 438,608 tons in 1890.

*The ton mentioned in the following quotations from this source is the long ton of 2,240 lbs.

"The production of the collieries of the Cumberland Railway and Coal Company was 459,395 against 419,012 tons in 1890, in spite of the delay caused by the explosion. Since that date the enlargement and completion of the air-way has been finished. New pumps, screens, etc., have been put in, and the colliery generally placed in excellent order. Safety lamps alone are used underground, and no explosives. COAL. Discovery and development in Nova Scotia.

"The Chignecto mine has remained closed, and no returns of a satisfactory character have been received of the results of the prospecting carried on for other seams.

"A little work has been done on the Maccan River collieries by Mr. Smith and others. Mr. Sharp of Amherst, and others, have traced the Styles seams further to the east, and added materially to our knowledge of this part of the district.

"At the Joggins mines the system of long wall has been continued, and improvements made to the railway and wharf. The output was 60,056 tons.

Pictou County.

"The sales were 405,096 tons as compared with 430,509 tons in 1890.

"The home sales were 265,098 against 277,753 tons in 1890.

"The province of Quebec took 63,219 tons compared with 90,461 tons in 1890.

"The output of the Acadia Company was 286,372 tons, and of the Intercolonial Company 140,728 tons. The Black Diamond colliery was purchased by the Acadia Company, which will continue the extraction of the pillars, etc.

"At the Albion colliery the work of reopening the Ford pit has been continued with success.

Intercolonial Coal Mining Company, Westville.—"The principal work in this mine during the past year has been extracting the pillars on the 3,000 feet lift; on the north side the pillars have been very satisfactorily drawn, and all the plant from that side taken to the south side. A large proportion of the work done was in the S. Holmes area, in which they are successfully mining a large percentage of coals. There are yet, however, on their own area, a block of coal, 450′ × 1,800′, standing with (4) four back-balances driven up to mine bord on next lift. A tail-rope running with 22 boxes on each trip is used on this level, and has proved an economical feature in underground haulage, and from the success obtained in its use I would wish to draw to it special attention, as

COAL.

Discovery and development in Nova Scotia.

with it in this district one boy can alone do the work that hitherto (8) eight horses and as many drivers were required to do, which success, I trust, will induce others to follow the example. From this level a tunnel has been turned off to strike the Scott pit seam ; the tunnel, it is computed, will require to be driven a distance of (600) six hundred feet, and to strike the seam down a distance of about 3,000 feet from the surface. As the Scott pit seam improves in quality to the dip, it is believed that at this point the coal will be of extra good quality. On the lift below this the levels have been driven in on each side a distance of about (600) six hundred feet, and they intend driving them until the line is reached on each side, before extracting the coal, any further than to put up balances for returns, and then bring back the pillars on the fresh timber. There is sufficient coal on the 3,000 feet lift to keep the mine working until the levels in the lower lift are in to the line. The Scott pit is now idle, and will remain so until the next season's shipping begins. The management intend to commence sinking another lift of (600) six hundred feet. The new winding engine, of which I made mention in last year's report, hoists (11) eleven boxes each trip.

" Considerable expenses have been incurred this year in building the most important of which was a new brick engine house for the hoisting engine, also a new car shop ; and the bank house being too small, was enlarged.

Acadia Mine, Westville.—" In last year's report I made mention of the difficulties they had to contend with in this mine, viz., firedamp and bad roof. I regret to say that in this respect during this year the difficulty has not lessened, but increased. This mine has a perpendicular depth of about 1,500 feet, and as the coal is tender and contains a large percentage of gas, the enormous pressure causes the gas to evolve from roof, pavement and sides, and the mine being as well very dusty, it is therefore difficult to manage. * * * * * All the workmen are now in the 3,560 feet lift, as the 3,100 feet lift is finished ; the pressure was so great on this lift that some little coal was lost in the finishing up, being the first coal lost in this mine in my time ; the air returns were damaged some, but are pretty well opened up now. The new hoisting engine is giving good satisfaction, also the new pump. It is difficult to describe the difficulties met with in a mine of this description, and only the men who work in it, and the management who anxiously conduct it, can fully estimate or realize the trouble and cost of keeping air-ways open, and the mine in good order and safety.

Vale Colliery, Thorburn—Six Foot Seam.—"In my last report I spoke of the introduction of the long-wall system. This has been carried on during the year in the lower lift 2,000 feet down, but is not meeting with the desired success; the roof is of a very strong nature, and the slips run into the coal face, giving considerable trouble, making it expensive to keep the working faces open. On the 1,000 feet lift during the year, pillar work principally has been carried on with very good results. Some very heavy feeders of water have been struck in this mine, entailing considerable loss and expense, as the pumps were of insufficient capacity to keep the water out; they were obliged to flood the lower mine bord, causing them to carry the air for hundreds of feet with brattice, and the bottom being of a soft nature, caused falls in the mine bord, which had to be cleaved and timbered. The management were obliged to place two new Knowles pumps in the mine; these pumps throw about 560 gallons per minute. The mine was partly idle for 7 or 8 weeks until the pumps were started, reducing the output of coal considerably. The following buildings, viz., the locomotive shop, carpenter's shops, office, stables, store house and boiler house, were moved from the McBean slope and put up at this mine, and caused considerable expense in so doing. Culm is used in firing the boilers instead of coal. Now that everything is placed and the mine in good order, I would not be surprised to hear of a larger output of coal next year.

McBean Seam, Thorburn.—"No attempt has been made to open up this mine during the past year.

McGregor Pit, Stellarton.—"At my official visitation of this mine, on 24th April, I found the pillar work spoken of in last year's report stopped, and masons busily employed building them off, the temperature kept continually rising, and as it was beginning to get alarmingly high, the management, after careful survey, decided it was all but on fire, and therefore determined to close up this portion of the mine with brick, stone, sand, &c. Through the past summer the north and south slants have been connected at the bottom, and as in consequence the north engine can hoist all the coal, the south engine is idle, and in future can be used for sinking purposes. Two new back-balances have been started off during the year, but as there is now a very large area of this mine resting on pillars, it is not desirable to make very rapid progress until the overlying seams are dealt with, but as these seams are now being developed, it is only a matter of time until the pillars can be safely drawn. The depth of the mine is now about 2,670 feet down, angle of descent from 16° to 25°.

COAL.
Discovery and development in Nova Scotia

Foord Pit.—"It has been found necessary in the development of this mine to build some very extensive brick arches, the roof having been broken to such a height it was supposed the air was getting into the old workings. The stone arches around the bottom of the shaft were very much wrecked by the fire, and there is now some 500 feet of brick arch about the bottom, all well filled and packed at the back with sand, thus making them air-tight, and giving a soft rest to the pressure. The bottom now looks very well. Quite a number of other large brick stoppings have been built. Two slants have been sunk to the dip, a distance of about 400 feet, and still sinking. Soon they will be mining the coal from the deep.

"The coal-cutting machine did not prove as satisfactory as anticipated; the lower part of the seam having some very hard boulders, it was not quite able to cope with them. Some changes are now being made in the machine to meet this difficulty. The pit-head gear has been renewed and the latest improved screens and tipples fitted up, and everything around the pit-head is new. Fifty new coke ovens have been built, and a tunnel driven to conduct the gas from the ovens to the boilers to utilize the gas for raising steam in lieu of coal, which must undoubtedly result in great economy of labour and coal.

"On one side of the mine the temperature is about 80°, and necessitates a considerable quantity of air to keep it cool enough for the men to work; and as they proceed to the dip the gas makes freely, and, unless greater power be used, there is no means of increasing the volume of air, and as it is necessary to obtain increased air-way, the English slopes that were sunk 1,700 or 1,800 feet have been started sinking again, and a place turned off the north level of the Foord pit to cross-cut the measures and meet the slants; thus as there are two slants, when completed, will make a good travelling-way and air-way, and give a good field of coal, giving the Foord pit two more seams, viz., the Cage pit and four feet seam immediately overlying it, all down hill for the coal excepting through the tunnel, which will be about 300 or 400 feet, and as the water now finds it way to the Foord pit they will not experience much difficulty from that source. There has been some five or six places driven into the old works, which would seem to indicate some errors in the old plans. These places had to be built off with iron rails and brick and sand. They have had many difficulties to contend with, but so far every difficulty has been met, and this mine is again assuming its usual appearance.

"*Third Seam Slopes.*—It is understood that the Cage pit and Third Seam are connected by a tunnel some 250 feet in length, and the

extension of this tunnel has cut another 4 feet seam of the best coal probably in this county and a band of iron stone which carries 45 per cent of iron. It takes time to advance levels and get new works like this opened out, but I am pleased to say that this has been systematically and quickly done. During the year there was a back-balance driven up on the north side of Third Seam, and nine bords turned away, and the levels extended a considerable distance beyond. COAL. Discovery and development in Nova Scotia

"On the south side there has been a balance with 8 bords worked out nearly, and the levels extended. In the Cage pit seam the levels on north and south side have been rapidly extended and balances driven up.

"In the Four Feet Seam the levels are also being extended and places driven up hill. Some of the iron has been taken out and roasted at the mine with satisfactory results. This seam of coal will be worked long wall.

Spring Hill Mines.—"It is unnecessary for me to say anything at length in reference to the explosion which occurred here on the 21st of last February, the investigation having been published in last year's report. * * * * * *

"It was only two weeks after the explosion when the mine was again being partially worked, the damage underground being slight when we think of the terrible loss of life. These collieries are now comparatively clear of gas. At the working faces there are times when a few inches is found by the fire-boss, more especially in up-hill places where the brattice is not kept close up; but as to gas being in standing places or old work, I never found it, nor do I know of any man who ever did. The overlying strata in Cumberland county does not carry firedamp like the Pictou county coal seams. The Pictou county coal basin has for its cover bituminous shale, while Cumberland county coal basin has more freestone and fireclay, which accounts for being less gas than in Pictou collieries. Safety lamps is the only kind of light now used in this mine. Explosives are not used.

"There has been quite a lot of work done in the air-ways, and the volume of air considerably increased. The new lift which was sunk last year in the east slope has been opened up this year, and levels driven east and west. During the year the west slope has been sunk down to 1,200 feet. There is also a new lift in the north slope, and one in the east slope 600 feet each, and 1,200 feet in the west. Properly speaking, we do not know the extent this lift may be driven westwardly, as every year further developments are made of this seam westerly, until now they are proven for some miles with slight varia-

COAL.
Discovery and development in Nova Scotia

tions southerly, caused by up-throw dikes or faults. Easterly the No. 5 slope is proved to some extent a distance of one mile, roughly speaking.

"There are somewhere about 1,400 men and boys employed in these mines, and when we take into consideration the hazardous nature of their employment the casualties that do occur are comparatively few. During the year there has been placed in the north slope a new duplex pump—high and low pressure, water barrel 10 inches, stroke 36 inches, water-column 10½ inches; the pipes are lined inside with wood.

Joggins Mines.—"All the work done in this mine during the year was long wall. It has proved very successful here, as the coal taken out under this system is larger, and a larger percentage of coal is won. I would say that 95 per cent of all the coal is taken out, it may require more timber, but the larger percentage of coal obtained amply pays the difference. The men also can dig a larger quantity per shift than under the old system.

"The water level has been cleaned and timbered from the shore to the slope, a distance of one mile and an eighth.

"Formerly the road for delivering the coal at shipping, which was one mile and an eighth in length, was laid with double tracks and operated by an endless rope, the engine operating it being at the mine. The coal was then dumped into a chute of about 150 feet in length, and run into the vessels lying at the wharf, of which only one could be loaded at a time. During the past year the whole business has been remodelled. At the wharf, instead of the chute, in the same place there have been two tracks laid and the wharf extended, and several places made in which vessels can lie and be loaded at the same time with different kinds of coal. At the head of these two tracks is placed a drum barrel with brake attached, and the full boxes running down bring up the empty ones. Instead of two tracks from the pit and an endless rope, there is now only one track with sufficient descent in it for the full boxes to run down with rope attached, and the engine then pulls back the empty ones, thus doing away with half of the track and rope formerly used.

"The mine is now in order to yield a large output of coal. There has been no gas reported in this mine during the year, and during the same time has been free from any kind of accidents.

"No explosives are used in working the coal; the powder and dynamite used was in stone, and in cutting through a large fault in three places, and some brushing for horse roads.

Minudie.—"This mine was worked for two or three months last winter, and then remained idle until the middle of November, when it

Discovery and development in Nova Scotia

was started again with 10 or 12 men, the object being local sales for the winter.

Lawson Mine.—"This mine was idle for two or three months during the summer on account of their engine-house being destroyed by fire. It has been rebuilt, and the mine at work again with from 8 to 10 men employed in it.

Chignecto Mines.—"This mine was worked during the winter along the crop, a few men being employed getting out coal for local sales. In the spring Frank Burrows, the underground manager, started prospecting the property. He was supplied with a diamond drill, capable of drilling 1,000 feet, and had 10 to 12 men employed, and has up to my last visit, December 1st, continued at work, and has drilled a series of holes from near Athol station to the Stoney half-mile. I learned he had drilled through some of the coal measures. He has now drilled three holes of about 600 feet depth each, and has began to drill the fourth.

Scotia.—"Alexander Dewar, reported as having 3 or 4 men employed at this mine, ceased operations at the end of the year, and has not resumed since.

Black Diamond Mine.—"Principally pillar work done here during the year. They are getting along very successfully and mining a good percentage of coal. It is now under the management and control of the Acadia Coal Company, Limited.

East River Area—John Muir and Sons.—"Work has been carried on here just as usual.

"On November 28 and 30 I visited Leicester in Cumberland county, where coal was reported to have been discovered. I found Mr. Sharp at work with 6 men east of the Styles mine, on the bank of a brook. He had 5 seams of coal exposed; about sixty feet of measures were between the first three seams, which appeared in thickness to be as follows: 1st seam, 3 feet; 2nd seam, 5 feet 4 inches; 3rd seam, 3 feet 6 inches. Then 107 yards south were the other two seams, one 6 feet and the other 9 feet, dipping south 10° west at an angle of 45°.

"There are good indications further east, lots of drift coal on the surface and a good level country. I cannot probably do justice to this section of the country, as the crop-out of the seams appeared disturbed. I never saw any coal burn better than it does in a stove.

Cape Breton County.

"The total sales for this county were 982,392 tons against 916,994 tons in 1890.

COAL.
Discovery and development in Nova Scotia

"The increase was principally in the home sales and those to the province of Quebec.

"During the past year the Gardener mine was got into good working order by the Burchell Bros., who introduced a Jeffrey's electrical coal-cutting machine. The Sydney and Louisburg Coal and Railway Company reopened the Emery seam. Both these mines are said to yield a coal ad pted for steamer uses. Preparations are being made for introducing mechanical coal-cutting machinery into several mines in the Cape Breton district. As a result of the construction of the Cape Breton Railway, coal from this district is burned on the Eastern Extension Railway.

"Prospecting was carried on at several points in Cape Breton county, and it is claimed that a new and workable seam has been found underlying the Gardener seam. Such a seam would prove, owing to the great extent of country it would underly, a great addition to the coal resources of the Island.

"At East Bay, Mr. Young, on behalf of some American capitalists, has been engaged in sinking on a bed of hard coal, and will continue with better sinking appliances in the spring.

"The Mabou Gypsum Company have opened one of the Mabou seams and sold a few tons. The seam is 7½ feet thick and of good quality. A wharf has been built, and it is expected that next summer a considerable trade will be done with Nova Scotia and Prince Edward Island.

Sydney Mines.—"The north side pump deep has been driven further to the dip and a new landing opened there, 291 yards below the old landing. No. 1 angle deep, south side of pit bottom, has been driven through the trouble and extended, so that a new landing has been opened at 330 yards further to the dip than the old landing; also No. 2 angle deep, south side, has been extended and a new landing opened out 330 yards further to the dip than the old one.

"A new and larger spur wheel has been put on the north side underground engine to increase its hauling capacity. A new Jack engine drum and ropes have been put in for lowering and drawing the men from the pit. Also the back of the cages are boarded in and an iron bar placed across the front for safety.

"The ventilating fan has been much improved in efficiency by tacking sheet rubber to the periphery or margin of the blades, also by enlarging the outlet for the escaping air. A second new apparatus has been erected to help the filling away of the bank coal during shipping season. Cast iron tubing has been provided with which to line the

Discovery and development in Nova Scotia

pumping shaft at points where the stone is wasting away by reason of the heat from the steam of the underground engine.

"The heapstead pit tops, boiler seats, and engine houses, have been lighted by electric lights. A small horizontal engine and dynamo have been put up for that purpose, all of which gives satisfaction.

Victoria Mines.—"Work has been brisk at this mine during the last season. Since my last report the east levels in the 1,800 feet lift has been driven 380 yards, and another balance has been driven up. The west levels in the same lift have been driven about 150 yards; and a balance won out. The 1,200 feet east levels have also been extended about 400 yards.

"Stoping has been successfully carried on during the shipping season. A new angle deep has been driven off the main east slope, at a much lighter angle of dip, for the purpose of shortening the haulage in the level by horses; and also to enable the surface hauling engine to bring out a much larger trip of coal each time. The west levels in the 1,200 feet lift in the west slope have been standing nearly all this season, and only one balance is being worked at present; but the main slope is being driven down to win out another lift of 600 feet. The new engine for the fan mentioned in my last report has been placed and working for some months.

"A tubular boiler, 14½ feet long and 5 feet diameter, with 75 tubes in it, has been placed near the fan, and is quite able to supply the two fan engines with steam.

"A new fan shaft, 8 feet square and 40 feet deep, has been sunk and connecting with the main air-way.

"The erection of another Champion or Murphy fan, 8 feet diameter, has commenced. They have also put in another common egg end boiler, 36 feet by 5 feet 4 inches diameter, in place of two small ones. A gangway was erected in the spring between the coal bank and heapstead, and a donkey engine placed underneath it to draw the coal to the screens.

Lingan.—"A few men have been working in the pit there this season, getting out some coal which has been taken to Sydney Mines to make coke of.

Gardener Mine.—"Since last report this mine has been dried, equipped, and put in operation. Its condition was found to be better than was anticipated. Engine-house, forge, office, and dwelling-house are all being repaired, also a new store has been built. The heapstead has been finished, the shaft has been cribbed, buntings and guides put in. The two Cameron pumps that remained in the mine under water

COAL.
Discovery and development in Nova Scotia

for about twelve years were in good condition, and with slight repairs are found to be all that is necessary for keeping the mine dry.

"The air-shaft has been cribbed and the water that formerly used to go down it has been dammed off. Ladders are placed in it for the workmen's convenience. In the latter part of the season the air was changed from its former course bringing it in a shorter direction to where the men work; this made a marked improvement in the ventilation.

"The bottom of the main roads both north and south of the pit bottom have been blasted up, admitting the use of larger horses for hauling; also the management has disposed of the tubs formerly used in this mine, and instead are using on the south side of the pit a tub of double the capacity.

"The extension of the south level and the next rooms above it shows a marked improvement in the thickness of the seam. The Jeffery coal-cutting machine has worked steadily since August; the results attained are satisfactory. A gradual gain is made as the men get more acquainted with the machine.

"Mr. Burchell informs me that in the latter part of December a cutting of 270 square feet was made by the machine with two men in three and one half hours, which would be equal to 770 square feet in a shift of 10 hours. The electrical plant was manufactured by Messrs. A. Robb & Sons, Amherst, N.S. This plant, besides furnishing power for the machine, supplies the engine-house and bankhead with electric light.

Caledonia.—"During the last season the main or west deeps have been extended about 600 feet, and two sections on both sides won and opened there. The west high lift levels have been extended and rooms broken off. The levels on the east side from the bottom of the 700 feet deep slant have also been extended and a large section opened out.

"The workings to the rise were carried on as usual. A line of stone stoppings has been built and put in place of where the wood and board stoppings were, from the furnace to the lower landing on the main deep. A second furnace of the same size has been added to the former one; it is built on the east side, and the escaping air goes from both through the same shaft and cupola. This furnace ventilates the east side of the pit and the former the west side, both having separate inlets and returns, all of which have made a great improvement in the ventilation. On surface a new building of 100 x 28 feet has been erected, to be used as a forge and a carpenter's work-shop. A new stone boiler-house has also been built.

Discovery and development in Nova Scotia

Old Bridgeport.—"A new incline plane 900 feet long has been driven and put in operation from the south side of the pit bottom towards the rise. The south levels have been extended, and are now about 1,600 feet from the bottom of the shaft. The ventilation has been greatly improved in this mine during the past season.

"Stoppings have been put up along the levels, headways and through the rooms where required, also a return air-way has been driven from the south side of the high workings direct to the back part of the furnace, giving two returns.

Reserve Mines.—"This mine has been worked pretty busily during the last season. The French or east slope has been driven down 350 feet further, and levels turned off south and north. The south levels were driven 600 feet, and the north levels about 450 feet. A new landing has been made there and a fine section of rooms opened out. The coal is hauled from this section by means of a new steel wire rope leading from one of the engines on surface to the low landing. The trip is taken from this landing to the upper landing, when it is caught there by another rope and engine drawing it to the surface; this works remarkably well. Very little time is lost in unhooking from the empty and hooking on the full trip, and *vice versa*. The pillars have been nearly all drawn from the west side of the main slope. Work ceased there in October. A new cupola has been built on the east side instead of the old one that was blown down in October by a heavy gale.

Emery Mines.—"The dip slants have been driven about 650 feet and rooms broken off and worked during the latter part of the season. The north levels on the high lift have been extended about 650 feet, and the south side levels 320 feet. As the dips are extended the coal seems to improve in quality and thickness of seam.

Ontario Mines.—"Mr. Alexander McPherson commenced in the latter part of last March to secure and timber the slope and horse roads, and also to pump the water out of the dip. He succeeded while the weather remained dry, but as soon as the fall rain came he found that he was unable to keep the water down, so he finally abandoned the work. However, during the season he mined coal from a few rooms on the south side of the slope, below the high level.

Gowrie Mines.—"This mine has worked in its usual systematic way during the most part of the year. From the bottom of the west deep slant a horse road has been driven northerly over the fault, and a pair of levels turned off and driven westerly a distance of 300 yards, and a section won out between the fault and the anticlinal.

COAL.
Discovery and development in Nova Scotia

Also, south and parallel to the fault the levels have been extended westerly 200 yards.

"A good travelling road for the workmen has been made from this district to the high level near the pit bottom. On the east side main deep, where the roof was considered dangerous, 150 yards of it has been taken down an average thickness of 3 feet, and the place well secured with timber 1 foot or more in diameter.

"The levels going east have been driven 300 yards, and those going west extended about 400 yards, those levels have struck the fault that is leading from the west dip slant.

Little Glace Bay.—"During the past year the north levels have been driven about 900 feet, the south levels have been stopped, leaving a large barrier between them and the seashore at the harbour. The management has commenced driving a new deep on the south side of the pit bottom, with the intention of gaining a lift of 600 feet.

"A new shaft 40 feet deep and 8½ feet square has been sunk as an air-shaft, and an 8-foot fan placed in position. This is called the Murphy ventilating fan, and is reversible, the same as the one at the International. It works admirably well, and will be used as a blow-down this winter if required.

"A new double-acting 12-inch fire pump, with 9-inch columns, is being put in for the purpose of relieving the pumps now in use. A new block of four tenants are added to the workmen's houses. A new block of crib-work, 160 feet long, has been built and placed on the southern side of the harbour for its protection.

International Mines.—"The south side slant deep road has been extended down 600 feet deep, and another landing opened out there. This is the second landing on that road below the main level.

"The main overcast north side of pit bottom has been reconstructed in the shape of an arch with old railroad rails bent for that purpose. They make a good strong arch and suit well where the roof is bad. They are lasting and can be moved to any other part of the pit for the same purpose if required.

"An air-shaft has been sunk 90 feet deep, 10 feet diameter, and an 8-feet fan, known as the Murphy ventilator, erected there. It is so constructed that it can be made to either exhaust or blow down, and is at present working as a blow-down, but the intention of the management is to have it exhaust in summer seasons. It is capable of giving 80,000 cubic feet of air per minute if required. There have also been two new locomotives purchased and running during the past season in place of two of the old ones.

McAdam's Lake, East Bay.—"Prospecting has been going on at this place during part of the season by American capitalists. * * * * A shaft 65 feet deep by 8 feet long, and 4 ft. 6 in. in width, has been sunk on a seam of very black shale. There are several seams of this shale showing on both sides of a brook that runs down towards the lake crossing the strata.

Discovery and development in Nova Scotia

Cariboo Cove.—"I visited this mine on the 18th of December, and found twenty-two men employed there. A shaft has been sunk 130 feet deep, 14 feet by 6 feet, divided in three compartments. The seam of coal that it is sunk on is called the 7-feet seam, but has not been proved as yet to be over 3 feet 9 inches thick. The coal is hard and burns well.

"A new engine-house has been built and a double cylinder friction hoisting engine, 35 horse-power, put in position; also a pumping engine, 7-inch cylinder, 15-inch stroke, and a portable boiler 10 by 5 feet diameter. This engine, besides pumping the water from the shaft, drives a fan which ventilates the pit.

"A level has been driven from the seashore in on the 11-foot seam, a distance of 125 feet, and well timbered. A new dwelling-house has been built, an office, barn and forge. The company operating this mine reside in Rhode Island, U.S. President of the company, W. B. Gincks; secretary, T. A. Buel; underground manager, James W. Wilson. The management says it is the intention to ship coal early next spring."

The following shows the average thickness of the coal seams now worked in the dip workings in Cape Breton mines:—

Name of Mines.	Thickness of Seam.	
	Feet.	Inches.
Sydney Mines	5	6
Victoria Mines	6	8
Gardner Mines	4	4
Old Bridgeport Mines	5	9
Reserve Mines	8	9
Emery Mines	4	9
International Mines	5	10
Little Glace Bay Mines	5	10
Caledonia Mines	8	6
Ontario Mines	8	4
Gowrie Mines	5	8

COAL.

Discovery and development in Nova Scotia

NEW BRUNSWICK.—For this province, a total production of 5,422 tons, valued at $11,030, has been reported. As formerly, it all results from operations on the seams of the Grand Lake coal field. These operations continue to be of the desultory nature and limited extent of those of past years, resulting mostly from the work of the inhabitants of the district for short periods on the small seams found there.

The work is done near the surface, and the coal obtained is used locally in the provinces.

The nature of these operations can be judged when it is pointed out that the returns show that the number of men employed by the different operators, varied from two to eight, working for periods of from two to nine months.

Some of the operators complain that the industry is crippled by lack of good roads and of railroad communications, and by the scarcity of miners in the district.

East Albert Company's Property.—Prospecting has been done on this property by the New Brunswick Mineral Developing Company. The work done so far shows three small vertical veins of albertite, running a little south of east, the largest measuring about twelve inches in width. The Albert mines are still idle.

NORTH-WEST TERRITORIES.—The amount of coal produced in this region, viz., 174,131 tons, shows an increase over last year of 45,178 tons. Returns were received from operators located at various points in the Territories. Of the mines mentioned, the only three that were worked extensively were those of the Alberta Railway and Coal Company, with mines at Lethbridge; the Canada North-west Coal and Lumber Syndicate, with mines at Canmore in the Cascade Coal Basin, where the coal produced is a semi-anthracite, and those of Messrs. H. W. McNeill & Co., working in the same basin.

The latter company commenced operations in June, having leased the mines of the Canadian Anthracite Coal Company, and it is reported that a vigorous policy has been inaugurated with a view to taking rank amongst the chief producers of Canada.

Mr. R. G. McConnell, of the Geological Survey Staff, in his report to the director speaks as follows of the results of his work in this district during a short period in the spring:—

"This work was carried out during the month of June and was undertaken with a view of ascertaining whether the coal-bearing Cretaceous rocks of the Cascade basin recur east of the mountains. The section along the Bow proved to be too complicated and was intercepted by too many concealed intervals to trace the sequence of the formations

definitely throughout, but sufficient evidence was collected to show that in all probability the conglomeritic beds exposed at the Kananaskis Falls are the equivalents of those overlying Marsh's mine, south of the Gap siding in the Cascade basin, and that the underlying dark shales consequently represent the coal-bearing formation. East of the mouth of the Kananaskis the conglomerates and underlying shales fold over a light anticlinal, and several hundred feet of the latter are exposed without any coal seams being seen. The summit of this anticlinal, which occurs three-quarters of a mile east of the mouth of the Kananaskis River, offers the most favourable site for testing by means of a bore hole for the presence of coal. The coal horizon of Marsh's mine, assuming the identification of the conglomerates to be correct, lies at this point at a depth of 1,300 feet below the surface. There is, however, no absolute certainty that even if this depth was reached coal would be obtained, owing to the lack of persistence of the Cretaceous coal seams, and on the other hand workable seams might be struck at a much less depth. The rocks near the mouth of the Kananaskis River are comparatively undisturbed, and coal, if present, would be much less crushed and also more easily worked than is the case with many of the seams inclosed between the more highly inclined beds of the Cascade basin, and on this account a bore hole to test its presence would be desirable."

COAL. Discovery and development in Nova Scotia

The remainder of the coal production credited to this region, results from the operations of farmers and others working for longer or shorter periods during the year, in the outcroppings of lignite and lignitic coal found on their properties, for the purpose of meeting a local demand for fuel in a district where wood is scarce.

These seldom employ more than three or four men, and that only for a few months during the year, the total annual production of any one amounting to but a few hundred tons. The seat of these activities is chiefly in the vicinity of Calgary, in the foothills of the Rocky Mountains, about the creeks forming the headwaters of the Bow and Belly rivers, and to the northward, in the vicinity of Edmonton.

Similar operations have been inaugurated in the Souris and Turtle Mountain districts, south-west from Brandon, in the province of Manitoba.

BRITISH COLUMBIA.—In this province, the coal-mining industry shows a most encouraging increase of over fifty per cent on the figures for 1890. See graphic Table E.

British Columbia.

COAL.

Production, etc., in British Columbia.

The following tables, Nos. 12 and 13, give statistical data regarding the industry, and afford a means of comparison between the two years, 1890 and 1891 :—

COAL.

TABLE 12.

BRITISH COLUMBIA.

PRODUCTION, SALES, &C., FOR 1891.

Name of Colliery.	Coal raised.	Sold for home consumption.	Sold for exportation.	On hand, 1st Jan., 1891.	On hand, 1st Jan., 1892.	Number of men employed.
	Tons.	Tons.	Tons.	Tons.	Tons.	
Nanaimo ...	590,751	157,652	429,952	6,802	9,949	1,464
Wellington	386,604	61,291	316,346	2,794	11,760	957
E. Wellington..	46,666	7,748	40,523	1,605	....	188
Union.	128,567	329	116,435	3,720	15,523	585
Totals.....	1,152,588	227,020	903,256	14,921	37,232	3,194

COAL.

TABLE 13.

BRITISH COLUMBIA.

PRODUCTION, SALES, &C., FOR 1890.

Name of Colliery.	Coal raised.	Sold for home consumption.	Sold for exportation.	On hand, 1st Jan., 1890.	On hand, 1st Jan., 1891.	Number of men employed.
	Tons.	Tons.	Tons.	Tons.	Tons.	
Nanaimo	436,246	110,141	327,946	10,744	6,802	1,493
Wellington ...	195,436	78,141	119,035	3,416	2,794	646
E. Wellington..	49,954	9,502	39,348	612	1,605	170
Union.....	77,881	1,659	82,933	10,431	3,720	350
Totals.....	759,517	199,443	569,262	25,203	14,921	2,659

COAL.

Markets for British Columbia coal.

The details given below are quoted from the report of the Minister of Mines for the province to show the present condition of the industry, and its progress during the year :*—

"Continuing the statements of the various sources from which California, our chief foreign market for coal, is supplied with that commodity, I beg leave to submit hereunder a statement compiled up to the end of 1891, from an authentic commercial source :—

	1888. Tons.*	1889. Tons.*	1890. Tons.*	1891. Tons.*
British Columbia	345,681	417,904†	350,388	517,477‡
Australia	271,612	408,032	153,920	275,490
England and Wales	126,167	32,890	53,374	200,777
Scotland	10,680	12,727	1,490	34,225
U. S. Eastern States	30,118	18,950	32,701	42,237
Puget Sound	568,948	372,514	450,762	393,163
Coos Bay and Mount Diablo	81,194	87,600	74,210	90,684
Japan	13,808	1,340	13,250	20,506
Carmel Bay				1,200
Alaska				150
Total at San Francisco	1,448,208	1,351,957	1,130,095	1,575,909
At Lower Ports, viz. : Wilmington, San Pedro, and San Diego, in California	211,598	11,805	123,312	160,820
Total California	1,659,806	1,363,762	1,253,407	1,736,729

"The totals above stated are of the quantities of coal actually received into California, while some of the coal shipped in 1891 from this province, destined for that state, would be on the way and not arrive until 1892. And, on the other hand, some of the coal shipped in the province in 1890 would have arrived there in 1891, and be included in the above statement. The last year's total of coal delivered by collieries of this province and Washington State, also Coos Bay, in Oregon, called in the market 'Coast Collieries,' together with the totals of 'foreign' shipments (other than those of this province), shows a growing power of absorption of our great 'natural product' of coal, by our friendly neighbours and customers of many years past, that is most gratifying from a commercial and industrial point of view. It will be seen that in 1888 California touched the present total within about 77,000 tons, so that it may be hoped that a total of two

* The ton mentioned in the following quotation from this source is the long ton of 2,240 lbs.

† Some of this export, as of other exports in this column, were delivered at lower ports in Carlifornia, but the returns in 1889 did not distinguish the quantities, beyond the 11,805 tons. There were altogether 139,060 tons from various sources delivered at lower ports in 1889.

‡ In addition to this export of 517,477 tons from British Columbia, there was an export to and delivery at lower ports, from the province, of 123,534 tons, which is included in the 160,820 tons, noted as delivered at lower ports.

Coal. Markets for British Columbia coal.

millions will soon become the normal amount of coal consumption in California, with a rapid progressive increase, and that by wise legislation and negotiation on the part of Dominion statesmen, a treaty of reciprocity with the United States, in the article of coal, may enable our coal industry to hold its own against the severe competition it has now to sustain from the cheaper mined coal of other countries, as well as to maintain and increase our enormously developed capacity for production of this necessary staple article, of undoubted quality and utility, proved and established in the market.

"Owing to the absence of an equitable reciprocity treaty between Canada and the United States, within the past few months excessive shipments of coal from distant countries to California have so disturbed the balance of supply and demand that existed during the greater part of the past year, that a prudent diminution of output and shipment of coal took place generally from the collieries of this province, in order to ease off the glut that was brought about by such extraordinary deliveries into California, and it is calculated that early in the spring the market will have assumed its normal condition, and that the collieries of British Columbia will be worked up to their highest power, with a brisk trade, which is a result devoutly to be wished for, on behalf of our very numerous and deserving body of miners in this province, who have been for some time working only four days or less a week, while their personal, family and household expenses have been going on all the time at full rate. Otherwise, I can truly say that the collieries of Nanaimo, Wellington, and Comox were never in better condition than now, and that prospects never looked so well for putting out coal; and it may be expected that after the present lull in the coal market blows off, we shall see every mine worked to its full capacity and to the best advantage of all concerned.

Development and discovery.

"*Nanaimo Colliery.*—With the exception of a few days at the end of the year, the coal has been in good demand from this colliery during the past year.

"*No. 1 Pit, Esplanade, in Nanaimo.*—This mine, being part of the Nanaimo Colliery, belongs to the New Vancouver Coal Mining and Land Company, Limited, and is a most valuable mining property, with resources of coal that are practically inexhaustible. Now, as in previous years, the workings from No. 1 pit have been from what are known as the Nos. 1 and 2 north levels. The No. 1 level is from the bottom of the shaft (or pit), in a northerly direction, going under the water of Nanaimo Harbour, with its windings, for about two miles, being the longest underground hauling road of any colliery in the district. The face of the level is under Protection (or Douglas) Island.

Coal in here has been very good. The level is not working at present, but it stands on good coal. The coal is worked from this level on the pillar and stall system, and will average about six feet in thickness. In some parts it is thin, but at other places it is thick, and will be about the average named. All the work, for about 1,400 yards, has been on the west side, and much of this is not started away from the level. On the east side it is all solid for the above-mentioned distance; except near to the face there is a slope down 300 yards in good coal all the distance. The object of this slope is to connect with the shaft being sunk on Protection Island, which I shall refer to under its own heading.

"No. 3 level is also in good coal, and from this level a considerable quantity of coal has been taken out through the year. There has been much rock work here, but now they have got into good coal, about seven and a half feet thick, and to all appearances they have got into the same tract of excellent coal that they have been and are now working in the No. 1 level, but a long distance to the eastward of No. 1.

"Ventilation in this mine is good. When I was down in December, I found that there were 59,600 cubic feet of air passing per minute for the use of 120 men and 18 mules—23,400 feet to No. 1 level, and to No. 3 level, 36,200. The motive power to keep this volume of air circulating consists of two double fans, on the Murphy principle, on the up-cast (or No. 2) shaft, driven by steam engines, with water gauge eight-tenths. Very little gas has so far been discovered in this mine, and there is also freedom from dust.

"The management have been making great preparations in the levels, and tramways, underground, and also on the surface, for carrying out the purpose of the company to have the coal brought from those long roads to the shaft by electricity, so that in about a month, or as soon as the electric works are completed, an opportunity will be afforded of seeing the electric motors hauling the coal under the harbour, and the ships in the harbour taking the coal away to the other countries.

"*No. 3. Pit (Chase River), Nanaimo Colliery.*—This mine of the New Vancouver Coal Company has worked steadily most of the year, excepting a day occasionally for repairs. The coal from this pit has been exceptionally good, both as regards hardness and quality. As I have previously mentioned the workings here are on the pillar and stall system, and during the year, up to the 12th October, nearly all the mining had been at those pillars, but on the above date the company suspended work, and the mules, etc., were taken out of the mine. There is, however, a considerable quantity of coal

COAL. Discovery and development. —British Columbia.

obtainable in the mine, and it is the intention of the manager to let it stand till the coming summer, or till late in the spring.

"Ventilation was always good; at the time the mine stopped 45,000 cubic feet of air were passing per minute for the use of 40 men and 8 mules. The motive power here was a large fan on the up-cast shaft.

"*Southfield Mines, Nos. 1 and 2.*—Both are known as the Southfield mine of the New Vancouver Coal Company. The mine is worked by a slope, down 800 yards, but there has not been much mining done near the bottom. It has been and is now the greatest producing mine of the extensive Nanaimo colliery. The coal is hard and good. In some places the coal is 12 feet thick, much of it with a strong conglomerate roof close to the coal, making it safe to work with ordinary care. Much of the mining here is now done at the pillars, which represent fully one-third of the whole original seam of coal. Besides this, coal has been mined in stalls. This has been and is now a valuable mine, but the company have had, and yet have, faults to contend with in the workings.

"Ventilation, good; motive power, a large fan. This mine is worked on the separate split system, having three splits—two to the south and one to the north side of the slope. When I was down in December, there were 98,000 cubic feet of air passing per minute for 130 men and 9 mules. There is seldom any gas. The mine is also free from dust.

"*No. 4, Southfield Mine.*—In this slope a great deal of work has been done. The prospects not being encouraging work has been stopped for the present. Another shaft has been put down to the coal further to the dip—the shaft next mentioned as

"*No. 5 Pit, Southfield.*—In a previous report you will have seen that this shaft of the New Vancouver Coal Company, was down 100 feet, and that their trouble was then commencing, as the water was coming in freely, while the rock was very hard; but perseverance, in most cases, is sure to be rewarded, and in this case it was, for, after the company had persevered against water and hard rock, the coal was struck at the depth of 508 feet, and proved six feet and a half thick. It was somewhat soft in the bottom of the shaft, but as they worked out it got better, and is now much improved and a fine vein of coal. In starting a new work like this, after the coal is reached, there is a large amount of work to be done in the way of headgear, engines, railway, and many other things that an onlooker does not notice, and they all take time. Now they have started in earnest, and appearances are most favourable here for a good mine. This shaft is to the dip of both

Southfield Nos. 1 and 2 and No. 4 mine, and is quite a valuable acquisition to the New Vancouver Coal Co.'s colliery, and it is sincerely hoped by all their well-wishers—and they are many—that this mine will roll out the coal for years to come. This coal is much wanted in the California market, and always commands the highest market price when it is taken there. COAL. Discovery and development. —British Columbia.

"*Protection Island Shaft.*—This is the property and new work of the New Vancouver Coal Company, and is on the south point of Protection (or Douglas) Island, and on the north side of Nanaimo Harbour. The workings of No. 1 shaft, Esplanade, Nanaimo, extend under this island, and the company knowing that the coal was good, but having a long distance to haul it underground, and judging from the character of the formation on the surface along the coast line and into the sea that, in all likelihood, the coal extended for miles, concluded to put this shaft down on the island. The contract for sinking the shaft was let early in the spring of 1891, and on the 12th of March work commenced, and has continued on to the finish almost without a stoppage of any kind until the 12th of January of this year, when it was successfully finished at a depth of 670 feet. The size of the shaft is 18 by 12 feet in the finish, timbered with plank four inches thick, and with a partition dividing it into two compartments from top to bottom. Here, as was expected, the coal is five feet thick. On the 22nd January, 1892, they holed through on to the slope mentioned, as put down near to the face of No. 1 level in No. 1 shaft, and, after arrangements are complete, that will be the intake for the air of No. 1 level, which will be a great relief to that mine. The air will only have to go through, in place of having to go in and come out. Although the shaft is down, there is yet much work to be done before they can say that they have got fairly started to ship coal from the Protection Island shaft.

"The company are now erecting a large double hoisting engine, which will be the machine for taking out the coal from this place. The cylinders of this engine are 26 inches, with 42-inch stroke. It was made by the Hamilton Manufacturing Co., Peterborough, Ont. The headgear is also framed and put together, ready for hoisting into position, but, in addition to what is already accomplished, there is much to be done, viz., the putting up, and the fillings about the pit head. There is only a short piece of railway to make, and that is nearly ready for the rails. There is a complete set of new wharfs to build, which will have to be done before much coal can be taken away from this new pit, but from what I have seen this company do, I am satisfied that all the works required here will be carried on with the

COAL.
Discovery and development. —British Columbia.

greatest speed, so that they may be able to take coal into the ships for foreign ports. With the great prospects here for coal, and the largest ships being able to go within 400 feet of the mouth of the shaft, the company will be able to compete for putting the coal into the market as cheaply, if not at less price, than any that can oppose them.

"The New Vancouver Coal Company has made a large outlay of capital, but it would be hard to represent the vast amount of coal that stands in view against the outlay, and to all appearance this is going to be the coal mine of Nanaimo.

"*Northfield Mine, Nanaimo Colliery.*—This mine, mentioned in a previous report, is in the northern part of the extensive estate of the New Vancouver Coal Mining and Land Company, hence the name Northfield, which seems to be very appropriate, as in the other end of the estate there is the Southfield mine. This mine is entered by a shaft, and from the bottom of the shaft there is the south level, and on the north side there is also a level of this name; but the principal part of the mining at present is from a slope starting from near the shaft on this side, running about north-east.

"Work has been going on steadily during the past year, except on occasions that could not well be avoided, as the repairing day must come to all works where machinery is one of the prime movers. The coal from the Northfield mine is hard and of a very good quality. It is in brisk demand in the Victoria (B.C.) and California markets, and in other places where it has been introduced always commands the highest price.

"The coal is worked on the longwall system, from the levels and both sides of the slope, and is of a varied thickness of from two to four feet.

"Ventilation is good, but owing to the system in use the air goes along the face, and about shot-firing time in some places there is smoke, quite a large quantity of powder being used. The ventilation being on the separate split system, the smoke soon goes past. When I was down, in December, I found that there were 62,640 cubic feet of air passing per minute for the use of 130 men and 5 mules, and in the following divisions: two main splits from the shaft to the north and south sides; to the north split there were 30,960 cubic feet; this goes down the slope, and is again divided to each side along the face of the workings to where it has to leave them, when it goes along the air-way to the up-cast shaft. On the south side there was 31,680 cubic feet passing per minute. This went in by the south level and returned by the way of the face (coal) to the up-cast shaft. There is little or no gas in the mine, which is also free from dust.

Discovery and development. —British Columbia.

"*The Harewood Estate (Nanaimo Colliery).*—This estate is now the property of the New Vancouver Coal Mining and Land Company. Considerable prospecting has been done on this estate at different times, but the company got the diamond drill to work during the past summer, at about one mile and a half in a south-east direction from the old Harewood mine. This bore-hole got on well, and when down 150 feet they struck the coal, which proved by boring to be five feet six inches thick. They were so well satisfied with the prospects that they commenced to sink a shaft as soon as tools and machinery could be got on the ground, and expect to reach the coal early in the spring. It is to be hoped that this company will be successful in their enterprise. Previous to the company acquiring the property, two parties attempted coal mining here, but both failed to make it a success, and I trust that it now remains for the New Vancouver Coal Company to be the winning party.

"*Prospecting by the New V. C. Co.*—There has been much prospecting and exploring by the New Vancouver Coal Company. In addition to the sinking of the shaft mentioned, they have just put down a series of bores in their Northfield estate, and from the encouragement afforded by the prospects of those bores, we may expect to see a shaft started in the Northfield estate soon.

"*Wellington Colliery—No. 1 Pit.*—This pit is near to Departure Bay, and was put down to the coal about fourteen years ago, but excepting a little coal taken out of one of the upper seams, no mining was performed. Work was resumed here about four months ago to erect machinery and all the necessary works for the sinking of a shaft. As this shaft was only a small hole, they started at the surface to enlarge it to the usual size of the shafts in this colliery, expecting to reach the coal early in the spring. The calculation is that good coal will be found here, which will be good for the district, as well as for Messrs. Dunsmuir & Sons.

"*No. 3 Pit, Wellington Colliery.*—With the exception of keeping the water out, there has been little or no mining done here, yet there is quite a large quantity of coal to come out of this shaft.

"*No. 4 Pit, Wellington Colliery.*—This pit is about 1,000 yards to the east of No. 3 shaft, and is connected by a good travelling road to the same. Here, as in all the working mines of this colliery, the men have been working regularly during the past year, except a day now and again to perform repairs that were necessary. The coal is in good demand in the California market and in other places to where it was sent, as well as by steam-boats calling for fuel, and for home consumption.

COAL.
Discovery and development. —British Columbia.

"This mine is worked on the pillar and stall system, and in some districts there has been much mining done, in taking out the pillars, which are fully a third of the whole. The coal is hard, and of the usual good quality of the Wellington coal. This is a very extensive mine, being well spread out. It is worked in four districts, viz., south, east, north, and west. No expense is spared to make the works safe. Ventilation is very good. Motive power, a large fan on the up-cast shaft, which is about 500 yards north of No. 4 shaft. The south side is ventilated from No. 3 pit. You will have seen that this mine is ventilated on the separate split system. The air is split at the bottom of the shaft, taking, what are called, the north and south sides. That going to the south is diverted to the east level, and that to the north is for the north and west workings, and, as I have said, the south side is ventilated from No. 3 pit. When I was down in December I found that there were 130,400 cubic feet of air passing per minute, with a velocity of 1,450 feet per minute, and this was for 196 men and 18 mules. The mine is free from coal dust, but in some places they have a regular system of pipes to put water on, where or when it might be required.

"In addition to the manager there is a general superintendent, and the overman and fireman, besides a staff of shot lighters, to examine and see that everything is safe before a shot can be fired, and also to examine the place after the shot is fired, to see that the place is safe, and to give instructions if it is otherwise. The staff use safety lamps only, and in the absence of the overman have all the power that is necessary to have everything that may be found or appear to be dangerous made safe. There is now very little gas to be found in this mine.

"*No. 5 Pit, Wellington Colliery.*—As mentioned in a previous report, this is the only mine of the Wellington Colliery that has connection with the Esquimalt and Nanaimo Railway, by which the principal part of this famous coal which is used in Victoria finds its way to the market. To this mine Messrs. Dunsmuir & Sons have also an extension of their own railway system in connection with their shipping point at Departure Bay.

"In this pit, as in the other mines of this colliery, the men have been working steadily the most of the year, except a day occasionally during the past two months.

"This is a very extensive mine. The coal is brought to the shaft from the east by a level, from the north by a slope, and from the south and west by a self-acting incline. In the east the coal is mined on the pillar and stall system: in the slope it is longwall, and in the south

Discovery and development.—British Columbia.

and west incline all the mining is at the pillars (coal) which contains fully one-half of the whole which was in the district. In the longwall, down the slope, there is a long face working of about half a mile in one stretch, all good coal, without a fault of the smallest kind, and from four and a half to eight feet thick, so that in all the districts of this mine it never looked better nor had as good an opening for taking out coal as there is now.

"Ventilation is very good. Motive power, a large fan on the upcast shaft driven by a steam engine. When I was down, in December, I found that there were 112,222 cubic feet of air passing for the use of 197 men and 19 mules; fan making 99 revolutions per minute; water gauge $\frac{8}{10}$ of an inch. This mine is ventilated on the separate split system, the three main divisions being at the bottom of the shaft, to the east level, 35,340 cubic feet per minute, which is again split away further in the level, for the use of 70 men and 10 mules. There were 32,860 feet per minute going down the slope, this being also divided into two currents down the slope, and being for 80 men and 3 mules. In the south incline and west level there were 44,020 cubic feet circulating per minute, for 47 men and 6 mules. In this division it will be observed, that there are the least men, but most air passing. That is owing to the fact that all the mining being done here is at the pillars (coal) and sothat all the caves from the roof may be kept clear. There is very little gas now found here, but occasionally it is seen in the longwall workings, when there is a fall of rock, and then not often, as there is a strong air blowing along the face. This mine is also free from coal dust.

"In addition to the overman and fireman, there is a staff of shot lighters and examiners in each district. These men have to be in all the places at different times every shift, so that very little that happens can escape their notice. They cannot be long in one place unless something special requires them to stay.

"*No. 6 Pit, Wellington Colliery.*—This pit is mentioned in a previous report as being about 900 yards east of No. 4 pit, yet the workings of the two mines are quite close to each other, leaving a solid strip of about 40 yards, as it is not intended that the two should be connected. This will be an extensive mine, there being a very large area of ground solid in coal to be taken out. Coal is hard, and of the usual good quality of the Wellington seam, varying in thickness from four to eight feet. There is much of this mine worked on the pillar and stall system, which works well; but there are two other districts where longwall is found to work well, and this is the favourite work of this mine for getting coal.

COAL.

Discovery and development. —British. Columbia.

"Ventilation is very good, and on the separate split system; there are five separate splits in the air, all of them near to the bottom of the shaft, three on the east and two on the west side from the shaft, and the air is well conducted to the face of the pillar and stall working, by brattice and otherwise. In the longwall works the air goes along the face, some escaping at each road, is caught when it gets to the face; this keeps the roadway free from any impurities. In December last, when I was down, there were 75,000 cubic feet of air passing per minute. The motive power of this is a fan on the same shaft as the coal is hoisted from, there being a tight partition in the shaft, and one-half of the shaft being the intake and the other the exhaust.

"The air passing as above per minute is for the use of 130 men and 8 mules. There is very little gas found in this mine, but what is found comes mostly from the roof in the longwall, when it breaks up in holes.

"This pit is now connected and has a travelling road to No. 5 pit; the connection is only in one place; and there are doors, so that one pit cannot injure the other by taking away the air; both being independent, except the travelling road.

"This mine is free from coal dust; it is not what can be called a wet mine, and yet it is not dry.

"*No. 2 Slope, Wellington Colliery.*—There has not been any work done here during the past year.

"*Alexandra Mine.*—This mine belongs to Messrs. Dunsmuir & Sons, and is about one mile south of the Southfield mine of the New Vancouver Coal Company's Nanaimo colliery. There has not been any work done here during the last year, but I have been informed that it is expected something will be done with this place in the spring.

"*East Wellington Colliery.*—This colliery belongs to the East Wellington Coal Company, and comprises two shafts.

"In No. 1 pit only a few men are mining coal, and that is near to the No. 2 pit. The coal is of excellent quality, hard, but thin for what is known as the Wellington seam. The coal on the west side of this shaft is getting well worked out. On the east side, or what is called the east level, there has not been any regular vein of coal yet, but they are working in the place where the coal should be, and there are yet good hopes that there will be good coal got in this side, which is where the larger area of the company's land is situated, and the expectation is that it will in the near future prove to the company that it is the most valuable part of their property in this district.

"*No. 2 Pit, East Wellington.*—In this pit they have been working steadily all the year, except when repairs have been needed. Coal is good and is in full demand in the San Francisco market.

COAL. Discovery and development. —British. Columbia.

"This mine, as well as the No. 1 mine of this company, is worked on the longwall system, although the roof is very soft, and the coal has been considerably broken, which makes it very difficult to work. There is quite a large body of coal in sight, with narrow roads run into it. Some of the places look well, and it is hoped that these prospects will not disappoint the fair expectations raised by them, as the company and its management have been persevering and pressing forward, and are highly deserving of success.

"Ventilation is good. Motive power a fan, erected near the top of No. 1 pit, which is the up-cast for both No. 1 and No. 2 pits. When I was down in December I found there were 20,000 cubic feet of air passing per minute for the use of 35 men and 5 mules. This current is split at the bottom of No. 2 shaft; 5,000 per minute going to those in the west side, and 15,000 to the east side, but both connect and go in one volume to the No. 1 pit. This being longwall working, the greater part of the air goes along the face, the remainder escaping at the roads and keeping them clear. There is very little gas seen in this mine, there not being much chance for it to collect, the old works being well filled in nearly every particular, and every precaution is taken to prevent accidents of any kind. In addition to the manager and overman, there are three firemen, one on each shift of eight hours, going about the works. As there are not many miners working the fireman can see all the places frequently during the day.

"*Union Colliery, Comox.*—This colliery belongs to the Union Colliery Company. The mines are only a few miles from the extensive farming settlement of Comox, with a good road thereto. There have been three mines on three veins here, but at present the company are working in two of the veins. The upper seam (or vein) comes out on the hill in the south side of the railway, and into this there are the Nos. 1 and 2 tunnels or adit levels. No. 1, the lowest one, is in about 600 feet; No. 2 is in about 1,000 feet. Coal is hard and of a good quality, and from two to three feet thick, with a strong sandstone rock for a roof. This is mined on the longwall system, making very safe workings.

"Ventilation very good. Motive power a furnace; the air going in both tunnels and returning by the way of the face of the workings. There has not been any gas found in this mine, and it is free from dust.

COAL.
Discovery and development.—British Columbia.

"*No. 1 Shaft, Union Colliery.*—There is nothing being done here at present, and there has been very little done during the past year.

"*No. 1 Slope, Union Colliery.*—This slope is mentioned in a previous report as down about 700 yards. There are three levels from this slope to the north side. The coal here is of good quality and very hard, but they are much troubled with faults, although it is improving as they go north, and now it varies in thickness from three to seven feet. This is worked on the pillar and stall principle; some of the places are very soft, and in other places it is very strong.

"Ventilation good. Motive power a fan on Murphy principle, driven by a steam engine. This mine is ventilated on the separate split system, the intake being the slope, afterwards it is split into two divisions, one for No. 4 level and the other for No. 3; after going round the working places it again gets into one volume and goes along the air-way and out at the up-cast shaft. When I was down in December I found that there were 23,400 cubic feet of air passing in this mine per minute, for the use of 70 miners. The mine gives off some gas, as the roof is soft in some places and it falls out, leaving a hole, and those are the places that give the trouble. There is a fireman on each shift to examine and attend to the safety of the mine, in conjunction with the overman. There is no dust in this mine, it being wet throughout.

"*No. 4 Slope, Union Colliery.*—This is the new mine mentioned in my former report as No. 2 slope, and then just getting opened out. This is now down about 400 yards. The coal is of varied thickness, from five to eight feet for the whole distance.

"The coal is very hard and of good quality; in texture it resembles Wellington coal. The engineer of one of the large steam-ships that load here informed me that it gave better results than any coal he has used on the coast. At the face of the slope just now the coal is seven feet thick and hard, proving a most valuable piece of property to the company. This mine is worked on the pillar and stall system, the works being to both sides of the slope. They are now taking about 400 tons of coal per day from this mine.

"Ventilation is very good, and on the separate split system. The laying out of the mine is very well arranged for proper ventilation; motive power is a fan. In December, on my inspection, there were 39,200 cubic feet of air passing per minute, the fan running slow, for the use of 100 men. The mine is free from dust. There is no gas in the mine.

"From what the management know, by a series of bore-holes, great work is expected from this place, and no expense is spared to put it in first-class order.

Coal.

Discovery and development. —British Columbia.

"There is a large trestle work from the entrance of this mine, rising gradually until it gets to the height required; then there is quite a long flat place where the cars that come out of the mine can stand, so that little energy is used to make them go either way. The car dumping or tipping appliances here are the finest and easiest on coal, so as not to break it, of any in the province, and quite a mechanical invention. The loaded car goes on to the tipper just enough to let the coal out, when it comes back again to the level and the next car comes along, sends the first car over the machine and gets on to a lower level, then runs back nearly to the top of the slope, or far enough to fill in when there is a train of them. The connection between the hoisting and tail ropes seems to work to perfection, one or two men being able to handle all the coal that can be brought from the mine. At this mine there is also a large double winding engine, specially constructed and geared to double drums, which is the mode used here and seems to work very well. The steam engine and machinery for both the tipping and hauling came from the Eastern States.

"In this mine the company have introduced, and have been working for the past five months, coal mining machinery from the Jeffrey Manufacturing Company, Columbus, Ohio; operated by electricity. With the exception of the coal mining machines, the engines, dynamos, and all other appliances are out on the surface about 300 feet from the entrance of the mine; the connection being made to the mine by heavy wire, which is easily connected to the coal mining plant, of which there are four different motors with coal cutters. Either one or all four can be used as required, and at any place, just to suit where work is wanted to be done. They do good work, and, what is about the hardest to do, viz., undermining, this being the work that they are made for. The machines, when at work, stand end on to the face of the coal, with the cutter bar three feet three inches long; this at regular distances from each other is set with teeth, so that there is four inches cut, neither more nor less. After the machine is set in motion, in four minutes it has undermined a hole close to the floor three feet three inches wide, six feet in the face and four inches high; when it has done this work it comes out again, and then it is put over for another cut, which takes about five minutes, and so on until the place is all undermined, when a shot in each corner will bring all the coal down that is undermined. About one of the best day's work that one of these machines has done here was to undermine ninety feet long and six feet deep; this must have been a great saving in powder and coal, not to say anything in the saving of labour.

COAL. Discovery and development. —British Columbia.

"*Tumbo Island Coal Mining Company.*—The island of the above name is situated at the south-east entrance of the Straits of Georgia, and about two miles north-west of East Point Lighthouse. There has been but little work done here during the past year. The old company have negotiated with another party, who has started in earnest and is now sinking a shaft on the south side of the island, this having been previously bored to the coal at the depth of 325 feet. It is hoped that the company will make a successful find in this valuable property. A colliery here will not be out of the way for steam-boats going between Victoria and the mainland, and would also be most convenient for the coaling of the China steam-ships, as they go close past, within hailing distance. A good colliery here would be a fine thing for the company having the same, and also for the province in general.

"*Nanaimo Colliery.*—Name of seams or pits—Southfield No. 2, Southfield No. 3, Southfield No. 5, No. 1 Esplanade shaft, and No. 1 Northfield shaft.

"Value of plant—$350,000.

"Description of seams, tunnels, levels, shafts, &c., and number of same—Southfield No. 2, worked by slope, seam 6 to 10 feet; Southfield No. 3, worked by shaft, seam 5 to 10 feet; Southfield No. 5, worked by shaft, seam 5 to 10 feet; No. 1 Esplanade shaft, worked by shaft, seam 5 to 12 feet; No. 1 Northfield shaft, worked by shaft, seam 4 feet 6 inches.

"Description of length of tramway, plant, &c.—Railway to Southfield, 6 miles, with sidings; railway to No. 1 shaft, 1 mile, with sidings; railway from Northfield mine to wharf at Departure Bay, 4½ miles; rails are of steel, 56 pounds per yard, of standard gauge, viz., 4 feet 8½ inches; 8 hauling and pumping engines; 15 steam pumps; 5 locomotives; 200 coal cars (6 tons), besides lumber and ballast cars; fitting shops for machinery repairs, with turning lathes, boring, drilling, planing, screw-cutting machines, hydraulic press, steam hammer, &c., &c.; diamond boring machinery for exploratory work (bores to 4,000 feet); wharfs, 1,070 feet frontage, at which ships of the largest size can load at all stages of the tide.

"*Wellington Colliery.*—Name of seams or pits—Wellington.

"Value of plant—$150,000.

"Description of seams, tunnels, levels, shafts, &c., and number of same—4 shafts with slopes, air-ways and levels; 3 air shafts; 1 shaft sinking.

"Description and length of tramway, plant, &c.—5 miles of railway, with sidings and branches; 6 locomotives; 250 coal cars; 13 station-

ary engines; 9 steam pumps; 4 wharfs for loading vessels; and bunkers. COAL. Discovery and development. —British Columbia.

"*East Wellington Colliery.*—Name of seams or pits—East Wellington Coal Co.'s Nos. 1 and 2 shafts.

"Value of plant—$100,000.

"Description of seams, tunnels, levels, shafts, &c., and number of same—1 seam, 2½ to 7½ feet; 2 shafts; 7 levels.

"Description and length of tramway, plant, &c.—4½ miles standard narrow gauge; 2 locomotives; 31 (4½-ton) coal cars; 2 hoisting engines; 2 donkey engines; 1 steam pile driver; 1 steam saw-mill, capacity 12,000 feet per day; 5 steam pumps.

"*Union Colliery.*—Name of seams or pits—Union and Lake.

"Value of plant—$100,000.

"Description of seams, tunnels, levels shafts, &c., and number of same—Nos. 1, 2, and 4 slope, with air-ways and levels; Nos. 1 and 2 tunnels.

"Description and length of tramway, plant, &c.—12 miles of railway, 4 feet 8½ inches gauge; 4 locomotives; 100 coal cars, 25 tons each; 1 diamond drill; 3 stationary engines; 3 steam pumps; 1 steam saw-mill; 2 wharfs; 1 pile hammer."

Apart from the coal production of the above described districts, the coal of the interior was mined in the Tertiary rocks of the Nicola Valley. This was a very small amount and was for local consumption only. Nicola Valley

Attention has been directed, however, and a great deal of interest taken in the coal occurring in the vicinity of the Crow's Nest Pass, which crosses the divide between the province and the Territories. To this place the director of the Geological Survey paid a visit of inspection in July, the results of which he gives as follows :— Crow's Nest Pass.

"On the 30th of July we camped at Lee's Lake, on the Crow's Nest Pass trail. On the 31st Col. Baker joined me here, and on the following day we camped at the east end of Crow's Nest Lake, and on the next day, 2nd of August, we reached the coal prospecting camp situated about 1,200 feet above the trail, on the ridge which runs in a north-easterly direction between Marten Creek and Michel Creek and forms the west side of the valley of the west branch of Michel Creek. From this ridge a number of spurs with steep intervening gullies descend abruptly to the trail; in these and on the intervening ridges a wonderful series of coal seams is disclosed, one above the other from near the level of the trail to the summit of the ridge.

COAL. Crow's Nest Pass.

"No exact measurements were taken and it may be that some of the lower cannel seams are the upper ones repeated by faulting. The outcrops which can all be seen on the ground are as follows, twenty seams in all, showing a total thickness of 132 feet of coal :

	Feet.	
No. 1	5	No. 1 to 10 inclusive are cannel coals.
2	3	
3	4	
4	2	
5	4	
6	3	
7	2	
8	4	
9	5	
10	6	
11	4	
12 (Peter seam)	15	
13	7	
14 (Selwyn seam)	6	So named by Col. Baker.
15 (Jubilee do)	30	
16 (Williams do)	20	
17	5	These four are cannel coal.
18	3	
19	2	
20	2	
	132	

"The number and thickness of these seams in the above table are as supplied me by Mr. Fernie, who has superintended all the exploratory work that has been done on the seams. Between the most eastern outcrops I examined, and the western ones close to the junction of Marten Creek and the west branch of Michel Creek, is a distance of about two miles along the steep mountain side, to the north of the trail. Within this distance the outcrops were seen of nearly all these seams, either on the ridges or in the sides of the ravines which score the face of the mountain. The few hours I was able to spend on the ground, while not sufficient to enable me to affirm the absolute correctness of the details of the table, were, however, ample to enable me to see that there is in the Crow's Nest pass, between the eastern summit, 4,330 feet above tide, and the valley of Elk River, in British Columbia, an area of not less than 144 square miles, that is destined to be one of the most valuable and most productive coal fields in Canada. A rough calculation would give about 49,952,000 tons per square mile. If one-half of this is available, there are in each square mile 24,976,000 tons. The average elevation of the field is about the same as that of Canmore and Banff, or between 4,000 and 5,000 feet. From

Pincher Creek westward to Elk River, the pass presents no difficulties for railway construction. The eastern entrance to the pass in Alberta is 3,800 feet, and where it comes out on the Elk River is 3,300 feet; the highest intervening summit being 5,500 feet. A better route to the Elk River, however, than that of the present trail, would be to follow down Michel Creek, from near the eastern summit, and thus avoid the western and higher summit, and reach Elk River about ten miles above the mouth of Coal Creek. The distance through the pass from Lee's Lake, Alberta, to the Elk River, is about thirty-seven miles. COAL. Crow's Nest Pass.

"On the 4th of August, after devoting the forenoon to a further examination of the Marten Creek seams, we proceeded through the pass and reached Elk River at 6 p.m. No coal seams were seen till about four miles above the mouth of Coal Creek; here at the mouth of a steep rocky gully, about 200 yards to the right of the trail, a fine seam of coal, 7 feet thick, had been cut into. The section exposed showed in descending order:

Shale	10	feet.
Hard ferruginous band	1	
Coal	1·6	
Shale	7·6	
Coal	7·6	

"Cherty conglomerate and massive gritty sandstones are seen both above and below; the dip is about E. 10° N. 15°—20°. A close search along the mountain side, between here and the water-shed at the head of Coal Creek, would almost certainly disclose the outcrops of many more of the Marten Creek seams.

"On the 5th of August, we descended the Elk River valley, about seven miles, then turning to the left ascended the mountain, a steep climb of 1,500 feet. Here on top of a broken-down cliff of massive sandstone, about 50 feet thick, we came to the first of a series of coal seams; the dip being E. 20° N. 35° and the seam 25 to 30 feet thick, with a shale parting about 2 feet; bar. 24·93. Ascending 130 feet over shales and brown thick-bedded sandstone forming a similar broken-down cliff of about 50 feet, a second seam of coal was reached, also 30 feet thick; bar. 24·80. Above this four more seams were examined:

No. 3	15 feet,	bar.	24·57
4	4 do	do	24·50
5	7 do	do	24·42
6	30 do	do	24·35

COAL. Crow's Nest Pass.

"Above No. 6 there are six more seams which were not visited, but the particulars of which given me by Mr. Fernie are as follows :—

No. 7.....	10	feet—	100	feet from	No. 6
8.....	4	do	100	do	7
9.....	7	do	100	do	8
10.....	2	do	100	do	9
11.....	7	do	100	do	10
12.....	4	do	200	do	11

"The distances are approximate only, they have not been measured.

"The above gives a total thickness of 148 feet of coal against 132 feet in the Marten Creek area on the eastern side of the basin, while in other respects the seams correspond so closely as to make it almost certain that, except where cut out in the valleys, they are continuous beneath the whole intervening area. For much detailed information respecting the Crow's Nest Pass the Annual Report of the Geological Survey, Vol. I., part B., 1885, already cited, and the accompanying map, can be referred to.

"Many of the seams are first-class coking coals, and others are good gas coals, but none of them are anthracites. For analyses of those of the Jubilee and Peter seams, Marten Creek, see Annual Report Geological Survey, Vol. III., part II., pp. 12 s. to 15 s., and for those of the 'cannel' seams, Vol. IV., pp. 7 R. and 8 R.

"On the 6th of August I reached Pincher Creek, and Ottawa on the 14th."

Coke.

Coke.

In this industry there is little new to report. The production, viz., 57,084 tons, valued at $175,592, shows a slight increase over the figures of last year, which were 56,450 tons and $166,298 respectively. This all represents oven-coke and, as in former years, is all the production of the province of Nova Scotia.

Although slight, there has been a steady growth in this industry, as shown by the subjoined figures for past years, obtained from direct returns to this office :—

1886.....	35,396	tons,	valued at	$101,940
1887.....	40,428	"	"	135,951
1888.....	45,373	"	"	134,181
1889.....	54,539	"	"	155,043
1890.....	56,450	"	"	166,298
1891.....	57,084	"	"	175,592

Most of the product represented by the above figures, is used in the iron smelting industry.

The following table, No. 1, gives, as stated, the imports of oven-coke only, but besides this, the books of the Customs Department show an importation of a small amount of gas coke to the extent of 494 tons, valued at $1,934. This would represent a home consumption of 96,111 tons, apart from the large and unknown quantities of gas coke, resulting as a by-product from the manufacture of illuminating gas throughout the country. COAL. Coke.

COKE.

TABLE 1.

IMPORTS OF OVEN COKE.

Fiscal Year.	Tons.	Value.
1880	3,837	$19,353
1881	5,492	26,123
1882	8,157	36,670
1883	8,943	38,588
1884	11,207	44,518
1885	11,564	41,391
1886	11,858	39,756
1887	15,110	56,222
1888	25,487	102,334
1889	29,557	91,902
1890	36,564	133,344
1891	38,533	177,605

COPPER.

PRODUCTION.

In the matter of the production of this metal in the Dominion there is little new to report. The total amount is made up as under, viz. :— COPPER. Production.

	Lbs.
Quebec	5,401,704
Ontario	3,527,217
	8,928,921

This amount, taken at 13 cents per pound, which was the average market price for the year, gives a value of $1,160,760. As compared with last year'sfigures, viz., 6,013,671 pounds and $902,050, there is shown a considerable increase, over 46 per cent in the one case and over 28 per cent in the other. The lesser increase in the values is due to a lowering of the average price for the present year of two cents per pound as compared with 1890. The amount of the total, as given above, represents, as in former years, the copper contents of the sul-

COPPER. Production.

phuretted ores mined in the Eastern Townships of Quebec and of the nickeliferous pyrrhotite of the Sudbury district. The basis of valuation adopted has, as formerly, been the average market price of Lake copper for the year, but whilst it is manifestly best in illustrating the annual realization of the mineral resources of the community to conform thus to a uniform and definite standard of valuation for the metallic products, it must be borne in mind that the actual value to the producer is much below this and dependent upon the state of concentration in which he ships his product, its more or less refractory nature, etc. Thus for the same district different operators may ship very varying grades of material, raw ore, partly concentrated material, or, in some cases, the final metallic product itself, and further, the policy of the individual operators themselves is being constantly changed in this respect.

DISCOVERY AND DEVELOPMENT.

Discovery and development.

There is little or nothing new to note in this respect, the condition of the industry continuing much the same as last year.

Nova Scotia.

NOVA SCOTIA.—In Nova Scotia work was continued at the Coxheath copper mine, working sulphuretted ores of the metal, the particulars of which are given in the report of the Department of Mines for that province as follows:—

"There is little new to report. A lease to work copper ore at Brierly Brook was applied for by B. G. Gray and J. A. Grant.

"At Coxheath a good deal of work was done. The following will give an idea of the increased value shown by last season's operations at this important mine:—

"The principal mining development at the Coxheath mine during the year has been the sinking of No. 2 shaft to the 320 feet level; at that depth a cross-cut was driven to the north, which cut the 'B' vein at 89 feet from the centre of the shaft, which is about the same distance from the shaft at which this vein was encountered in the 250 feet level; the hanging wall was cut at 141 feet from the shaft. The main ore body in the vein is about 17 feet in width, and the ore averages in quality fully as high grade as in the upper levels; low grade ore is scattered through the remainder of the vein on this level, and the outlook is certainly encouraging for values entirely out of the usual order. The company intend to sink this shaft to the 400 feet level before hoisting ore for market.

"On the New Mountain vein, No. 3 shaft was sunk to its first level at 100 feet, but the vein was not driven upon when operations closed

for the season. This vein is of great promise, and several other explorative pits were sunk on it at various points, with good results; and the surface work has located the point of junction of this vein with vein 'B' at a location about 1,700 feet easterly from No. 3 shaft, and 1,300 feet easterly from No. 2 shaft. COPPER. Discovery and development. —Nova Scotia

"A new residence has been erected for the mining captain and staff, and a grade crossing of the Cape Breton Railway been granted by the Dominion authorities.

"On the Argyle area work was confined to additional surface prospect work. In August the mine was visited and reported upon by Geo. Grant Francis, M.E., of London, and Mr. Walter Ingalls of the staff of the 'New York Engineering and Mining Journal;' at that time it was estimated that the ore on the dumps amounted to about 3,000 tons, with a total amount of ore in sight of 42,732 tons; since then the cutting of 'B' vein on the 320 feet level has increased the ore in sight to about 50,000 tons.

"The following is the labour return for 1891:

	Days.
Skilled labour, underground.....	5,941
Unskilled " "	3,867
Skilled " overground.....	2,930
Unskilled " "	4,492
Coal teamster, &c.....	1,249
"Total	18,679

"During the year Mr. Peters visited the mine and perfected plans for concentrating and smelting works. As usual, the work at the mine has been lessened during the winter, but it is hoped that in the spring the construction of the railway will be proceeded with."

QUEBEC.—Development and production has been continued on the same lines as those of last year by the same firms and companies operating the mines at Capelton and Eustis and the Howard and Moulton Hill mines. At the two latter the work was largely of a developmental nature, as it was also at the Harvey Hill mine, near East Broughton, on the Quebec Central Railway. The Excelsior Copper Co., formerly operating this mine, has been reorganized, and is now known as the Leeds Copper Company (Limited). Active operations at this point were suspended late in the year. Quebec.

NEW BRUNSWICK.—In this province, outside of various reports of discovery of copper-bearing veins, about which no further details are to hand, there is nothing to report. New Brunswick.

COPPER.

Discovery and development. —Ontario.

ONTARIO.—As stated above, the copper shipped from this province is contained in the matte and other products resulting from the mining of the nickel ore deposits at Sudbury. As thus contained in the matte produced, its spot value is, of course, far below its market value when finally extracted from the same. As, therefore, it does not as yet suit the arrangements of the producers to push the process of extraction in Canada to its final end, the price obtained by them for the copper will be very low. One of the large operators explains to us that its value in this association will not be more than from 4 to 6 cents per pound. Taking them on an average of 5 cents, the spot value of the copper produced in Ontario will be $206,385.

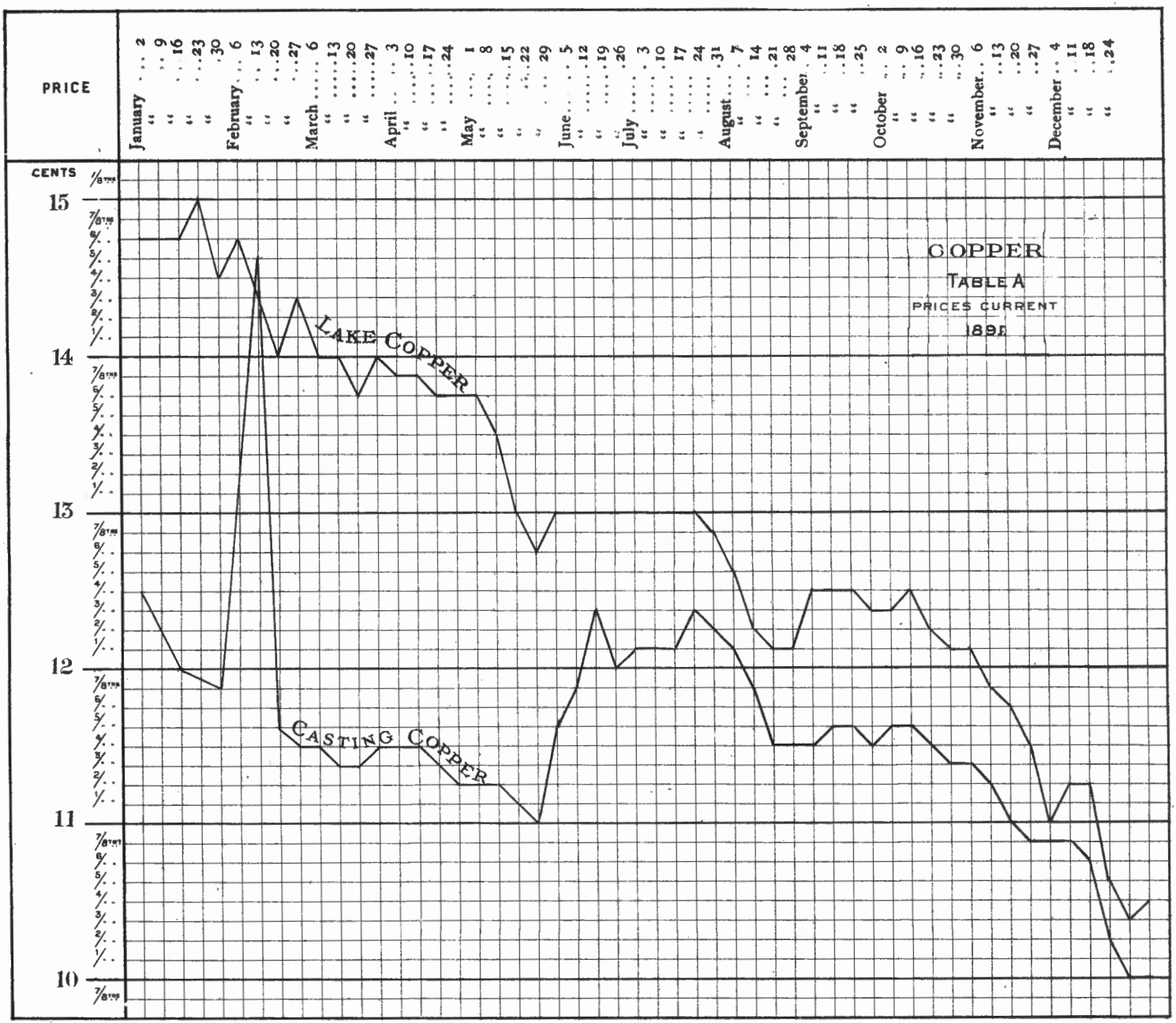
Outside of the productive operations above alluded to, the ordinary amount of sporadic prospecting has been carried on in the province, a specially interesting feature being the start made in the fall to further test the native copper-bearing rocks of the Keeweena formation at Mamainse, about 40 miles north-west of Sault Ste. Marie, on the east shore of Lake Superior. Here a small force of men has been placed with the necessary machinery and provisions for some months' work.

British Columbia.

BRITISH COLUMBIA.—From this province news continues to come in of new discoveries of veins carrying sulphuretted ores of copper, generally intermixed with galena, and of further test works prosecuted upon similar veins found in the last few years, which ores being argentiferous, particulars of the work done are given in the article on "Precious Metals."

Great interest centres in the Kootenay district, in which these veins are mostly located, and whilst the progress made towards establishing the mines upon a complete and profitable basis has not been so rapid as could be wished, still the opening up of the country by the various contemplated lines of railway can hardly be much longer delayed, when the realization may be fairly expected of the bright hopes entertained for the success of this section of the country, and a considerable addition can be expected to Canada's annual production of copper.

Outside of the Kootenay district, some interesting finds are reported in the report of the Minister of Mines for the province, one in the Similkameen district, where three veins of "peacock copper ore" have been located on Friday Creek, a tributary of the Similkameen River. On one claim a tunnel 100 feet long has been driven, at the end of which the vein is reported six feet wide. Over $1,000 have been spent on these three claims during the season. Other discoveries are alluded to situate on Copper Creek, which empties into Kamloops Lake about three miles east of Savona. "Some splendid samples of


PRICE
January 2 9 16 23 30
February 6 13 20 27
March 6 13 20 27
April 3 10 17 24
May 1 8 15 22 29
June 5 12 19 26
July 3 10 17 24 31
August 7 14 21 28
September 4 11 18 25
October 2 9 16 23 30
November 6 13 20 27
December 4 11 18 24
CENTS
15
14
13
12
11
10
LAKE COPPER
CASTING COPPER
COPPER
TABLE A
PRICES CURRENT
1891

native copper have been taken from them, but sufficient work has not been done to determine the importance of the deposit." COPPER.

MARKETS AND PRICES.

Markets and prices.

The accompanying graphic table "A" shows the fluctuation in the price of this metal, which, compared with last year, shows a continuation in the fall in price which began in the middle of November in that year.

Most of the copper products shipped from Canada go to the United States, a smaller proportion going to Great Britain. With regard to the nickel copper mattes shipped from Sudbury, the difficulties regarding the economical separation of the metals experienced by the refiners by late discoveries and methods adopted seem now to be largely removed; alluding to which fact the *Engineering and Mining Journal* of New York points out that owing to this "and the new and larger markets found for the nickel, the large development of these great Canadian deposits may be expected. The large purchases of nickel mattes by the United States Government for use in making armour plate has been a great advantage to the Canadian producer, even though the price he realized was far below any figure heretofore quoted."

Exports.

In the following tables will be found the figures of exports and imports as returned to the Customs Department:—

COPPER.

TABLE 1.

EXPORTS.

Year.	Ontario.	Quebec.	Total.
1885	.....	$262,600	$262,600
1886	$16,404	232,855	249,259
1887	3,416	134,550	137,966
1888	.....	257,260	257,260
1889	.....	168,457	168,457
1890	2,219	396,278	398,497
1891	64,719	283,385	348,104

COPPER.
Imports.

COPPER.

TABLE 2.

IMPORTS: PIGS, OLD AND SCRAP.

Fiscal Year.	Pounds.	Value.
1880	31,900	$ 2,130
1881	9,800	1,157
1882	20,200	1,984
1883	124,500	20,273
1884	40,200	3,180
1885	28,600	2,016
1886	82,000	6,969
1887	40,100	2,507
1888	32,300	2,322
1889	32,300	3,288
1890	112,200	11,521
1891	107,800	10,452

COPPER.

TABLE 3.

IMPORTS: MANUFACTURES.

Fiscal Year.	Value.
1880	$123,061
1881	159,163
1882	220,235
1883	247,141
1884	134,534
1885	181,469
1886	219,420
1887	325,365
1888	303,459
1889	402,216
1890	472,668
1891	563,522

GRAPHITE.

PRODUCTION.

GRAPHITE.
Production.

In last year's report much was said about Canadian graphite and graphite deposits, which it is unnecessary to repeat. With all the numerous known occurrences of the mineral in the Laurentian rocks of the Dominion, but little was done during the year in the way of development and discovery.

Altogether there was only a production of 260 tons, valued at $1,560. GRAPHITE. Production.

The production of back years was as follows:—

1886	500	tons, valued at	$4,000
1887	300	" "	2,400
1888	150	" "	1,200
1889	242	" "	3,160
1890	175	" "	5,200
1891	260	" "	1,560

From this it will be seen that the industry has never been extensive and is carried on in a very desultory manner.

DEVELOPMENT AND DISCOVERY.

NEW BRUNSWICK. The province of New Brunswick was visited by Mr. Brumell and information was obtained regarding development and discovery as follows:— Discovery and development.—New Brunswick.

"*St. John.*—W. F. Best *et al.* of this city are operating on the Hazen property on a continuation eastward of the vein operated until recently by S. S. Mayes. The vein, which is north-east of and near the Cantilever Bridge at St. John, lies at the contact of the crystalline limestone and a trap dyke or mass, and strikes N. 60° E.

"The vein at this working does not show on the surface, but was struck at a depth of 8 feet, where it started in about 2 inches wide. The shaft is now down 50 feet, at which point a level is run 14 feet to the east on the vein, which is 8 or 9 feet wide, divided in the centre by a "horse" of trap about 2 feet wide. The "horse" was found at 30 feet from the surface, and extended to 50 feet, where it disappears; what its lateral dimensions are is not known. The hanging wall of the vein shows a dip of 55° S. The shaft is very free from water, one man with a hand-pump being sufficient to keep it clear; the owners, however, intend putting up steam hoisting gear and pump. The graphite is sometimes associated with pyrite, which, however, breaks away easily, leaving the ore exceptionally pure. Price, f. o. b., $7 per ton.

"*Thorn Brook, N.B.*—On the land of Chas. McAlpin, on the east side of Thorn Brook, is a deposit of earthy graphite. The deposit is about 20 feet wide, striking north-east, and is in altered slates, which are very much jointed and broken up. The graphite is nowhere very solid where exposed, but can readily be dug with pick and shovel. It is said the deposit can be traced for over a mile on the strike of the vein."

GRAPHITE.
Discovery and development. —Quebec.

QUEBEC.—In Quebec new discoveries of graphite are reported from near Quebec city, and from lot 11, range 2, in the township of Lathbury, Ottawa county.

Walker Mine.—The Walker mine, in Buckingham township, Ottawa county, which was the chief centre of operations in 1890, has not been regularly worked, owing to financial troubles which obliged the operators to discontinue work on the mill then in process of enlargement.

Weart Mine.—Operations were being carried on in the same township near Plumbago Lake, on the old Pew and Weart's lots. Here work is being prosecuted upon what would appear to be a belt in the rusty gneisses of the vicinity, impregnated with graphite. The material mined is thus what is known locally as "disseminated ore," from the mineral occurring disseminated through the rock, as distinguished from the solid form of graphite filling the fissures often found cutting the formation. The works are operated by Mr. Jacob Weart, of Jersey City, N.J., U.S.A., the property comprising N. $\frac{1}{2}$ lot 26 in Range V., lots 25, 26 and 27 in Range VI., and the S. $\frac{1}{2}$ of lots 25 and 26 and lot 28 in Range VII. These lots have long been held for graphite, and some small amount of work was done in 1870, but they have been idle since then until this year, when operations were inaugurated for further development. These comprise the erection of the dwellings, offices and other buildings necessary to carry on operations, including a large mill-building, in which the graphite is separated from the associated rocky matter by the Napenberger process. This is a secret process, dependent, however, in general, upon the method of separating by air currents and the bolting of the crushed and powdered material. Previous to this stage in the treatment, the ore is roasted or burnt in a kiln, very similar to the common lime kiln, and then, passing through a Blake crusher, is finally reduced to powder in a corncracker. The object of the preliminary roasting is to render the rock more friable, a result so far attained, that it is claimed a small corncracker, costing $25, will put through 20 tons per day of the burnt ore.

The mining operations consist mostly of a number of strippings of the rock and shallow parts, together with one open cut about 50 feet long, 25 wide, and 40 deep into the side of a hill. These openings, some seven in all, are spread over an area measuring about 500 by 400 feet, and show the presence of the graphite in the rock exposed. The developments so far made, whilst not extensive enough to demonstrate the width of the belt, nor the length along its strike, for which it is graphitic, prove the existence of a satisfactory extent of ore ground.

A large dyke of columnar trap cuts the rocks in the vicinity of the pits. The property is being worked by the owner, chiefly for the purpose of supplying his own factory in the United States with suitable graphite, for use in the manufacture of his patent self-lubricating bushings. These are metal bearings for buggy axles, wind-mills, and for the moving parts of any other machinery. The requisite lubrication is effected by the graphite, which is compressed into spiral grooves on the inside of the bearings. As these uses do not call for very large quantities, the mine will only be operated for short periods, as necessity arises, unless the general demand for the material justifies more extensive and continuous work. The graphite required for the above-mentioned lubricating purposes, must be very pure, fine, and tenacious, in which latter quality, it is stated, the graphite of this mine excels the Ceylon material, which is too soft and friable for the purpose.

GRAPHITE.

Discovery and development.

EXPORTS AND IMPORTS.

As shown in tables Nos. 1, 2 and 3 below, there was a total exportation of $72 worth of this mineral, the value of the imports, apart from such highly manufactured articles as lead pencils, amounting to over $41,000.

Exports and Imports.

GRAPHITE.

TABLE 1.

EXPORTS.

Year.	New Brunswick.		Ontario.	
	Cwts.	Value.	Cwts.	Value.
1886.....	8,142	$3,586	.....	.....
1887.....	6,294	3,017	.....	.....
1888.....	2,700	1,080	.....	.....
1889.....	660	422	22	$116
1890.....	400	160	329	1,369
1891.....	464	72	.....	.....

GRAPHITE.
Imports.

GRAPHITE.

TABLE 2.

IMPORTS OF RAW AND MANUFACTURED PLUMBAGO.

Fiscal Year.	Plumbago.	Manufactures of Plumbago.
1880	$1,677	$2,738
1881	2,479	1,202
1882	1,028	2,181
1883	3,147	2,141
1884	2,891	2,152
1885	3,729	2,805
1886	5,522	1,408
1887	4,020	2,830
1888	3,802	22,604
1889	3,546	21,789
1890	3,441	26,605
1891	7,217	26,201

GRAPHITE.

TABLE 3.

IMPORTS OF BLACKLEAD.

Fiscal Year.	Value.
1880	$18,055
1881	26,544
1882	25,132
1883	21,151
1884	24,002
1885	24,487
1886	23,211
1887	25,766
1888	7,824
1889	11,852
1890	10,276
1891	8,292

GYPSUM.

GYPSUM.
Production.

The total quantity of gypsum mined and marketed in the Dominion during 1891 was 203,605 tons valued at $206,251, showing a decrease in quantity of 22,904 tons, while the value has increased $12,218. The production is, as in former years, altogether that of the provinces of Ontario, Nova Scotia and New Brunswick, as may be seen on reference to the following table :—

GYPSUM.

TABLE 1.

PRODUCTION BY PROVINCES.

GYPSUM. Production.

Provinces.	Tons.	Value.
Nova Scotia.	161,934	$153,955
New Brunswick.....	36,011	33,996
Ontario	5,660	18,300
Totals	203,605	$206,251

The greater part of the above quantity was shipped in the raw state to the United States.

The amount of rock ground and sold as land plaster was 5,400 tons, having a net value in the manufactured state of $23,499, and of plaster of Paris, 61,370 barrels, or 7,671 tons, which would be equivalent to 9,590 tons of crude rock, the value of the finished product being $55,039. There is thus shown to have been 14,990 tons of crude rock manufactured in Canada, or about seven and a half per cent of the total output.

Besides ground and calcined plaster, a quantity of "Alabastine" and "Plastico" was produced by the Alabastine Company, of Paris, Ont., and a considerable quantity of rock suitable for the manufacture of "terra alba" was shipped by the Albert Manufacturing Company, of Hillsboro', N.B.

The following figures are those of production for the past six years :—

1886	162,000	tons, valued at	$178,742
1887	154,008	"	157,277
1888	175,887	"	179,393
1889	213,273	"	205,108
1890	226,509	"	194,033
1891	203,605	"	206,251

Discovery and development.

There is nothing new to report in the industry, the work being carried on by the same firms as in 1890, viz. :—In Ontario : The Alabastine Co., Paris ; Thos. Martindale & Co., Cayuga ; L. H. Johnson, Caledonia ; W. Donaldson & Co., Mount Healy ; Grand River Gypsum Co., Cayuga. In New Brunswick : The Albert Mfg. Co., Hillsboro' ; McQueen & Stewart, Andover ; Jas. Stratton, St. John ; E. W. Lyndes, Hopewell Hill.

GYPSUM.
Nova Scotia.

Of those operating in Nova Scotia no list can be given here, as our returns are not received direct from producers, but through the Department of Mines for that province.

The following tables illustrate the exports and imports for the year, and explain themselves:—

GYPSUM.

TABLE 2.

Exports.

EXPORTS OF CRUDE GYPSUM.

Years	ONTARIO.		NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1874	.....	.....	67,830	$ 68,164	.....	.....	67,830	$ 68,164
1875	.....	.....	86,065	86,193	5,420	$ 5,420	91,485	91,613
1876	120	$ 180	87,720	87,590	4,925	6,616	92,765	94,386
1877	.....	.....	106,950	93,867	5,030	5,030	111,980	98,897
1878	489	675	88,631	76,695	16,335	16,435	105,455	93,805
1879	579	720	95,623	71,353	8,791	8,791	104,993	80,864
1880	875	1,240	125,685	111,833	10,375	10,987	136,955	124,060
1881	657	1,040	110,303	100,284	10,310	15,025	121,270	116,349
1882	1,249	1,946	133,426	121,070	15,597	24,581	150,272	147,597
1883	462	837	145,448	132,834	20,242	35,557	166,152	169,228
1884	688	1,254	107,653	100,446	21,800	32,751	130,141	134,451
1885	525	787	81,887	77,898	15,140	27,730	97,552	106,415
1886	350	538	118,985	114,116	23,498	40,559	142,833	155,213
1887	225	337	112,557	106,910	19,942	39,295	132,724	146,542
1888	670	910	124,818	120,429	20	50	125,508	121,389
1889	483	692	146,204	142,850	31,495	50,862	178,182	194,404
1890	205	256	145,452	139,707	30,034	52,291	175,691	192,254
1891	5	7	143,770	140,438	27,536	41,350	171,311	181,795

GYPSUM.

TABLE 3.

Imports.

IMPORTS OF CRUDE GYPSUM.

Fiscal Year.	Pounds.	Value.
1880	1,854	$3,203
1881	1,731	3,442
1882	2,132	3,761
1883	1,384	3,001
1884	.....	3,416
1885	1,353	2,354
1886	1,870	2,429
1887	1,557	2,492
1888	1,236	2,193
1889	1,360	2,472
1890	1,050	1,928
1891	376	640

GYPSUM.

TABLE 4.

IMPORTS OF GROUND GYPSUM.

GYPSUM. Imports.

Fiscal Year.	Pounds.	Value.
1880	1,606,578	$5,948
1881	1,544,714	4,676
1882	759,460	2,576
1883	1,017,905	2,579
1884	687,432	1,936
1885	461,400	1,177
1886	224,119	675
1887	13,266	73
1888	106,068	558
1889	74,390	372
1890	434,400	2,136
1891	36,500	215

GYPSUM.

TABLE 5.

IMPORTS OF PLASTER OF PARIS.

Fiscal Year.	Pounds.	Value.
1880	667,676	$2,376
1881	574,006	2,864
1882	751,147	4,184
1883	1,448,650	7,867
1884	782,920	5,226
1885	689,521	4,809
1886	820,273	5,463
1887	594,146	4,342
1888	942,338	6,662
1889	1,173,996	8,513
1890	693,435	6,004
1891	1,035,605	8,412

The market for gypsum in Canada will therefore be, as shown by the foregoing tables, equivalent to about 33,000 tons, as follows :— Home consumption.

Production	203,605	tons.
Imports, crude gypsum	376	"
do ground do	18	"
do plaster of Paris	518	"
	204,517	"
Less exports	171,311	"
	33,206	"

IRON.
Production.

IRON.

PRODUCTION.

The production of iron ore during 1891 shows somewhat of a decrease compared with that of 1890, the figures being 76,511 tons, worth $155,380, for the latter, as compared with 68,979 tons, valued at $142,005, for the former.

Nova Scotia still continues the main contributor, its production constituting over seventy-five per cent of the grand total, the rest being produced in the province of Quebec, with a small quantity from British Columbia.

The following table (No. 1) illustrates the course of the iron mining industry in the province of Nova Scotia :—

IRON.

TABLE 1.

NOVA SCOTIA: ANNUAL PRODUCTION OF ORE.

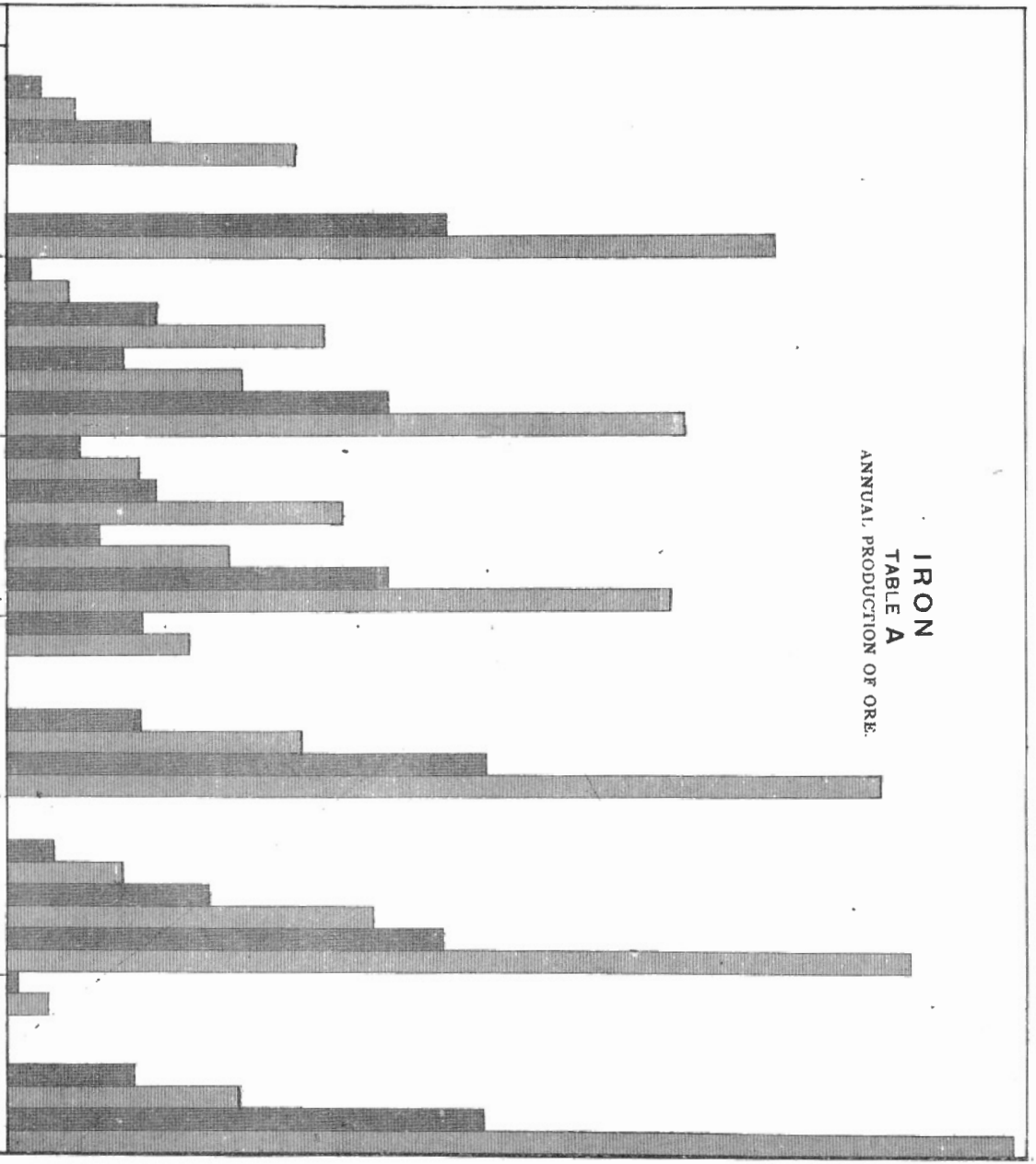
	Tons.
1876	15,274
1877	16,879
1878	36,600
1879	29,889
1880	51,193
1881	39,843
1882	42,135
1883	52,410
1884	54,885
1885	48,129
1886	44,388
1887	43,532
1888	42,611
1889	54,161
1890	49,206
1891	53,649

IRON

TABLE A

ANNUAL PRODUCTION OF ORE.

Year	Province	Quantity	Value
		TONS	$
1886	B. C.	3,941	7,882
	ONT.	16,032	32,064
	QUE.	.....	.....
	N. S.	49,735	87,036
1887	B. C.	2,796	6,990
	ONT.	16,598	36,218
	QUE.	13,404	26,808
	N. S.	43,532	76,181
1888	B. C.	8,372	14,950
	ONT.	16,894	37,710
	QUE.	10,710	24,899
	N. S.	42,611	74,509
1889	B. C.	15,487	20,742
	ONT.	.....	.....
	QUE.	14,533	33,091
	N. S.	54,161	97,867
1890	B. C.	.....	.....
	ONT.	5,000	12,500
	QUE.	22,305	41,196
	N. S.	49,206	101,684
1891	B. C.	950	4,750
	ONT.	14,380	24,510
	QUE.	53,649	112,745
	N. S.		



ANNUAL REPORT FOR 1891; DIVISION OF MINERAL STATISTICS AND MINES.
E. D. INGALL, M. E., IN CHARGE.

EXPORTS AND IMPORTS.

Iron.
Exports and Imports.

The exports as shown by the below given table have fallen off very considerably since last year. This is chiefly due to Ontario having shipped none, and some of the Quebec mines having produced less :—

IRON.

TABLE 2.

EXPORTS OF ORE.

Province.	1883.		1889.		1890.		1891.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario.	31,161	$36,397	4,108	$10,407	18,601	$38,967	2,259	$3,932
Quebec..... .	10	380	.....	2,700	120	1,640	191	2,683
Nova Scotia	.....	.....	.....	100	.....	. .. .	.....	... .
British Columbia.	7,300	18,400	13,335	26,680	33	83	359	4,958
Totals.... ..	.... .	$55,177	.....	$39,887	18,754	$40,690	2,809	$11,573

As usual no ore has been imported into Canada.

DISCOVERY AND DEVELOPMENT.

Discovery and development. —Nova Scotia

NOVA SCOTIA.—In Nova Scotia, according to the report of the Department of Mines for the province, " the past season has exhibited a general increased interest in iron smelting, etc. The Londonderry Iron Company have rebuilt one of their furnaces and raised it to a height of seventy-five feet instead of sixty-three, as originally built. Two new kilns for roasting the spathic ores found so abundantly on the company's property, and having a capacity of 100 tons daily, have been erected.

" The New Glasgow Iron, Coal and Railway Company expect to have their furnace in blast next June. Their railway to Bridgeville is about completed, and their development work secures them an abundant supply of good ore. The furnace is sixty-five feet high ; bosh, twenty-five feet six inches ; hearth, nine feet nine inches. Three hot blast stoves. Two blowing engines of 1,000 horse power each. Capacity, 15,000 feet of air per minute. Anticipated yield, 100 tons

IRON.

Discovery and development. —Nova Scotia

per day. The coke ovens are of the Coppee pattern, and are likely to be the first of their pattern to go into operation in America. Capacity of each oven about six tons, making seventy to eighty tons of coke per day. The coal is all to be crushed and washed before coking, and the ash reduced to about four or five per cent in the coal.

"The Pictou Charcoal Iron Company have located themselves at Bridgeville, on the line of the New Glasgow Company's Railway, and the object of their work may be gathered from the following remarks of Mr. E. J. Sjostedt, Mines Manager :—

"'Our object is to establish a charcoal iron plant here at Bridgeville, and to use the brown ores principally, and to produce a charcoal iron specially adapted for car wheel making, and also for especially strong machine castings. With this object in view we have purchased mining rights of iron ore, limestone and manganese ore, and some six thousand (6,000) acres of hardwood land. The size of our furnace will be eleven feet bosh, and fifty feet in height, and the estimated output for the first few years, five thousand tons per annum.'

"The following memorandum of the operations at Torbrook will be of interest, as marking the commencement of a mining industry in Annapolis county, which promises to be valuable and permanent :—

"'About the beginning of March last active operations were first commenced at Torbrook, Annapolis county, on the bed of red hematite ore discovered there during the previous year. The ore extends along the base of the South Mountain, the strike being about N. 60° E., and has been traced on the surface from Nictaux Falls eastwards to the King's County line, a distance of four miles. The bed has an average thickness of five and a half feet clear ore, and is so tilted up as to dip at an angle varying from seventy to eighty degrees. Both the hanging and foot walls are of a variegated talcose slate, very light in colour and between eighteen to twenty-four inches thick. These walls form a fairly good support for the time being, although slightly soft The country rock is of a dark bluish state, probably of upper Devonian age. A fair sample of the ore yields about sixty per cent metallic iron ; silica, nine to ten per cent ; lime, four to five per cent ; phosphoric acid, 0·3 per cent ; sulphur, trace.

"'When decided operations were first entered upon, a shaft was sunk in the ore eighty feet deep, levels driven east and west, and the ore taken out by back stoping. Inside of a month another shaft was sunk, about 350 feet from the first, and the ore mined by underhand stoping. A hoisting engine was soon got into position, and ore raised at the rate of twenty-five tons daily. In the spring a survey was made, and

in the summer a railroad constructed from Wilmot station to the mines at Torbrook, a distance of three miles. The track runs alongside of the shafts, the cars being loaded from chutes. Since the construction of this branch line, two new shafts have been put down, and new hoisting gear has replaced the old. At present we have in operation one four-drum hoist, and one single drum hoist. Three small pumps are required to free the mine from water. Steam is supplied to engines and pumps from three boilers. Some slight difficulty has been experienced with faults; but these seem to grow smaller as the depth increases. Some having already disappeared even at the comparatively slight depth of the present workings.

IRON. Discovery and development —Nova Scotia

"'All the ore is shipped *via* Windsor Junction to Londonderry. Last month, January, 105 cars were loaded at Torbrook, in all about 1,650 tons.

"The following figures show the production of iron ore during the year:—

	Tons.
Pictou Charcoal Iron Co., Bridgeville, Pictou Co....	681
Londonderry Iron Co., Londonderry, Col. Co.....	46,350
Ore from Springville, Pictou Co.....	113
" Bridgeville "	680
" Pugwash, Cumberland Co.....	214
" Torbrook, Annapolis Co.....	7,273
New Glasgow I. C. & Ry. Co., Springville, Pictou Co..	2,000
Total.....	57,311

NEW BRUNSWICK.—In New Brunswick a small amount of work has been done in prospecting some of the deposits of ore found there and regarding which Mr. H. P. Brumell during his visit to the province, reports as follows:— New Brunswick.

"On the Millstream River, Gloucester county, about one mile east of the Rocky Brook galena vein and on the north side of the river a property has been taken up by W. R. Payne and John Ellis, of Bathurst. On it is a bed of magnetic iron ore interstratified with a highly altered and siliceous argillite. The bed is about twenty-five feet thick, the upper and lower parts being somewhat intermixed with the country rock which strikes E. and W. at an angle of 90°. The ore contains a considerable proportion of iron and copper pyrites, sufficient in the specimens and exposures seen to materially decrease its value.

"Developments consist of a tunnel about twenty-five feet long and a shallow shaft on the bed at the end of the tunnel."

IRON.

Discovery and development —New Brunswick.

Mr. Chalmers, of the Geological Survey corps, calls attention to the various deposits in Kent county, visited by him during the course of his field work, as follows :—

"Bog-iron ore was found on the south side of Buctouche Harbour, Kent county, occupying an area of several acres. Where openings were made in two places, the deposit showed a thickness of from twelve to fifteen inches.

"Just south of Richibucto Head, another deposit of this material was observed, but its extent and thickness was not ascertained. Bog-iron ore was also noticed on the south side of the mouth of Kouchibouguac River by Mr. Wilson, and in a number of other places. No use has yet been made of it."

Quebec.

QUEBEC.—In the province of Quebec, work is still being prosecuted by the Canada Iron Furnace Co., with works at Radnor, and by Messrs. Jno. McDougall & Co., operating at Drummondville. The former employ about 350 and the latter about 125 men. The ores used at these furnaces, for the most part, continue to be those from the bog-iron ore deposits of the vicinity, regarding which the following notes are furnished by Messrs. Giroux and Low of the Geological Survey. According to the former :—

"A pretty good deposit of bog-iron ore was observed in the county of Joliette, along the railway. The Canada Iron Furnace Co., of Radnor, began to work this deposit last July, and their foreman informed me in September, 1891, that he thought he would be able to ship about 200 car loads of the ore to the blast furnace in Radnor by the fall."

Mr. Low writes as follows, of the working of these deposits and others in his district :

"On the north side of the Mekinac River and along a tributary flowing out of Trout Lake, large masses of iron ore have been found in a dark greenish-red gneiss composed chiefly of orthoclase and epidote, but as all the ore yet found contains a large percentage of titanic acid it is practically of no value. Similar ore is found in a large quartz vein, on the west side of the St. Maurice River, about seven miles above the Grandes Piles and near Lake Bouchard, in the Seigniory of Radnor, also in the township of Shawenegan, and about the lakes of the Laurentide Fishing club.

"At Lac Tortue, the Canada Iron Furnace Company have lowered the water of the lake some four feet, and as the lake is very shallow with slightly sloping banks, a large area is laid bare around its edge, and here the bog-iron ore which has been formed in the lake as

flat concretions is washed out of the surface mud with hand sieves, while the ore in the deeper part of the lake is raised by a dredge which carries three rows of buckets on an endless belt. IRON. Discovery and development —Quebec.

"Apart from Lac Tortue, in all the flat country about Three Rivers on both sides of the St. Lawrence, bog-iron ore is found in patches which vary from three to eighteen inches in thickness. The ore is gathered by the farmers from their lands, and brought in and sold at the furnace. As iron smelting has been in operation about Three Rivers since 1737 the supply of ore in the vicinity is somewhat exhausted, but new supplies of great extent have been found about Gentilly, opposite Three Rivers, and along the Joliette branch of the Canadian Pacific Railway, so that enough ore will be forthcoming to run the new furnace at Radnor which will have a capacity of thirty to fifty tons a day, smelting magnetite from St. Jérôme along with the bog ore.

"On a point about one mile above the mouth of the Mattawin River is a large vein of dark red pegmatite holding masses of magnetite, the only known locality in this region of such ore free from titanic acid."

It is reported of the St. Jérôme mine that it has been operated by capitalists of Albany, N.Y., who had a force of about twenty men at work.

The only other work done in this province was that at Bristol, in Pontiac county. The ore produced at this mine, which is worked by Messrs. Ennis & Co., of Philadelphia, is altogether shipped to the United States. A force of sixty men was employed for some seven months of the year, operations ceasing in July, when it is said a large amount of ore was in stock at the mine. The plant includes two furnaces for roasting the ore for the purpose of removing the sulphur it contains and which varies between fifteen and twenty per cent; this amount is, it is said, reduced to 0·025 per cent by the roasting process.

ONTARIO.—For Ontario, as is shown by the graphic table A, there is no production to report. The exports represent ore mined in Quebec but entered at an Ontario port. In several parts of the province development has been done on various deposits. Ontario.

Mr. Brumell, during his summer's work, ascertained that "the Ledyard mine on lot 19, con. I. of Belmont, in the county of Peterborough, has lately changed hands, having been sold by Mr. T. D. Ledyard, of Toronto, to the Belmont Bessemer Ore Co., of New York, who were in November, 1891, busily engaged in connecting the property by rail with the Canadian Pacific Railway. On completion of this short piece of railway active operations will be commenced at once, and a large output is confidently looked for."

IRON.

Discovery and development —Ontario.

In the western part of the province in the Thunder Bay district, though no shipments have been made, considerable interest has been taken in the subject of the iron ore deposits. Development work has been in progress near Gunflint Lake, on the boundary, and in Marks township, both south-west of Port Arthur, and also near Finmark on the Canadian Pacific Railway, where the diamond drill was used.

The chief interest has centred, however, on the deposits of the Atic-okan River, where developments have been made by Messrs. Marks & Co., of Port Arthur, in further testing the deposits of magnetite. These were alluded to in last year's report, where the analyses given showed an iron content of from sixty-three to sixty-eight per cent of metallic iron, together with a complete absence of titanium in all the specimens examined, and a sulphur content ranging, where it is specified in the return, of from 0·052 to 0·185.

The work, mentioned in the above report as having been done to prove the property in the way of test pits and surface strippings, has been followed by extensive operations with the diamond drill to explore the deposit in depth. Of the details of the results of this work, however, no information is obtainable.

Mr. W. H. C. Smith, the officer of the survey intrusted with the geological investigation of the district, has not yet concluded his examinations, but gives the subjoined information tentatively :—"The ore in this belt would appear to occur as a series of lenticules lying in vertical attitude which in some cases overlap each other, as shown by one of the diamond drill borings, which was put down at a large angle with the horizon, passing through two such lenses and an intervening rib of rock.

"The stripping done has not been sufficiently extensive to admit an accurate measurement of the size of these lenticules, but they are estimated at between one hundred and two hundred feet long and from thirty-five to fifty feet wide. The depth, so far as determined by diamond drill borings, is not yet made public, but from the position of the ore bodies they are probably of great proportional depth. There is good reason to believe that these isolated ore bodies occur at various depths below the surface.

"The ore is associated with a schistose chlorite rock merging into and probably derived from compact fine-textured greenstones. The rocks flanking the ore bodies to the north have every appearance of being a volcanic series. The valley of the river conceals for the most part the rocks to the south, but they would seem to be more micaceous and to merge into the mica schist of the Coutchiching series.

"From his preliminary investigations, Mr. Smith inclines to the opinion that these greenstones mark a definite ferruginous volcanic horizon in the formation probably referable in age to later Huronian times." IRON. Discovery and development —Ontario.

The developments made have extended over the belt for a length of about 1,400 feet and a width of about fifty to seventy-five feet.

Negotiations were in progress for the transfer of these properties to Belgian capitalists, and at the close of the year it is reported that a basis of agreement had been arrived at by which the owners give till November, 1892, to test the deposits, and that if these tests result satisfactorily, the mine will be worked upon a royalty with a guaranteed output of 300,000 tons, and a railroad will immediately be built to connect the mine with the Canadian Pacific Railway.

BRITISH COLUMBIA.—From British Columbia there is little to report. The Puget Sound Iron Company report that no work has been done at their mine at Texada Island, but that operations may be again proceeded with next year. British Columbia.

The only other item with regard to iron is given in the report of the Minister of Mines for the province, as follows :—

"*Glen Iron Co.*—Work on the Glen Iron Mining Company's ground, consisting of 200 acres of land, situated at Cherry Creek Bluff, about twelve miles west of Kamloops, has been prosecuted with commendable activity during the past year, with results which admit of no doubt in regard to its value.

"The veins, four in number, vary from ten to twenty feet in width, and are visible on the surface at distances from three hundred to six hundred feet in length, and possess the great advantage of being situated near the track of the Canadian Pacific Railway. The works are supplied with a chute three hundred feet long, and an aerial wire tramway thirteen hundred feet in length, capable of delivering one hundred tons per ten hours on the cars.

"The ore is pure magnetite of the best quality, particularly adapted to the manufacture of Bessemer steel, and capable of being utilized for the purpose without any intermediate treatment. Seven hundred and fifty tons were shipped last summer to Tacoma, Wash., U.S., and two hundred tons to the Revelstoke Smelting Works for fluxing operations. There is every prospect of heavy shipments being made during the present year. This new mining industry is capable of wide expansion, and promises, in the near future, to assume proportions of great extent, which cannot be overestimated in its influence on the prosperity of the surrounding country."

IRON.

PIG IRON AND STEEL.

Pig iron production.

Of the 68,979 tons of iron ore mentioned above as produced in Canada during 1891, the returns show that 60,933 tons were smelted, producing 23,891 tons of pig iron, showing an increase over last year's yield of 2,119 tons.

This quantity resulted from the running of four furnaces, operated by the following firms :—

The Londonderry Iron Co., Londonderry, N.S.

The Canada Iron Furnace Co., Radnor, Que.

Jno. McDougall & Co., Drummondville, Que.

The two latter firms use charcoal for fuel in smelting the bog ores as before mentioned and produce a pig iron which is used for the manufacture of railroad car wheels.

The following table, No. 3, gives further details.

IRON.

TABLE 3.

PIG IRON PRODUCTION : CONSUMPTION OF ORE, FUEL, ETC.

Production and Consumption.	1890.		1891.	
	Quantity.	Value.	Quantity.	Value.
Pig Iron made ..... Tons.	21,772	$331,688	23,891	$368,901
Iron ore consumed. . .... . "	57,304	117,880	60,933	130,955
Fuel consumed. Charcoal ..... Bush.	589,860	29,493	441,812	22,091
Fuel consumed. Coke ..... Tons.	32,832	97,659	30,626	98,402
Fuel consumed. Coal ..... "	1,241	2,638	2,170	2,868
Flux consumed .... "	18,478	18,361	11,377	11,546

Table No. 4 below gives the exports of iron and steel goods from Canada, and tables 5, 6 and 7 following give data regarding the country's consumption of similar commodities, whose value is based rather upon the amount of iron they contain than upon their highly manufactured condition.

IRON. IRON.

TABLE 4.

EXPORTS OF IRON AND STEEL GOODS, THE PRODUCE OF CANADA.

Exports of iron and steel goods.

Province.	Pig Iron.	Scrap Iron.	Iron Stoves.	Iron Castings	Iron, all other, and Hard-ware.	Steel and Manufac-tures of.	Totals.
Ontario	.....	$2,463	$1,244	$943	$ 9,460	$13,326	$27,436
Quebec	$95	801	308	1,218	39,530	11,087	53,039
Nova Scotia	.....	8	1,231	546	20,413	41,540	63,738
New Brunswick	.....	.....	235	.....	5,367	.....	5,602
P. E. Island	.....	.....	.....	.....	14	.....	14
Manitoba	.....	.....	107	45	4	188	344
British Columbia	..	1,600	.....	15	810	321	2,746
Totals	$95	$4,872	$3,125	$2,767	$75,598	$66,462	$152,919

IRON.

TABLE 5.

IMPORTS OF PIG IRON, ETC.

Imports of pig iron.

FISCAL Year.	PIG IRON, CHARCOAL.		PIG IRON, ALL OTHER.		PIG IRON, KENTLEDGE, &C.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1880	.....	.....	23,159	$371,956	.....	.....	23,159	$371,956
1881	.....	.....	43,630	715,997	.....	.....	43,630	715,997
1882	6,837	$211,791	56,594	811,221	.....	.....	63,431	1,023,012
1883	2,198	58,994	75,295	1,085,755	.....	.....	77,493	1,144,749
1884	2,893	66,602	49,291	653,708	.....	.....	52,184	720,310
1885	1,119	27,333	42,279	545,426	.....	.....	43,398	572,759
1886	3,185	60,086	42,463	528,483	.....	.....	45,648	588,569
1887	3,919	77,420	46,295	554,388	.....	.....	50,214	631,808
1888	.....	.....	.....	.....	48,973	$648,012	48,973	648,012
1889	.....	.....	.....	.....	72,115	864,752	72,115	864,752
1890	.....	.....	.....	.....	87,613	1,148,078	87,613	1,148,078
1891	.....	.....	.....	.....	81,317	1,085,929	81,317	1,085,929

IRON.

IRON.

TABLE 7.

Imports, iron and steel goods.

IMPORTS: IRON IN SLABS, BLOOMS, LOOPS AND PUDDLED BARS, ETC.

Fiscal Year.	Cwt.	Value.
1880	195,572	$244,601
1881	111,666	111,374
1882	203,888	222,056
1883	258,639	269,818
1884	252,310	264,045
1885	312,329	287,734
1886	273,316	248,461
1887	522,853	421,598
1888	110,279	93,377
1889	80,383	67,181
1890	15,041	45,923
1891	41,567	38,931

IRON.

TABLE 8.

IMPORTS OF IRON AND STEEL GOODS.*

Fiscal Year.	Value.
1880	$6,620,260
1881	8,484,175
1882	8,578,685
1883	8,613,739
1884	6,143,870
1885	4,606,193
1886	4,698,882
1887	6,084,704
1888	5,147,111
1889	7,108,052
1890	7,260,845
1891	9,188,502

* These figures do not include those of hardware, engines, agricultural implements, or other highly manufactured iron or steel goods.

LEAD.

LEAD.

Production.

The amount of this metal produced in Canada is small for this year as in the past, our returns only giving 588,665 lbs., which, at the average market price of the metal for the year of 4·35 cents per lb., would have a value of $25,607. Small as this is, however, the figures are five times as great as those of last year.

Regarding discovery and development there is little to say.

NEW BRUNSWICK.—In New Brunswick development work was done on veins of argentiferous galena on "Rocky Brook," a branch of the Millstream River, in Gloucester county, and at the Britton mine, near Woodstock. Discovery and development.

QUEBEC.—In Quebec the galena mine at the head of Lake Temiscamingue was operated for a few months, but was closed down in March, and the work was suspended. This had been begun in the previous year, and included a thorough outfitting of the mine with plant for mining, concentrating and smelting the ore.

ONTARIO.—In Ontario there is only developmental work to report, and that chiefly on two of the galena-bearing veins traversing the rocks of the Nepigon series of the Black Bay district, near Port Arthur, on Lake Superior.

BRITISH COLUMBIA.—In British Columbia the work done in testing the promising veins carrying argentiferous galena, and copper ores of the new districts in the S.E. corner of the province has resulted of course in the extraction of much lead-bearing material. As this was not shipped, however, it does not enter into the statistics of this year. This stocking of the ore mined has been due to the heavy tariff imposed by the "McKinley Bill" on such ores entering the United States which, with the present condition of communication of these districts, must form for a time the chief market for these ores.

The following tables explain themselves :—

LEAD.

TABLE 1.

IMPORTS OF LEAD. Imports.

Fiscal Year.	OLD, SCRAP AND PIG.		BARS, BLOCKS, SHEETS.		TOTAL.	
	Cwt.	Value.	Cwt.	Value.	Cwt.	Value.
1880.....	....	.....	.....	....	30,298	$124,117
1881.....	16,236	$ 56,919	18,222	$70,744	34,458	127,663
1882.....	36,655	120,870	10,540	35,728	47,195	156,598
1883...	48,780	148,759	8,591	28,785	57,371	177,544
1884..... ...	39,409	103,413	9,704	28,458	49,113	131,871
1885.....	36,106	87,038	9,362	24,396	45,468	111,434
1886.....	39,945	110,947	9,793	28,948	49,738	139,895
1887.....	61,160	173,477	14,153	41,746	75,313	215,223
1888...	68,678	196,845	14,957	45,900	83,635	242,745
1889.	74,223	213,132	14,173	43,482	88,396	256,614
1890.....	101,197	283,096	19,083	59,484	120,280	342,580
1891..... ..	86,382	243,033	15,646	48,220	102,028	291,253

LEAD.

Imports.

LEAD.

TABLE 2.

IMPORTS OF LEAD MANUFACTURES.

Fiscal Year.	Value.
1880	$15,400
1881	22,629
1882	17,282
1883	25,556
1884	31,361
1885	36,340
1886	33,078
1887	19,140
1888	18,816
1889	16,315
1890	25,600
1891	23,893

MANGANESE.

MANGANESE.
Production.

Compared with years previous, the production of manganese for 1891 is only small, as but 255 tons, valued at $6,694 were exported. What the actual production was could not be ascertained, though it is not thought to have been much more than the above amount. For comparison, the following table is presented wherein it will be seen that the decrease in exports, and consequently in production, is very material.

MANGANESE. MANGANESE.

TABLE 1.

EXPORTS OF MANGANESE ORE SINCE 1873. Exports.

Years.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1873	....	....	1,031	$20,192	1,031	$20,192
1874	6	$ 12	776	16,961	782	16,973
1875	.....	200	194	5,314	203	5,514
1876	21	723	391	7,316	412	8,039
1877	106	3,699	785	12,210	891	15,909
1878	106	4,889	520	5,971	626	10,860
1879	154	7,420	1,732	20,016	1,886	27,436
1880	79	3,090	2,100	31,707	2,179	34,797
1881	200	18,022	1,504	22,532	1,704	40,554
1882	123	11,520	771	14,227	894	25,747
1883	313	8,635	1,013	16,708	1,326	25,343
1884	134	1,054	469	9,035	603	20,089
1885	77	5,054	1,607	29,595	1,684	34,649
1886	(a) 441	854	1,377	27,484	(a)1,818	58,338
1887	578	14,240	837	20,562	1,415	34,802
1888	87	5,759	1,094	16,073	1,181	21,832
1889	59	3,024	1,377	26,326	1,436	29,350
1890	177	2,583	1,729	34,248	1,906	36,831
1891	22	563	233	6,131	255	6,694

(a) 250 tons from Cornwallis should more correctly be classed under the heading of mineral pigments.

Regarding the imports of manganese the following table (2) is thought to be sufficient. No ore is imported. Imports.

MANGANESE.

TABLE 2.

IMPORTS: OXIDE OF MANGANESE.

Fiscal Year.	Pounds.	Value.
1884	3,989	$ 258
1885	36,778	1,794
1886	44,967	1,753
1887	59,655	2,933
1888	65,014	3,022
1889	52,241	2,182
1890	67,452	3,192
1891	92,087	3,743

MANGANESE. Discovery and development.

As in years previous, operations were confined to the provinces of Nova Scotia and New Brunswick, wherein are found extensive deposits, and for a description of which the reader is referred to the report of this Division for 1890.

NOVA SCOTIA.—Of operations in Nova Scotia the only available data are the following notes obtained from the report of the Minister of Mines for Nova Scotia for 1891 :—

"Mr. J. W. Stephens took out a few tons from his Teny Cape mine. A few tons were shipped from the Onslow mine ; and Mr. E. T. Moseley, of Sydney, reported having shipped twenty-eight casks of ninety per cent ore from St. Peter's. It is anticipated that a larger out-put will be made during the year 1892."

Regarding the operations in New Brunswick, Mr. Brumell furnishes the following notes as the result of his visits to the districts during the summer.

"*Gowland Mountain.*—Since my visit of the year previous small development operations had been carried on, several shallow pits were sunk and a stripping made in the bed of a small creek on the land of Geo. Harrison. In all of these, very small shows of low grade ore—psilomelane—were found in the granite. No limestone is found on the property, so the probability of large masses of manganese occurring is not good. About twenty tons of rock were taken out on the creek stripping, the rock containing about twenty-five per cent of low grade psilomelane.

"*Markhamville.*—Operations were being carried on by a small force of men who were employed in sorting and milling dump stuff and exploring by means of diamond drill. In all seventy-one holes, averaging 100 feet each, had been sunk—8th September, 1891. In hole No. 68, twelve feet of iron had been bored through, and in No. 69 twenty-five feet of ore ground. Very little ore was being shipped, only sufficient to pay working expenses.

"*Jordan Mountain.*—This property is still idle, and in litigation, after having been bonded to an American company for $40,000. The sale is said to have been prevented through lack of ability to give a clear title. Twenty-five tons of ore now at Sussex awaiting sale or shipment consist principally of manganite with a small proportion of pyrolusite.

"Operations were suspended during the year at Quaco Head and Dawson Settlement, neither of which points were visited owing to lack of time.

MICA.

Production.

During the past few years there has been a steady growth in the production of mica, the output in 1891 having a value of $71,510, an increase over the previous year of $3,436.

The production for the past few years is given below :—

1886	$29,008
1887	29,816
1888	30,207
1889	28,718
1890	68,074
1891	71,510

Of this the greater part was used in electrical construction, though small quantities were sold to various Canadian stove founders, and a certain quantity was ground for lubricants and fireproof paints and cements.

During 1891 there were exported 388,064 pounds of crude and cut mica, valued at $35,252, and $2,338 worth of ground mica, the latter being from Quebec, while of the crude and cut product the exports were as follows :—

Ontario	384,964 pounds, valued at	$35,077
Quebec	3,100 " "	175

During the past few years the exports have been as follows :—

1887	$ 3,480
1888	23,563
1889	30,597
1890	22,468
1891	37,590

MINERAL PIGMENTS.

Ochres.

Ochres.—The only material produced in Canada during 1891 that might be classed as a mineral pigment was ochre, the production of which was 900 tons, valued at $17,750, showing an increase over last year of 625 tons and $12,625.

The production was altogether that of the province of Quebec, where many extensive deposits of ochre are known to occur.

The production of ochre for the past four years is as follows :—

1887	385 tons, valued at	$	2,233
1888	397 " "		7,900
1889	794 " "		15,280
1890	275 " "		5,125

MINERAL PIGMENTS.

In the summary report of the Geological Survey Department for 1891, Mr. Low speaks thus of the occurrence of ochre in Champlain county, Que :—

Ochres.

"Ochre is a common mineral in this part of the province and is at present worked in two localities—at St. Malo, eight miles from Three Rivers, and at St. Tite junction on the Piles Branch railway.

"At St. Malo the deposit has been proven across twenty-two lots and in width from 100 to 300 yards, with a depth of from one to twenty feet. At St. Tite junction the ochre occurs in two gulleys which join, and run into the St. Maurice; the ore has been proven along both gulleys for nearly half a mile and has everywhere a considerable thickness.

"The St. Maurice Metallic Paint Co. and the Johnson Paint Co. have furnaces for burning the ore at St. Malo, the former grinding the burnt material at Cap Magdeleine, near Three Rivers, the latter at Montreal. At St. Tite junction a furnace and grinding mill are in course of erection by the Radnor Paint Co."

During his summer's work in New Brunswick, Mr. Brumell visited a deposit in Northumberland county, New Brunswick, of which he reports as follows :—

"About one mile above Chaplin's Island, on the north-west branch of the Miramichi River and about 18 miles from Newcastle, occur a number of small veins of a very heavy pure oxide of iron. The deposits, which are small, are scattered throughout the rocks of the district—altered slates—and are rather of the nature interbedded lenticular masses than veins. The rocks strike east and west dipping 65° north. The largest deposit exposed was about three inches wide, and possibly ten or twelve feet long, the depth being unproved.

"The deposits are well developed on the land of Daniel Dennis, which is under a mining license held by John Ferguson, of Newcastle.

"Although the material is remarkably pure there does not seem sufficient to be of great commercial value."

The imports of ochre are shown in the following table 1 : MINERAL PIGMENTS. Ochres.

MINERAL PIGMENTS.

TABLE 1.

IMPORTS OF OCHRES.

Fiscal Year.	Pounds.	Value.
1880	571,454	$ 6,544
1881	677,115	8,972
1882	731,526	8,202
1883	898,376	10,375
1884	533,416	6,398
1885	1,119,177	12,782
1886	1,100,243	12,267
1887	1,460,128	17,067
1888	1,725,460	17,664
1889	1,342,783	12,994
1890	1,394,811	14,066
1891	1,528,696	20,550

Baryta.—No baryta was produced during 1891, nor was any imported as may be seen on reference to the following table 2. Baryta.

MINERAL PIGMENTS.

TABLE 2.

IMPORTS OF BARYTA.

Fiscal Year.	Cwt.	Value.
1880	2,230	$1,525
1881	3,740	1,011
1882	497	303
1883		185
1884		229
1885	7	14
1886		62
1887	379	676
1888	236	214
1889	1,332	987
1890	1,322	978
1891		

MINERAL PIGMENTS. Litharge.

Litharge.—As in previous years, there is no production of this material to report; the only statistics available are those of imports, as follows :—

MINERAL PIGMENTS.

TABLE 3.

IMPORTS OF LITHARGE.

Fiscal Year.	Cwt.	Value.
1880	3,041	$14,334
1881	6,126	22,129
1882	4,900	16,651
1883	1,532	6,173
1884	5,235	18,132
1885	4,990	16,156
1886	4,928	16,003
1887	6,397	21,865
1888	7,010	23,808
1889	8,089	31,082
1890	9,453	31,401
1891	7,979	27,613

MINERAL WATER.

MINERAL WATER.

Production.

Returns were received by this office which show that during the year there were 427,485 gallons of mineral water placed upon the market, with a value at the springs of $54,268. This shows a very material decrease from last year, amounting to 133,680 gallons, having a value of $11,763. The production for the past three years has been :

1888	124,850 gallons	$11,456
1889	424,600 "	37,360
1890	561,165 "	66,031

The producers making returns for 1891 were :—

St. John, N.B. ..... John R. Smith.
Havelock, N.B. ..... Havelock Mineral Springs Co.
Camperdown, Ont. ..... Emily Wensley.
Ottawa, Ont. ..... King Arnoldi.
do ..... Wm. Borthwick.
do ..... F. O. Ring.
West Winchester, Ont. ..... Dr. W. J. Anderson.
Brecken, Ont. ..... L. Forrest.
Treadwell, Ont. ..... W. K. Kains.
Preston, Ont ..... Chris. Kress.

St. Léon Springs, Que.....St. Léon Mineral Springs Co. MINERAL
St. Hyacinthe, Que .....La Cie. d'eau Min. dé St. Hyacinthe. WATERS.
Montreal, Que. .....J. H. M. Hart.
St. Casimir, Que.....Jos. Douville fils.
Wilmot, N.S.....Wilmot Spa Springs Co.

A marked feature of the industry is the St. Léon mineral water, of which during the year some 200,000 gallons were shipped. This is, of course, irrespective of the water consumed in the baths and the hotel at the springs. This water is now retailed in all the important cities of the Dominion, and a considerable export trade has been initiated, water having been sent even to South America, where it has been very well received. No statistics of exports are available. The following table illustrates the imports, of which the greater part are from Europe :—

MINERAL WATERS. Imports.

TABLE 1.

IMPORTS.

Fiscal Year.	Value.
1880.	$ 15,721
1881....	17,913
1882.....	27,909
1883..... ...	28,130
1884....	27,879
1885...	32,674
1886...	22,142
1887....	33,314
1888.....	38,046
1889.....	30,343
1890.....	40,802
1891.....	41,797

MISCELLANEOUS.

MISCELLANEOUS.

Production.

The production of the several materials which are produced to a slight extent only, is given comparatively with the year previous in the following table :—

MISCELLANEOUS.

TABLE 1.

PRODUCTION.

Product.	1890.		1891.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	$	Tons.	$
Felspar	700	3,500	685	3,425
Fire clay			250	750
Moulding sand	320	1,410	230	1,000
Platinum		4,500		10,000
Precious stones		700		1,000

Felspar.

Felspar.—The production of this mineral is largely that of Ontario, a small quantity only being from Ottawa county, Que. The shipments were made to St. John's, Que., where the material was used in the manufacture of porcelain and finer grades of pottery.

Platinum.

Platinum—As in previous years, the production of platinum is altogether that of British Columbia, where it is found in placer workings associated with gold. As may be seen on reference to the following table, the production shows a marked increase over that of previous years, the increase being, however, largely due to the higher price of the metal, which is now increasingly used in dentistry and electricity.

The yearly production since 1887 has been :—

1887	$ 5,600
1888	6,000
1889	3,500
1890	4,500
1891	10,000

The following table shows the imports of this metal in all forms. No exports are reported. Miscellaneous.

Miscellaneous. Platinum.

Miscellaneous.

Table 2.

Imports of Platinum.

Fiscal Year.	Value.
1883	$ 113
1884	576
1885	792
1886	1,154
1887	1,422
1888	13,475
1889	3,167
1890	5,215
1891	4,055

Precious Stones.—The production of precious stones given in the first table is that of cut gems and does not include the value of the many rough and polished agates, chlorastrolites, etc., of Lake Superior. The minerals most frequently used as gems are found to a great extent in Ottawa county and consist of the various forms of garnet, tourmaline, asteriated quartz and albite, smaller quantities only of the Nova Scotia agates and jaspers being used. Precious stones.

The value of the various precious stones, including diamonds, imported during the fiscal year ending 30th June, 1891, was $77,988.

Whiting and Chalk.—The two following tables give the imports of these two materials and comprise all the available information regarding them:—

Miscellaneous.

Table 3.

Imports of Whiting.

Fiscal Year.	Cwts.	Value.
1880	84,115	$26,092
1881	47,480	16,637
1882	36,270	16,318
1883	76,012	29,334
1884	76,268	28,230
1885	67,441	23,492
1886	65,124	25,533
1887	47,246	15,191
1888	76,619	20,508
1889	84,658	22,735
1890	96,243	27,471
1891	84,679	27,504

MISCELLANEOUS.

MISCELLANEOUS.

TABLE 4.

Chalk.

IMPORTS OF CHALK.

Fiscal Year.	Value.
1880	$2,117
1881	2,768
1882	2,882
1883	5,067
1884	2,589
1885	8,003
1886	6,583
1887	5,635
1888	5,865
1889	5,336
1890	7,221
1891	8,193

Mercury, tin and zinc.

Mercury, Tin and Zinc.—The following tables illustrate the imports of these metals of which none has as yet been produced in Canada :

MISCELLANEOUS.

TABLE 5.

IMPORTS OF MERCURY.

Fiscal Year.	Pounds.	Value.
1882	2,443	$ 965
1883	7,410	2,991
1884	5,848	2,441
1885	14,490	4,781
1886	13,316	7,142
1887	18,409	10,618
1888	27,951	14,943
1889	22,931	11,844
1890	15,912	7.677
1891	29,775	20,223

MISCELLANEOUS.

TABLE 6.

IMPORTS OF TIN AND TINWARE.

Tin.

Fiscal Year.	Value.
1880	$ 281,880
1881	413,924
1882	790,285
1883	1,274,150
1884	1,018,493
1885	1,060,883
1886	1,117,368
1887	1,187,312
1888	1,164,273
1889	1,243,794
1890	1,289,756
1891	1,206,918

MISCELLANEOUS.

TABLE 7.

IMPORTS OF ZINC IN BLOCKS, PIGS AND SHEETS.

Zinc.

Fiscal Year.	Cwts.	Value.
1880	13,805	$ 67,881
1881	20,920	94,015
1882	15,021	76,631
1883	22,765	94,799
1884	18,945	77,373
1885	20,954	70,598
1886	23,146	85,599
1887	26,142	98,557
1888	16,407	65,827
1889	19,782	83,935
1890	18,236	92,530
1891	17,984	105,023

MISCELLANEOUS.

TABLE 8.

IMPORTS OF ZINC, MANUFACTURES OF.

Fiscal Year.	Value.
1880	$ 8,327
1881	20,178
1882	15,526
1883	22,599
1884	11,952
1885	9,459
1886	7,345
1887	6,561
1888	7,402
1889	7,233
1890	6,472
1891	7,178

MISCELLANEOUS.

Zinc.

MISCELLANEOUS.

TABLE 9.

IMPORTS OF SPELTER.

Fiscal Year.	Cwts.	Value.
1880..	1,073	$ 5,310
1881..	2,904	12,276
1882.....	1,654	7,779
1883.....	1,274	5,196
1884..	2,239	10,417
1885.....	3,325	10,875
1886.....	5,432	18,238
1887..	6,908	25,007
1888.....	7,772	29,762
1889.....	8,750	37,403
1890..... . ..	14,570	71,122
1891...	6,249	31,459

NATURAL GAS.

Ontario.

NATURAL GAS.

By H. P. H. BRUMELL, F.G.S.A.,

Assistant to the Division.

During 1891, as in previous years, active operations in search of natural gas were principally confined to Ontario where several large "gushers" were struck. Successful operations during the year were confined to Essex, Welland and Haldimand counties where heavy flows of gas were obtained, while wells sunk at Belleville, Toronto and Kingston afforded very small and short-lived flows. In view of the many failures to obtain gas it cannot be too strongly impressed upon the public that there are certain definite laws governing the production and distribution of gas and that many thousands of dollars are annually spent in futile efforts to obtain gas in ground that is known to be either barren or flooded. Gas is not to be obtained everywhere or anywhere, and before expending many dollars it would be well if investors and promoters of companies should inform themselves as to the district wherein they intend operating. Of course the greater part of the advice possible for the geologist to give is necessarily of a negative character, experiment alone making *absolute certainty* of the productiveness of any gas territory.

Welland County.

Active operations were carried on in this county, notably by the Provincial Natural Gas and Fuel Co., the Erie County Natural Gas Co., and the Mutual Natural Gas Co., several individual wells

having also been sunk, among others, those of Ephraim Morningstar and Geo. Zimmerman of Humberstone, S. Hopkins of Port Colborne, and Murray Kerr of Hamilton, as well as those of local companies at Welland and Ridgeway. NATURAL GAS Ontario.

The Provincial Company during the year finished thirteen new wells, making twenty-six in all, as follows :—

		Cubic Feet.
No.	1 with a daily flow of.....	2,050,000
"	2 "	375,000
"	3 "	600,000
"	4 "	2,200,000
"	5 "	8,500,000
"	6 "	70,000
"	7 "	3,000,000
"	8 "	Abandoned.
"	9 "	3,500,000
"	10 "	4,500,000
"	11 "	300,000
"	12 "	5,500,000
"	13 "	300,000
"	14 "	Abandoned.
"	15 "	500,000
"	16 "	12,500,000
"	17 "	2,500,000
"	18 "	2,000,000
"	19 "	1,500,000
"	20 "	300,000
"	22 "	2,600,000
"	23 "	Abandoned.
"	25 "	500,000
"	26 "	2,750,000
"	27 "	Abandoned.
"	28 "	Nil.
making a total daily flow of.....		56,045,000

NATURAL GAS Ontario.

These flows of gas are, with the exception of that in No. 15, all from the white Medina sandstone, according to the following record which is that of No. 1 well:

Character of Beds.	Thickness.	Formation.
Surface deposits.	2 feet.	Drift.
Dark gray limestone	25 "	Corniferous.
Drab and gray dolomite, black shales and gypsum.	390 "	Onondaga.
Gray dolomite passing into brown	240 "	Guelph and Niagara.
Black shales	50 "	Niagara.
White crystalline dolomite, gray towards bottom	30 "	Clinton.
Red sandstone	55 "	Medina.
Red shale	10 "	
Blue shale	5 "	
White sandstone	5 "	
Blue shale	20 "	
White sandstone	15 "	Gas horizon.

In well No. 15 the gas was struck in the Clinton formation at a depth of 625 feet, or five feet above the summit of the Medina.

This company have now three mains supplying the city of Buffalo and carrying the gas across the river from the Canadian side, near the International bridge, to Black Rock on the American side. From the wells these mains are fed by an eight-inch main extending through the entire length of the field, feeders being run from individual wells throughout. As was stated in last year's report, it was the intention of this company to carry well No. 14 to the Trenton limestone to test the gas-producing properties of that formation in this district this was done, without, however, economic result as the limestone was found to be barren.

The record of the well was as follows :—

Character of Beds.	Thickness.	Formation.
Surface deposits	47 feet.	Drift.
Drab and gray dolomites and shales	293 "	Onondaga.
Gray and brown dolomites	240 "	Guelph and Niagara.
Black shales	50 "	Niagara.
White and gray dolomites	30 "	Clinton.
Sandstones and shales	1,000 "	Medina.
Limestone and shales	865 "	Hudson River & Utica.
Limestone	195 "	Trenton.
Total depth of well	2,720 feet.	

A small flow of gas, 5,000 cubic feet was struck at 750 feet, or 90 feet below the summit of the Medina, at which point the boring would be in the second white sandstone bed. Salt water was struck at 525 feet, and the casing carried to 660 feet, or to the summit of the Medina.

The Erie County Company, an American company, have recently begun active operations and are now supplying gas to a considerable number of consumers in Buffalo. This company purchased several wells, and since their inception have sunk several more. For supplying Buffalo they have two six-inch mains laid across the river to Black Rock. Full particulars regarding this company were not obtained, owing to lack of time and the absence of some of the officials.

NATURAL GAS

Ontario.

Haldimand County.

Two companies have operated successfully in this county, viz. :—The Cayuga Natural Gas Company, Limited, and the Dunnville Natural Gas Company, Limited. The former incorporated with a capital stock of $20,000, drilled one well on lot 19, east side of Ouse Street, in the village of Cayuga. The well attained a depth of 710 feet, in which gas was struck at 563, 603 and 680 feet, the combined flow from these points being 250,000 cubic feet per day. The record of the well is as follows :—

Character of Beds.	Thickness.	Formation.
Surface deposits	23 feet.	Drift.
Limestone	120 "	Onondaga.
Shale bluish	132 "	
Very hard limestone, with salt water	232 "	Guelph and Niagara.
Shale bluish	41 "	
Limestone	15 "	Clinton.
Shale, light blue	5 "	
Sandstone, red	35 "	Medina.
Shale, red	62 "	
Sandstone, white	15 "	
Shale, red	30 "	
Depth	710 feet.	

The mouth of the well is at an elevation of ten feet above the Grand River at Cayuga, and consequently about 600 feet above tide level. Gas is now being supplied to the town, throughout the greater part of which pipes have been laid.

Of the operations of the Dunnville Natural Gas Company less can be said, as owing to lack of time the information was not obtained the record of drilling would, however, be very similar to that at Cayuga or Port Colborne. Three wells were drilled by this company the production of which is now being piped through the town, supply ing many shops and private houses.

Essex County.

The only operations in this county in search of natural gas were those undertaken by the Kingsville Natural Gas and Oil Company

who, during the year, finished their Nos. 3 and 4 wells. No. 3, drilled on lot 4, con. I., township of Gosfield South, was carried to a depth of 1,015 feet, where it was abandoned on account of salt water having been struck at 1,010 feet. The drilling began beneath a surface covering of eighty-three feet and was finished in limestone. Casing was carried to a depth of 573 feet only. In No. 4, however, the company were more successful, obtaining a daily flow of about 2,500,000 cubic feet of gas. This well is located on lot 7, con. I., Gosfield South, and was carried to a depth of 1,063 feet, in which at from 1,030 to 1,035 feet gas was obtained. Water was encountered at 160 feet and the casing carried to a depth of 531 feet, below which no further flows of water were noted. The company have put in place a new regulator for the town supply and a smaller one on the branch main to the Mettawas Hotel, and are now supplying, as well as shops, private houses and hotels, one saw-mill, grist-mill, woollen-mill, foundry, turning shop and sash and door factory in Kingsville. In Ruthven it is their intention to supply a fruit-evaporating establishment, as well as private houses and shops generally. NATURAL GAS Ontario.

Time has not allowed of the examination of the many specimens obtained from the wells of Essex County, but it is expected that the writer will be enabled to make these examinations shortly and make the result known in continuation of the report on gas and oil operations in Ontario now in press.*

York County.

In a well drilled by Messrs. Taylor Bros. on lot 11, con. III., township of York, and near their paper mill (middle mill), a small show of gas was noted in the Trenton limestone at from 700 to 750 feet. The record of the well, kindly furnished by Mr. W. F. Tasker, of Toronto, is as follows:—

Character of Beds.	Thickness.	Formation.
Surface deposits	38 feet.	Drift.
Shale	440 "	Hudson River and Utica.
Limestone, hard	300 "	Trenton.
do soft, with shale	185 "	
do hard	146 "	
"Arkose" beds	10 "	
Granite	8 "	Archæan.
Depth of well	1,127 feet.	

* Annual Report, Geological Survey of Canada, Vol. V., Part Q, 1889-90-91.

NATURAL GAS Ontario.

The well was started at an elevation of about fifty feet above Lake Ontario or 297 feet above mean tide level.

Hastings County.

The Belleville Natural Gas and Oil Company, of Belleville, drilled three wells during the year in search of gas, and in all cases unsuccessfully. The well known as No. 1 was drilled near the Grand Trunk Railway station and reached a depth of 252 feet, the lower 11 feet being in either granite or the "Arkose" beds. No. 2 well, sunk on the bay shore a short distance west of the river, was carried to a depth of 280 feet, and No. 3 on Massagasauga Point to a similar depth. In the latter the boring passed through yellow quartzose sandstone, presumably Potsdam, which rested immediately above the granite in which the boring finished. In No. 2 well a very heavy flow of mineral water was struck, and continues to flow. The water is sulphurous and contains a considerable proportion of sodium chloride.

Frontenac County.

At the Insane Asylum in Kingston, a well was drilled by the Provincial Government, the result being a very small flow of gas. The amount obtained was barely sufficient to burn above the mouth of the casing. The well was shallow, being but 171 feet deep, boring ceasing on the appearance of salt water.

During 1891, the following companies were incorporated under the Joint Stock Companies Act of Ontario, for the purpose of boring for natural gas :—

Name of Company.	Head Office.	Capital Stock.
Belleville Natural Gas and Ore Co.	Belleville	$ 25,000
Canadian Natural Gas Co.	Sherkston	100,000
Dunnville Natural Gas Co.	Dunnville	20,000
Farmers Natural Gas and Oil Co., of Gosfield	Windsor	100,000
Mimico Natural Gas Co.	Toronto	100,000
Mutual Natural Gas Co. of Ontario	Welland	20,000
Superior Natural Gas Co. of Ontario	Sherkston	100,000

Quebec.

QUEBEC.—For many years vague rumours of large flows of gas in the neighbourhood of St. Hyacinthe have been published in the press, and many inquiries have been made of the Geological Survey as to the gas-producing properties of the district. In response to these, Dr. Selwyn, Director of the Geological Survey, as well as the writer

visited the district when it was seen that the operations already carried out have not proved it to be gas-bearing to any economic extent. NATURAL GAS Quebec.

Dr. Selwyn speaks of his investigations in his summary report for 1891, as follows :—

"I proceeded to St. Hyacinthe, and, accompanied by Mr. Beauchemin and Mr. Desaulles, I visited the several sites where gas was reported. The first examined was on the farm of Antoine Laplante, about six miles north of St. Hyacinthe, on the concession St. Amable, two miles south-west of the village of St. Barnabé, and the same distance west of the Richelieu River. Here Laplante had recently, with the aid of a small hand-boring tool, succeeded in reaching the rock at a depth of 90 feet, a continuous, though not large, flow of gas being the result. The material penetrated consisted entirely of clay, with some small stones near the bottom. This boulder clay covers and almost entirely conceals the older rocks, and forms the level surface of the great plain of the Richelieu and Yamaska rivers. A pipe, 1½ inch diameter, has been inserted in the hole, and a continuous, though not powerful, flow of gas was coming from it. On inquiry, I found that, within a radius of 400 yards from this well, there were four places, sites of old wells, where gas is escaping. One of these was sunk 45 years ago, and the gas has been escaping ever since. The others are more or less recent trials for water, and have penetrated to rock through from 85 to 100 feet of clay, and, in all, gas comes from the bottom. In three, an inch and a-half pipe has been inserted, and the escaping gas ignites readily and burns steadily, but the pressure is light. On lot No. 18, parish of St. Hyacinthe, range St. Francis, on the farm of Emile Lorquet, close on the east side of the railway to Farnham, I also found gas escaping in a similar manner from a small pit sunk about two feet into the black soil. Near this, two wells had been sunk, one 150 yards east, 106 feet deep; the other about 500 yards north, 110 feet deep, and in both, I was informed, gas has been encountered at the bottom. The sinking was through clay, like that in the bore-holes on the St. Amable concession, which lies about eleven miles nearly due north, and on the other, or west, side of the Yamaska river."

NORTH-WEST TERRITORIES AND MANITOBA.—It was reported during the year that gas had been encountered at two points in Manitoba and the Territories. At Dominion City, on the Emerson branch of the Canadian Pacific Railway, gas is said to have been found in a well drilled for water, though of its character or quantity no authentic in- N.-W. Territories and Manitoba.

NATURAL GAS

formation is at hand. Gas was also obtained in two or three wells drilled at Medicine Hat, though to what extent is not known.

British Columbia.

BRITISH COLUMBIA.—In British Columbia one company alone was formed, under the title of the Steveston Natural Gas and Development Co., Vancouver, with a capital stock of $50,000. Of its operations, if any, no data are to hand.

NICKEL.

NICKEL.

Production.

The improvements in the economic condition of the nickel industry have greatly enhanced the value of Canada's deposits of nickeliferous pyrrhotite, and the benefit to the country accruing from their exploitation.

PRODUCTION.

These effects are clearly illustrated in the figures of production, given below which show the amount of pure nickel represented in the shipments of nickeliferous material for 1891 to be considerably over three times as great as those of the previous year :—

	Pounds of pure Nickel in matte, &c.		
1890	1,435,742,	valued at $	933,232
1891	4,626,627	"	2,775,976

The proportional increase has not been so great in the value as that shown for the amount, the average price for the metal as far as could be ascertained being 60 cents, or 5 cents per pound lower than the price for 1890.

The figures as above calculated represent, of course, the extreme and final value of Canada's nickel production, but the proportion of this value accruing to the various operators is comparatively small being dependent upon the point to which they follow the process of concentration and extraction. This varies at the different mines, the shipments made including mattes of varying degrees of richness and concentration, whilst some small quantities of raw ore even are included, as in the following statement :—

Total quantity of ore mined.....	85,500	tons.
Quantity of ore treated in production of matte.....	72,558	"
Quantity of ore shipped.....	175	"
do matte shipped.....	10,336	"

The shipments of matte vary considerably in their metallic contents, some small lots running as low as 11 per cent of nickel and 5 per cent

of copper, and others as high as 32 per cent of nickel and 17 per cent of copper. The great bulk of the matte shipped would, however, average about 22 per cent of nickel and 17 per cent copper. NICKEL. Production and values.

The price paid for the metals in this condition is said to be, for nickel, from 13 to 21 cents per pound, and for copper, from 4 to 6 cents per pound, so that taking mean values as below we get the following approximation of the value of the nickeliferous products of the mines in the condition in which it leaves them.

Nickel contents of matte, &c., 4,626,627 lbs., at say 17c. per pound	$786,526
Copper contents of matte, &c., 3,527,217 lbs., at say 5c. per pound	173,361
	$959,887

There were shipped by rail from this district 10,886 tons of nickel matte, &c., figures which closely agree with those obtained by direct returns. The books of the Customs Department give the value of the exports of nickeliferous material as $667,280.

We are indebted to the Engineering and Mining Journal of New York for the undermentioned figures of exports of nickel from the competing foreign countries named, which compared with our own figures illustrate the important place Canada had won even last year in the nickel markets of the world:—

		Lbs.
Canada, production of nickel,	1890.....	1,435,742
New Caledonia*	"	885,300
Norway	"	149,872
United States	"	144,841
Sweden	"	17,632

The value to the Dominion of its nickel deposits has been greatly added to by the inventions facilitating the extraction of the useful metals from the matte. These improvements are a secret in the possession of the Orford Copper Company, of Constable Hook, N.J., by which it is said the nickel is extracted in the form of oxide.

There seems also to be a great likelihood of still further facilities in the immediate future, as soon as the Mond process arrives at the stage of being an industrial success. By this method it is proposed to first bring the nickel in the ore to the state of oxide by roasting and then reduce it to the metallic state by heating in a current of water gas.

*Consular returns of exports.

NICKEL.

The ore containing the reduced nickel is then subjected to the action of carbonic oxide gas at a moderate temperature. The nickel then passes off in combination with the gas, which is then decomposed by subjecting it to a higher temperature in another part of the apparatus, where the nickel is deposited on suitable receptacles.

As it is claimed that any article can be given a coat of the metal equal to that deposited by electrolysis, this process, if commercially successful, will not only be a vast improvement upon the old method of extraction by chemical solution and fractional precipitation of the various metals in the ores, but it may further extend the uses of the metal in plating.

Another bright feature in regard to this industry is to be found in the results of the renewal of the tests of nickel-steel armour plate. These again demonstrated the superiority of this alloy for these purposes, which should assure a growing market for the metal apart from the steadily increasing demand for it in its other and older uses.

DISCOVERY AND DEVELOPMENT.

Discovery and development —New Brunswick.

NEW BRUNSWICK.—During the season the deposits of pyrrhotite near St. Stephen, N.B., were visited by Mr. H. P. Brumell, who gained the following information :

"Throughout the country to the north of St. Stephen are large areas of diorite, associated with which are many more or less extensive deposits of pyrrhotite. These pyrrhotite masses are almost invariably covered with a deposit of gossan resulting from the oxidation of the pyrrhotite.

"Three properties have been located and small development operations begun on them, viz. :—On the Rogers property by W. F. Todd, *et al.*, on a property to the E. S. E. by Messrs. J. A. Carroll and W. F. Best, and at Milltown by Mr. G. W. Ganong.

"*Todd's Location.*—On Todd's location the development consisted of a shaft 22 feet deep and several trenches which exposed the massive pyrrhotite beneath the gossan. In the shaft no distinct vein characteristics were discoverable, the shaft (12 feet by 12 feet) being completely in ore though occasionally masses of country rock were exposed in the sides. The country rock appears to be a very coarse-grained diorite, being in places much slickensided and showing other evidences of movement. The rock in the vicinity of the ore bodies is highly charged with pyrrhotite, and occasionally with chalcopyrite. On the north-west side of the shaft a rock shows which is found to be a very hard semi-crystalline limestone containing very sparsely scattered

grains of pyrite or pyrrhotite. What connection this has with the general 'country' rock could not be ascertained.

NICKEL. Discovery and development. —New Brunswick.

"Assays made of the ore show about 1·95 per cent of nickel to the ton. One made for W. F. Todd at the Institute of Technology, Boston, afforded 1·92 per cent nickel, and an average specimen from the trench alongside shaft—surface specimens—gave 1·98 per cent nickel. Both in the shaft and trenches, wherever the ore was exposed the copper contained was apparently of too small a percentage to materially affect the value of the ore.

"*Carroll Property.*—This was the first nickel property opened, and is situated about one-half mile or more to the E. S. E. of Todd's property. The owners, Messrs J. A. Carroll and W. F. Best have sunk a shaft about 14 feet deep, in the bottom of which the ore shows strong and clean. The surface indications were not good, consisting mainly of small scattered patches of pyrrhotite in the 'country' rock. The rocks and characters of this property are in every way similar to those at Todd's. An assay of a picked specimen from bottom of shaft afforded W. F. Best of St. John, 2·62 per cent nickel and 7·92 per cent copper. At the time the property was visited, August, 1891, it was stated that the property was under a four months' bond to American parties for $25,000.

"*Ganong's Property.*—On the north bank of the St. Croix River at Milltown, about two miles above St. Stephen, is a body of pyrrhotite showing in a stripping an exposure of ore about twenty-five feet by three feet. Owing to the somewhat inaccessible position of the deposit and the covering of river detritus, little more could be learned about it. The mining right to the property is held by Mr. G. W. Ganong, who says that an assay made of the ore by Mr. F. W. Smith, State Assayer, Boston, gave 1·10 per cent nickel. An assay of ore said to be from this deposit, was made in the Geological Survey laboratory, Report 18 0–1–2, page 16 H, and afforded 0·923 per cent nickel and 0·394 per cent copper.

"*Moore's Lake, Charlotte Co.*—Here a mining license has been granted to E. H. Barter and Geo. J. Clarke of St. Stephen, covering a property on which are several quartz veins. The most southerly of these are two parallel veins a few inches apart which are twelve and seven inches wide respectively, and carry considerable quantities of pyrites. Strike N. 70° E. dip < about 80°.

"In a shaft sunk on these, and about 15 feet deep, the two small veins come together and form a strong and highly mineralized ore body. An assay of this ore gave W. French Smith, of Boston,

8 lbs. copper.....
12·46 lbs. nickel..... } to the ton.

NICKEL.
Discovery and development.

"The "country" rock appears to be a highly altered schist heavily charged with pyrite or pyrrhotite.

"The rocks of the entire nickel district consist of coarse and finer grained diabases, those about 400 yards north of Ganong's opening being very coarse grained and holding large masses of plagioclase. Water and timber for mining purposes are both plentiful, and from Carroll's and Todd's properties an easy gradient is available to the mouth of the Dennis stream on the St. Croix where direct shipment can be made by either water or rail."

Quebec.

QUEBEC.—In the province of Quebec there is, so far, nothing of commercial importance to note. Pyrite is a very common mineral in the Laurentian rocks of the area north of the St. Lawrence and Ottawa rivers, and some deposits of pyrrhotite have been found. The gneisses of these districts will often be found to carry quite a large proportion of pyrite, but, so far, these have proved to carry too small a proportion of nickel to be of industrial value. As a further contribution to the evidence on this point, quotation is made below of the results of assays of pyritous specimens from these districts, made by Messrs. Ledoux & Co., of New York, as given in the report of Mr. Oblaski, the provincial mining engineer.*

"Magnetic pyrites in gneiss, on lot 1½ West, Range VIII., of Litchfield (Pontiac). This pyrite is rather abundant and is at a short distance from a small hill of diorite.

Nickel	0·28
Cobalt	Traces.
Copper	Traces.
Iron	22·24
Sulphur	9·45
Silver	0
Insoluble matters	57·03

"Iron pyrites in diorite, township of Clarendon (Pontiac county), lot 24½ N.E. range VII.

Nickel	0·55
Silver	0
Insoluble matters	52·41

---

* Report of the Commissioner of Crown Lands, province of Quebec, 1891.

"Analysis of another specimen of gneiss:

Nickel	Traces.

"Iron pyrites in gneiss, Clarendon Range VII... 27

Nickel	Traces.

"Magnetic pyrites in diorite. Calumet Island, Range IX., lots 2 and 3.

Nickel	Traces."

ONTARIO.—In this province the centre of activity is, as in past years, the Sudbury district. Here there were a number of operators working small gangs of men in proving various properties. Of these, the chief were the operations under the management of Mr. A. Merry, jr., on sundry lots in Levack township for capitalists of London, England, having options on the properties. Others making returns to this office are:—The Inez mine, lot 3, concession V., township of Drury, worked by the Drury Nickel Co., employing 75 men. The work done during the year was confined to the erection of buildings and plant preparatory to the inauguration of mining operations proper. Considerable ore had been mined up to the end of the year, said to run over 3 per cent in nickel. Ontario.

The Algoma Nickel Co. worked a force of 12 men on lot 11, con. V., township of Lorne, and mined some ore, but made no shipments.

A correspondent also writes us that "lot 1, con. II., township of Blezard, is said to be now in process of exploration by Toronto capitalists. The ore from this property is said to be very rich, and is certainly remarkable in appearance, somewhat resembling 15 per cent nickel matte."

Development work was also done on various properties in the vicinity of the Nelson Station, on the Canadian Pacific Railway, in the township of Craig, and at Nickel Mountain, near Wahnapitae Lake.

Mr. A. E. Barlow, of the Departmental Field Staff, furnishes the following notes regarding the district: "During the summer of 1891 very little prospecting was done, on account of the harshness of the Ontario Mining Act. The general condition of the industry is, however, on the whole satisfactory. Had the Customs Smelting Co. been able to get enough capital, the smaller properties would have been developed, but these will receive attention in the near future, and there seems no reason to doubt that the nickel industry has gained a good solid footing.

NICKEL.
Discovery and development. —Ontario.

"At the Worthington Mine a very white nickel ore occurs in the form of circular or oval patches, surrounded by the more common pyrrhotite or rocky matter. An assay of this made for me by Mr. Thos. L. Walker, M.A., late chemist of the Murray Mine, gave 4·5 per cent of nickel. A complete analysis of this ore was very kindly undertaken by Dr. W. F. Hillebrand, through Prof. F. W. Clark, Chief Chemist of the United States Geological Survey, with the following result:—

Iron	38·36
Nickel	4·57
Manganese	·10
Sulphur	45·11
Sulphuric acid	·95
Carbonic acid	1·49*
Calcic oxide	1·91
Magnesia	·41
Insoluble	4·80
Water at 100° C	·55
Water combined	?
Loss and oxygen	?

* Calculated on the supposition that all the calcium exists as carbonate.

"Dr. Hillebrand says: 'The sulphide is certainly not pyrrhotite, it is not magnetic, and there is far too much sulphur; neither is it polydymite. There is almost enough sulphur for a mixture FeS_2 with Ni_3FeS_5—the polydymite of Sudbury, according to Clark & Catlett. On heating in a closed tube a heavy sublimate of sulphur is formed, which is probably from FeS_2.' Prof. Clark says in his letter: 'It seems to me that the mineral is a mixture, not a definite species. Polydymite may be a constituent of it, but of this there is no proof. your Sudbury minerals deserve an exhaustive study, and the work would be well repaid.'

"At the Worthington Mine, also, another sulphide occurs, which is highly nickeliferous. The richer portions occur in the form of more or less rounded patches of various sizes, and are brighter and more crystalline. The clearest and brightest crystals taken afforded Mr. T. L. Walker, to whom I submitted the samples for assay, 30 per cent of nickel. A complete analysis was made of this sample. The portion used contained both the poorer nickel ore and the supposed mixture of millerite with other sulphides, and also a small amount of rocky matter.

Sulphur	36·13
Iron	43·43
Nickel	17·48
Insoluble	·50
Moisture, copper and loss	2·46
	100·00

"*Emmons Nickel Co.*—The discovery of gersdorffite and niccolite on lot 12, con. III., township of Dennison, became known early in 1891, these minerals being recognized in a small specimen brought to the Geological Museum by Mr. Eagleson, of Ottawa, who had obtained the specimen from Mr. D. O'Connor, of Sudbury, the owner of the property.

"Mr. T. L. Walker made an analysis of these minerals together, as they were so intimately mixed in the specimen I had given him that the two minerals could not be separated. The results he gives as follows:—

Nickel	20·87
Cobalt	·64
Copper	Trace
Iron	2·43
Sulphur	10·60
Arsenic	26·04
Silica	26·70
	87·28

"'I had intended to make a complete analysis, but time was wanting. The other 12·72 per cent is made up of Al_2O_3; MgO; CaO and Na_2O. Of these, I estimated only Al_2O_3, which is 5·43 per cent. Possibly the iron given above was contained in the rock matter and in part of the nickel ore.'

"Mr. Hoffmann has made a complete analysis of the pure gersdorffite. His samples were procured by me from lot 12, con. III., of Dennison."

The Canadian Copper Company have during the year erected plant similar to that installed last year at the Murray mine for concentrating the low grade matte. The description of this process as given in last year's report*, together with further details kindly furnished by Mr. Barlow from his notes, is as follows:—

*Report of Division of Min. Stat. and Mines, 1890, p. 139 s.

NICKEL.

Discovery and development. —Ontario.

The process is very similar to that followed in Bessemerising iron. The Manhé converters are cylindrical shaped vessels with convex ends measuring usually about eight feet in length with a diameter of about four feet. They are made of boiler plate and lined with a thick layer of clay mixed with quartz. The latter ingredient is obtained by the Murray Mine from the Bruce Mines, where great quantities of *skimpings* are found, resulting from the jigging of the ore of that mine during its operation in past years. This material consists of the crushed quartzose gangue of the vein cleaned of all but a small proportion of the sulphurets of copper constituting the ore. It carries but a slight amount of felspar. The converter rests with its axis horizontal on a carriage running on a track. It is provided on its upper side with a mouth or throat through which it can be charged. The blast is driven through the charge from two parallel series of small tuyere holes, piercing the lining along either side below and along the length of the vessel. Opposite each of these tuyere holes, corresponding holes are pierced through the tubes which run along the outside of the converter to supply them with blast. These holes are closed with wooden plugs, removable to admit an iron bar, which being poked through them successively during the process of blowing keeps the tuyeres clear and the charge stirred.

A gearing enables the converter to be rotated on the car about its horizontal axis, and the throat having been thus lowered, a charge of low grade matte from the well or forehearth of the cupola is run into it. It is then rotated back till the mouth is again vertical and run around underneath a large hood connected with a stack in another part of the smelter house where it is connected with the blower.

The blast having been continued for about an hour, the converter is again rotated about its longer axis and its contents thus poured into moulds. The slag having been removed, a high grade matte remains, containing from 38 to 40 per cent of nickel, with an equal quantity of copper, which forms the product shipped.

The chief operators and those contributing most largely to the output of the district were, as in past years, the Canadian Copper Co., Messrs. H. H. Vivian & Co., and the Dominion Copper Co. The latter company, however, ceased operations in October, pending a change of ownership, but with the intention of starting up again in the spring. The returns show that from seven to eight hundred men find employment directly in connection with mining and exploring in the district, apart from those whose living depends indirectly upon the industry.

A visit was made to the Schreiber deposits by Dr. Selwyn, the Director of the Survey, in regard to which he speaks as follows :— NICKEL. Discovery and development. —Ontario.

"I left Deloraine on the 20th of April, the 22nd was spent at Schreiber in an examination of the cuttings, in the forenoon, four miles west, and in the afternoon, two miles and a half east, and to the openings lately made on a deposit of pyrrhotite precisely like those of Sudbury and occurring on the border of a mass of diabase, associated, as at Sudbury, with schists, breccias and some white granite rock, this latter being well seen near both ends of the first trestle east of Schreiber. The analysis of the samples of the ore that were collected gave only ·003 per cent of nickel, but as in all these deposits the nickel is very unevenly distributed an analysis of a few small samples is of little value as an index of the contents of the whole body. At the date of my visit the snow was still thick in the woods, and I was not able to do more than ascertain that the area over which the pyrrhotite occurred was more than sufficient to constitute a good mine, and was very favourably situated for working. The deposit was, I believe, opened by Messrs. Marks, of Port Arthur, towards the close of 1890. I cannot learn that any work has been done on it since the date of my visit in April last."

During the course of his investigations of the shores of Lake Winnipeg, Mr. Tyrrell, of the Survey staff, made a study of the area of Huronian rocks found on its eastern shore, near the southern end, which he compares with the Sudbury rocks as follows :—

"I also remained for two days at Sudbury for the purpose of comparing the rocks that are there so rich in copper and nickel with those found on the east side of Lake Winnipeg, and it was very gratifying to see the remarkably close similarity between the two sets of rocks."

In view of the importance which this metal is likely to assume in human affairs it would be well for prospectors to direct their attention to the examination of these areas of Huronian rocks, for although the mere presence of these rocks does not assure the existence of nickeliferous deposits, still the chances are good that in many places conditions similar to those accompanying the Sudbury ore deposits will be found to exist with the likelihood of finding similar deposits. These areas, with their extent and position will be found marked on the general geological map of the Dominion issued by the Geological Survey Department.

PETROLEUM.

PETROLEUM.

By H. P. H. BRUMELL, F.G.S.A.

Assistant to the Division.

The year 1891 was one of considerable interest to those operating in oil on account of the discovery of petroleum in Welland and Essex counties in Ontario, and of the further discoveries in the North-west Territories and British Columbia.

Lambton County.

Ontario.

ONTARIO.—In Ontario the most important district is of course that in Lambton county, of which but little can be said beyond the fact that it is still the only district wherein the production is utilized in the manufacture of the various products of petroleum. In the Petrolia and Oil Springs fields there were during the year, according to the *Petrolia Topic*, 5,335 wells producing oil, as follows:—In Petrolia and vicinity in Enniskillen township, 3,525; in Oil Springs, 1,553; in the township of Moore, 70, and in Sarnia township, 187. The usual number of exhausted wells were abandoned during the year and new ones drilled to replace them.

During the past two years there has been a steady decrease in the stocks held by the various tanking companies, as may be seen on reference to the following figures:—

	Bbls.
Stocks on hand, 1st January, 1890	198,219
" 1st February "	160,621
" 1st March "	144,149
" 1st April "	142,223
" 1st May "	150,665
" 1st June "	165,018
" 1st July "	168,454
" 1st August "	176,318
" 1st September "	167,071
" 1st October "	157,283
" 1st November "	139,449
" 1st December "	123,593
" 1st January, 1891	96,684
" 1st February "	89,248
" 1st March "	78,638
" 1st April "	64,347
" 1st May "	53,962
" 1st June "	52,458
" 1st July "	61,316

PETROLEUM. —Ontario.

This falling off in stocks may, however, very easily be explained by the fact that the consumption of crude oil is yearly increasing, as may be seen on reference to table 4. The supply of crude oil although not as great as that of many years ago, is still amply sufficient for the market and to-day the Enniskillen fields are yearly producing more by reason of the opening up of new territory and the sinking of new wells in the older portions of the field. Several new and successful wells were drilled west of Oil Springs and outside the recognized limit of that field, and explorations in Moore township to the north-west of the Petrolia field are extending the limits of the field in that direction. There is apparently no fear among the oil producers of any immediate famine, although they all recognize the inevitable falling off and final failure of supply that comes to all oil districts.

For any further information regarding this county, the reader is referred to the report of this Division for 1889—part S, vol. IV., Annual Report Geological Survey, 1888–89.

We are again indebted to Mr. James Kerr, of Petrolia, for the following information regarding the prices of crude oil as quoted on the Petrolia Oil Exchange.

PETROLEUM.

TABLE 1.

PETROLEA OIL EXCHANGE, CRUDE PETROLEUM BUSINESS FOR THE YEAR 1891.

1891.	Opening Price.	Highest Price.	Lowest Price.	Closing Price.	Average Closing Price.	Sales. (Barrels.)
January	$1 30	1 30½	1 28½	1 30	1 30	52,655
February	1 29½	1 29⅝	1 27¼	1 28	1 28½	28,649
March	1 28	1 36½	1 28	1 35	1 31¾	24,979
April	1 35½	1 38½	1 35½	1 38½	1 37	41,173
May	1 38⅝	1 38¾	1 36⅝	1 38	1 37½	29,375
June	1 38	1 38	1 36½	1 36½	1 37	19,811
July	1 36½	1 36½	1 32	1 34½	1 33⅝	31,289
August	1 34⅝	1 35	1 34½	1 35	1 34⅝	39,236
September	1 35	1 35½	1 34¾	1 35	1 35	45,095
October	1 35½	1 35½	1 34¼	1 34¼	1 35	30,675
November	1 34¼	1 34¼	1 26½	1 33	1 33¼	17,531
December	1 33	1 33	1 30	1 31	1 31½	16,985
Year 1891	1 30	1 38¾	1 26½	1 31	1 33¾	377,453
" 1890	1 01½	1 37	1 01¼	1 30	1 18	394,924
" 1889	1 21	1 21	80	1 01	92¾	400,932
" 1888	75½	1 23½	71	1 23	1 02¾	516,007
" 1887	92	92	66	76	78	406,203

Essex County.

PETROLEUM. —Ontario.

During 1891 Messrs. Hiram Walker & Sons, of Walkerville, were utilizing, as a lubricant, the crude oil obtained from their No. 2 well, of the Marshfield series. This well was producing daily about four barrels of oil very similar in appearance and gravity to that obtained at Oil Springs. During the fall the well, after being closed down for a short time, was reopened and cleaned out preparatory to having the boring carried to a greater depth.

No use was made during the year of the well at Comber wherein a small flow of oil had been found.

Welland County.

In this county a very interesting discovery was made during the year by the Provincial Natural Gas and Fuel Co., who, in two of their wells, encountered oil. The wells affording the oil are Nos. 20 and 28, located on lots 11 and 12, respectively, of concession III. of Humberstone, where the oil is accompanied in the case of No. 20 by 300,000 cubic ft. of gas per day, that in No. 28 occurring with little or no gas.

The record of these wells is as follows:—

Character of Beds.	No. 20.	No. 28.	Formation.
Surface deposits.	63 feet.	72 feet.	Drift.
Drab and gray dolomites.....	282 "	273 "	Onondaga.
Gray dolomite.....	240 "	240 "	Guelph and Niagara.
Black shale.....	50 "	50 "	Niagara.
White crystalline dolomite.....	30 "	25 "	Clinton.
Red sandstone.....	55 "	55 "	Medina.
Red shale..... ...	10 "	10 "	
Blue shale	5 "	5 "	
White sandstone.....	5 "	5 "	
Blue shale.....	20 "	20 "	
White sandstone	22 "	29 "	
Depth.....	782 feet.	784 feet.	

In well No. 20 salt water was encountered at 540 feet and was cased off, the casing being carried to a depth of 582 feet. Gas was struck in

the second white sand at 761 and 764 feet, in both instances being accompanied by oil which had an estimated daily flow of two barrels from each of these depths, or a total flow from the well of four barrels. In No. 28 the oil was found in the same horizon as the foregoing at a depth of 768 feet, or eight feet below the summit of the second sand, and was accompanied by but a small quantity of gas. The oil produced is equal to about two barrels per day. Salt water was cased off at 580 feet. PETROLEUM. —Ontario.

The oil is of superior quality its gravity being about 45° Baumé; when viewed by transmitted light it is a deep ruby red and by reflected light a dark olive green. As to the limits of the oil territory nothing can as yet be said, as no further explorations for their definition were made.

Gaspé County.

QUEBEC.—As the result of the operations of the Petroleum Oil Trust Co. of Montreal, a non-incorporate body, five wells were sunk in the vicinity of Gaspé Basin, in one of which a small show of light gravity oil was obtained. The oil, which is of about 40° Baumé gravity, is light green in colour and very similar in appearance to the oil found in Welland county, mentioned above. The district was not visited, but on interviewing Mr. James Foley, of Montreal, the president of the company, the following facts were elicited. Quebec.

In one well, that sunk at Seal Cove, the drilling was continued to a depth of 3,000 feet. Of this the first two feet were through surface deposits, beneath which were encountered 850 feet of bluish shale or slate, followed by 1,298 feet of yellow and white sandstone; fresh water, which flowed over the casing, was found at 30 and 70 feet. During the fall the property and operations were examined by an English expert, though with what result has not been made known.

Alberta.

NORTH-WEST TERRITORIES.—During 1891, Dr. Selwyn, Director of the Geological Survey, visited the district to the south of Pincher Creek to make investigations regarding the reported discovery of oil in that vicinity. In his summary report for 1891, he writes as follows:— N. W. Territories.

"I found considerable excitement existed in the village (Pincher Creek), in fact, a decided 'boom' in petroleum claims, and that a company had been formed to put down a boring, the site selected for the experiment being on sec. 21, township 3, range 29, some 18 miles south, a little east of Pincher Creek village.

PETROLEUM. —N. W. Territories.

"On Monday, the 20th of July, I proceeded to the locality named, accompanied by several gentlemen interested in the work. The country traversed is fine farming land, a richly grassed undulating prairie well watered by numerous small tributaries of Pincher Creek and the Waterton River, all of which eventually find their way to the Saskatchewan. The site of the proposed boring was on a small flat on the left bank of one of the tributaries of Waterton River. A gang of men were at work erecting a derrick and preparing to put an engine and boiler, already on the ground, in place.

"The evening of the 20th of July and the whole of the following day was devoted to an examination of the rocks that were exposed in the creek both below and above the site selected for boring. They were ordinary varieties of sandstone and sandy shales of the Cretaceous, with irregular dips from 15° to 20°. The last exposure of these rocks up the creek was about three miles and a quarter, then, for about three miles further there were no exposures up to where the creek emerges from a rocky gorge, all along which there are good exposures of hard flinty red, green and gray shales and sandstones, often gritty and quartzose and dipping to south-south-west at 25° to 30°. These are the Cambrian rocks which here form the base of the eastern spurs and ridges of the Rocky Mountains. It was stated that both in this gorge and at several places in pools on the prairie to the eastward, petroleum had been seen, but no one at the boring camp could show me any of these places.

"The whole country for many miles around and up into the entrance of the South Kootenay pass, nine miles to the south, was marked off with the stakes of the oil claims. On inquiry, I was informed that an 'expert' named Baring had been there and had expressed a favourable opinion as to boring where operations were being commenced. I was unable to learn any other reason for fixing the site. The note I made under date 21st July reads: 'There is nothing whatever to indicate the existence of petroleum in this vicinity. It seems highly improbable that it should be found here, though, of course, not impossible.' I subsequently heard that a copious flow of water had been struck and the boring abandoned. The cost of this very absurd and useless operation must have been considerable.

"On the 22nd of July, I left the boring camp and proceeded about eight miles in a southerly direction, gradually approaching the foot of the mountains, till we struck the Kootenay branch of the Waterton River, which here leaves the South Kootenay or Boundary Pass. This stream was then followed up about two miles and a half, where we camped

on the left bank, opposite a depression in the high range which here borders the pass on its southern side, and divides the waters of the Kootenay branch from those of "Cameron Falls" Creek. An ascent of about two miles by a somewhat rough trail mostly over gray and white heavy bedded dolomites, brought us to the summit of this depression. We then descended into the valley of Cameron Falls Creek. This creek takes its rise in a small lake near Camp Akamina of the boundary survey and flows north-east about seven miles to where we struck it, and where it makes an almost right angle bend and flows south-east into Waterton Lake. PETROLEUM.—N. W. Territories.

Cameron Falls brook is a rapid mountain stream, eight or ten yards wide. After following it up about a mile and a half on the left bank, Mr. Fernie, my guide, remarked that we must be close to where the oil had been found. He had scarcely spoken when, while still in the saddle and on the trail eight or nine feet above the brook, I noticed a powerful odour of petroleum. Descending to the edge of the water and stirring the stones and gravel in the bed of the stream, considerable quantities of oil at once rose to the surface and floated away. Crossing to the right bank it was again seen coming out of the bank, some inches above the then level of the stream. Here, skimming it off the surface of a shallow pool, a wine bottle full was soon collected. This can now be seen in the Geological Survey Museum. Sixty or seventy yards below where the oil was seen, a rocky reef of gray siliceous dolomite crosses the creek and rises into a steep bluff on the left bank; on the right bank, seven or eight feet above the creek, a broad, thickly timbered flat extends for 150 yards to the base of the bordering mountains which culminate six miles to the south-west at the boundary monument, 6,000 feet above sea level.

"No work whatever had been done to test the nature of the oil sources. A comparatively small outlay for some shallow sinking or boring on the flat above described would do this."

BRITISH COLUMBIA.—Continuing his investigations into British Columbia, Dr. Selwyn proceeds with the account of his work in the same report, as follows:— British Columbia.

Kootenay District.

"On the 23rd of July, we proceeded through the pass, crossing the summit and camping on Akamina Brook, about six miles down the western slope in British Columbia. On the 24th we proceeded down the valley and at about four miles north of the 49th parallel, the trail came down to the level of the brook, and here on the edge of a beaver dam pool there were ledges of hard dark blue shale, dipping

PETROLEUM. —British Columbia.

E. 30° N.< 12°. Lifting layers of this at and below the water a quantity of dark green circular patches of oil rose to the surface, and a precisely similar result followed by stirring up the mud in the bottom of the pool. This place is about fifteen miles in a direct line, west 10° south, from the occurrence on Cameron Falls Creek, the main watershed of the Rocky Mountains and Mounts Kirby, Spence and Yarrell intervening. Oil is said by the Indians (the Stoneys) who frequent this region, to occur at other points, in the Akamina Brook valley, both above and below that recorded. The Akamina joins the Flathead River in Montana, about four miles south of the international boundary. The Beaver Dam oil is of a dark greenish-black, and does not apparently differ much from that of Cameron Falls Creek. Preliminary tests might be made here by sinking a shallow shaft in the shales at the Beaver Dam pool, and by a boring on the sandy and gravelly flat country about two miles and a half north of the boundary line.

"On the 24th of July we camped in Montana, on the left bank of the Flathead River, about two miles above the mouth of the Akamina or Kish-e-ne-nah Creek.

"On the 25th we proceeded up the Flathead Valley, the trail passing for the most part along high terraces of sand, clay and gravel. At 8 a.m. we recrossed the boundary on one of these terraces, and then again descended to the river where we off saddled and waited for the pack train. It arrived at 10.30; and we then ascended again to the high level terrace and turning north crossed a number of ridges and gullies into the valley of Sage Creek, camping on the right bank at about nine miles above its mouth.

"At about a mile and a half higher up, the creek leaves the high mountains which border its upper course in a north-easterly direction up to the main watershed, some twelve or fourteen miles distant, and here at the edge of the water, on the left bank, I found hard dark flinty shales like those at the Beaver Dam pool on the Akamina, dipping S. 25°—30° W. <25°. Directly the layers of this rock are raised, the oil rises and spreads over the surface of the water in such abundance that a short time suffices with the aid of a tin cup to collect a bottle full. Here, also a considerable quantity of gas escapes from the cracks and joints in the rock and ignites freely on the application of a match.

"Less than half a mile higher up, on the right bank and on the opposite or west side of the valley, oil was again found issuing from the base of a bank of drift which has here filled the valley and caused the stream to make a sharp bend eastward to the base of the opposite

mountain. No rock was exposed here, but every stone in the bed of the creek, especially on being broken or rubbed, gave out a strong odour of petroleum. The oil collected here, a sample of which can be seen in the Museum, differs entirely in appearance from those of Cameron Falls Creek and Akamina or Kish-e-ne-nah Creek. PETROLEUM. —British Columbia.

"Some of it was of a light lemon yellow, but most of it nearly the colour of pale brandy and with a very powerful petroleum odour.

"The general geological structure, the character of the rocks and the physical aspect of the country in the South Kootenay, the North Kootenay and the Crow's Nest and other passes of the Rocky Mountains have been admirably described by Dr. G. M. Dawson,* and the South Kootenay Pass is also described in his Report on the Geology and Resources of the Forty-ninth Parallel, 1875. For details on the subjects named these works can be referred to. The present is, however, I believe the first recorded instance of the occurrence of petroleum in this region, as well as of its occurrence in Cambrian rocks. Whether the reference of the rocks to this age is correct, is not quite certain; that it is so as regards the somewhat similar siliceous dolomites and quartzose strata of the Kicking Horse Pass has been proved by the discovery of a Cambrian fauna and there seems no reason to doubt that the petroleum-bearing beds of the South Kootenay Pass are of the same age. At present, however, except on the traverses made by Mr. Dawson, little or nothing is known respecting the distribution of the formations in the great block of mountainous country which lies between the 49th and 51st parallels of latitude and the 115th and 117th degrees of longitude, and which comprises the Purcell, Hughes, Macdonald and Galton ranges, and covers an area of about 9,600 square miles, much of it densely wooded and with peaks ranging to eight and nine thousand feet."

STATISTICS.

Statistics.

Production.—During 1891 only ten refineries were working, the Canadian Oil Co. of Hamilton and the Sarnia Oil Co. of Sarnia having suspended operations. Among the refineries operating the only change from last year is that wherein the refinery owned in the past by the Messrs. M. J. Woodward & Co., passed into the hands of Samuel Rogers & Co. of Toronto.

Those operating were: The Imperial Oil Co., S. Rogers & Co., John McDonald; The Petrolea Crude Oil and Tanking Co., The Consumers' Oil Co., McMillan, Kittredge & Co., The Premier Oil Co., and John McMillan, all at Petrolea, and John R. Minhinnick, and W. Spencer & Co., at London.

*Annual Report, Geological Survey, 1885.

PETROLEUM. —Statistics.

From returns made direct to this office there were 27,860,719 gallons or 796,020 barrels of crude oil consumed. Assuming that the stocks carried into and out of the year by the different refineries were the same, and deducting the decrease in stocks held by the tanking companies of 38,715 barrels, there will be found to have been an approximate production of crude oil of 757,000 barrels, an increase over figures obtained in the same way for last year, of 62,000 barrels. At the average price for crude oil of $1.33 per barrel the value of the year's production would be $1,006,810.

As in previous years, however, the production of crude oil, as shown in the summary table of production, is obtained by computation from the inspection returns of the Inland Revenue Department.

The tanking companies operating as such were: The Petrolea Crude Oil and Tanking Co., The Crown Warehousing Co., and the Producers Tanking Co., all of Petrolea, all of whom kindly furnished returns of their operations during the year. These returns afford the following result:—

Stocks, 1st January, 1891.....	96,683$\frac{33}{35}$	barrels.
Quantity of oil received.....	505,646$\frac{25}{35}$	"
" " delivered.....	544.362$\frac{15}{35}$	"
Stocks, 1st January, 1892.....	57,968$\frac{8}{35}$	"
Decrease in stocks during year.....	38,715$\frac{25}{35}$	"

Of the operations of the refineries in the manufacture of the various products of petroleum, the following tables compiled from returns made direct to this office give the necessary information.

PETROLEUM.

TABLE 2.

PRODUCTION OF CANADIAN OIL REFINERIES.

Products.	1890.		1891.	
	Quantity.	Value.	Quantity.	Value.
Illuminating oils..... galls.	11,129,277	$1,264,677	10,427,040	$1,170,241
Benzine and naphtha... "	636,247	37,026	603,971	36,790
Paraffine oils..... "	446,888	64,713	622,287	75,772
Gas oil..... "	4,246,447	84,752	3,373,720	89,267
Lubricating oils and tar. "	2,877,388	130,349	2,500,000	101,752
Paraffine wax..... lbs.	913,730	56,903	741,611	60,687
Totals.....	.....	$1,638,420	.....	$1,534,509

PETROLEUM.

PETROLEUM. —Statistics.

TABLE 3.

CONSUMPTION OF CRUDE OIL AND CHEMICALS.

Articles.	1889.	1890.	1891.
Crude petroleum.....gal'ls.	25,066,275	28,267,746	27,860,719
Sulphuric acid..... .. .. lbs.	3,638,704	4,284,826	4,213,984
Soda..... "	380,487	336,758	319,736
Litharge..... "	477,969	443,922	394,715
Sulphur..... .... "	76,325	85,729	54,032

The data for the compilation of the following figures, and of tables 4 and 5, are taken from the books of the Inland Revenue Department, and show the number of packages of Canadian oil inspected during the calendar year 1891, as well as the total quantity of refined oil, imported and domestic oil, inspected during the fiscal years from 1881 to 1891 inclusive.

During 1891 the packages of Canadian oil inspected were:—

234,824.....at 10 cents inspection fee.
9.....at 5 "
40,553.....at 2½ "

Assuming that these packages contain 42, 10 and 5 gallons respectively there will be found to have been an inspection of

9,862,608 gallons in packages of 42 gallons each
90 " " 10 "
202,765 " " 5 "

or a total inspection of 10,065,463 gallons. This quantity computed at an average percentage of 38 would be equivalent to a consumption of crude oil of 26,435,430 gallons or 755,298 barrels, which at the average price of $1.33 would have a value of $1,004,546.

PETROLEUM —Statistics.

The following table, computed in a manner similar to the above, shows the quantity of crude oil used each fiscal year since 1881.

PETROLEUM.

TABLE 4.

CANADIAN OILS AND NAPHTHA INSPECTED AND CORRESPONDING QUANTITIES OF CRUDE OIL.

Fiscal Year.	Refined Oils Inspected.	Crude Equivalent Calculated.	Ratio of Crude to Refined.
	Galls.	Galls.	
1881	6,406,783	12,813,566	100 : 50
1882	5,910,787	13,134,993	100 : 45
1883	6,970,550	15,490,111	100 : 45
1884	7,656,011	19,140.027	100 : 40
1885	7,661,617	19,154,042	100 : 40
1886	8,149,472	21,445,979	100 : 38
1887	8,243,962	21,694,637	100 : 38
1888	9,545,895	25,120,776	100 : 38
1889	9,462,834	24,902,195	100 : 38
1890	10,121,210	26,634,763	100 : 38
1891	10,270,107	27,026,597	100 : 38

The following table (5) shows the total amount of illuminating oil, both domestic and imported, inspected during the fiscal years from 1881 to 1891, inclusive, and illustrates the market for that product in Canada :—

PETROLEUM.

TABLE 5.

TOTAL AMOUNT OF OIL, IMPORTED AND CANADIAN, INSPECTED.

Fiscal Year.	Imported.	Canadian.	Total.
	Galls.	Galls.	Galls.
1881	476,784	6,406,783	6,883,567
1882	1,351,412	5,910,747	7,262,159
1883	1,190,828	6,970,550	8,161,378
1884	1,142,575	7,656,011	8,798,586
1885	1,278,115	7,661,617	8,939,732
1886	1,327,616	8,149,472	9,477,088
1887	1,665,604	8,243,962	9,909,566
1888	1,821,342	9,545,895	11,367,237
1889	1,767,812	9,462,834	11,230,646
1890	2,020,742	10,121,210	12,141,952
1891	2,022,002	10,270,107	12,292,109

The following tables of exports and imports of oil are compiled from information obtained from the Customs Department and explain themselves :— PETROLEUM. —Statistics.

PETROLEUM.

TABLE 6.

EXPORTS OF CANADIAN CRUDE AND REFINED PETROLEUM FROM 1873 TO 1891.

Calendar Year.	Gallons.	Value.
1873	5,869,579	$1,287,576
1874	28,946	2,509
1875	11,836	2,214
1876	2,533,772	583,550
1877	1,431,883	323,013
1878	609,171	85,571
1879	235,171	17,032
1880	3,085	751
1881	501	99
1882	1,119	286
1883	13,283	710
1884	1,098,090	30,168
1885	337,967	10,562
1886	241,716	9,855
1887	473,559	13,831
1888	196,602	74,542
1889	235,855	10,777
1890	420,492	18,154
1891	447,355	18,575

PETROLEUM.

TABLE 7.

IMPORTS OF CRUDE AND REFINED PETROLEUM.

Fiscal Year.	Gallons.	Value.
1880	687,641	$131,359
1881	1,437,475	262,168
1882	3,007,702	398,031
1883	3,086,316	358,546
1884	3,160,282	380,082
1885	3,767,441	415,195
1886	3,819,146	421,836
1887	4,290,003	467,003
1888	4,523,056	408,025
1889	4,650,274	484,462
1890	5,075,650	515,852
1891	5,071,386	498,330

PETROLEUM —Statistics.

Subtracting the quantities of imported oils inspected (Table 5) from those shown in Table 7, there will be found to have been an annual importation of oil, crude and other than illuminating, as shown in the following Table 8 :—

PETROLEUM.

TABLE 8.

IMPORTS OF CRUDE AND MANUFACTURED OILS OTHER THAN ILLUMINATING.

Fiscal Year.	Gallons.
1881	960,691
1882	1,656,290
1883	1,895,488
1884	2,017,707
1885	2,489,326
1886	2,491,530
1887	2,624,399
1888	2,701,714
1889	2,882,462
1890	3,054,908
1891	3,049,384

The imports of paraffine wax and paraffine wax candles are shown in the following tables 9 and 10 :—

PETROLEUM.

TABLE 9.

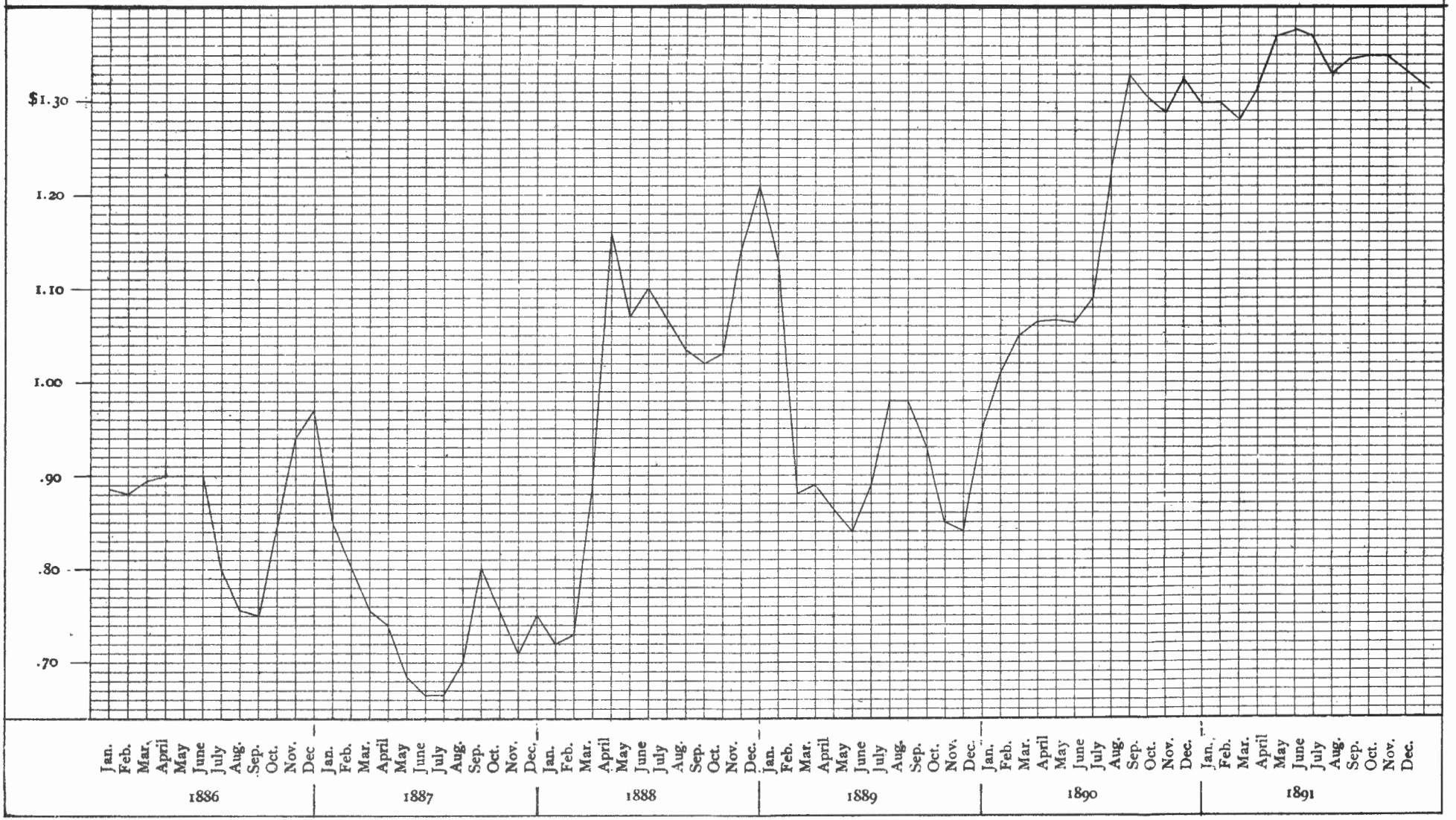
IMPORTS OF PARAFFINE WAX.

Fiscal Year.	Pounds.	Value.
1883	43,716	$ 5,166
1884	39,010	6,079
1885	59,967	8,123
1886	62,035	7,953
1887	61,132	6,796
1888	53,862	4,930
1889	63,229	5,250
1890	239,229	15,844
1891	753,854	50,275

PETROLEUM

TABLE A

RANGE OF PRICE (AVERAGE CLOSING PRICE) OF CRUDE OIL
DURING 1886, 1887, 1888, 1889, 1890. 1891.



PETROLEUM.

PETROLEUM —Statistics.

TABLE 10.

IMPORTS OF PARAFFINE WAX CANDLES.

Fiscal Year.	Pounds.	Value.
1880	10,445	$2,269
1881	7,494	1,683
1882	5,818	1,428
1883	7,149	1,734
1884	8,755	2,229
1885	9,247	2,449
1886	12,242	2,587
1887	21,364	3,611
1888	22,054	2,829
1889	8,038	1,337
1890	7,233	1,186
1891	10,598	2,116

PHOSPHATE.

PHOSPHATE —Production.

During 1891 there were 23,588 tons of phosphate (apatite) marketed, having a spot value of $241,603, the production being that of the provinces of Ontario and Quebec, as follows:—

Ontario, 2,344 tons, valued at ..... $ 35,187
Quebec, 20,244 " " 206,416

The production for this year shows a marked falling off in comparison with 1890, the decrease in quantity being 8,165 tons, and in value $119,442. For the past six years the production has been as follows:—

1886—20,495 tons, valued at $304,338
1887—23,690 " " 319,815
1888—22,485 " " 242,285
1889—30,988 " " 316,662
1890—31,753 " " 361,045
1891—23,588 " " 241,603

This falling off in production is almost entirely due to the decrease in prices, caused by the entrance into the market of the cheaper and lower grade phosphatic rock of Florida, of which large quantities have been shipped at a comparatively low cost.

The following Table 1 and graphic table A gives all the available information regarding exports of phosphate, the greater part of which goes to Great Britain.

PHOSPHATE.

TABLE 1.

PHOSPHATE —Statistics.

EXPORTS OF PHOSPHATE.

Year.	Ontario.		Quebec.	
	Tons.	Value.	Tons.	Value.
1878.	824	$ 12,278	9,919	$195,831
1879...	1,842	20,565	6,604	101,470
1880..	1,387	14,422	11,673	175,664
1881	2,471	36,117	9,497	182,339
1882	568	6,338	16,585	302,019
1883	50	500	19,666	427,168
1884	763	8,890	20,946	415,350
1885.....	434	5,962	28,535	490,331
1886....	644	5,816	19,796	337,191
1887..... ...	705	8,277	22,447	424,940
1888.....	2,643	30,247	16,133	268,362
1889.	3,547	38,833	26,440	355,935
1890.....	1,866	21,329	26,591	478,040
1891	1,551	16,646	15,720	368,015

In the following table it will be seen that Canadian apatite plays a by-no-means unimportant part in the trade of Great Britain in phosphates:—

PHOSPHATE.

TABLE 2.

GREAT BRITAIN: IMPORTS OF CANADIAN APATITE COMPARED WITH TOTAL IMPORTS OF PHOSPHATES IN THAT COUNTRY.

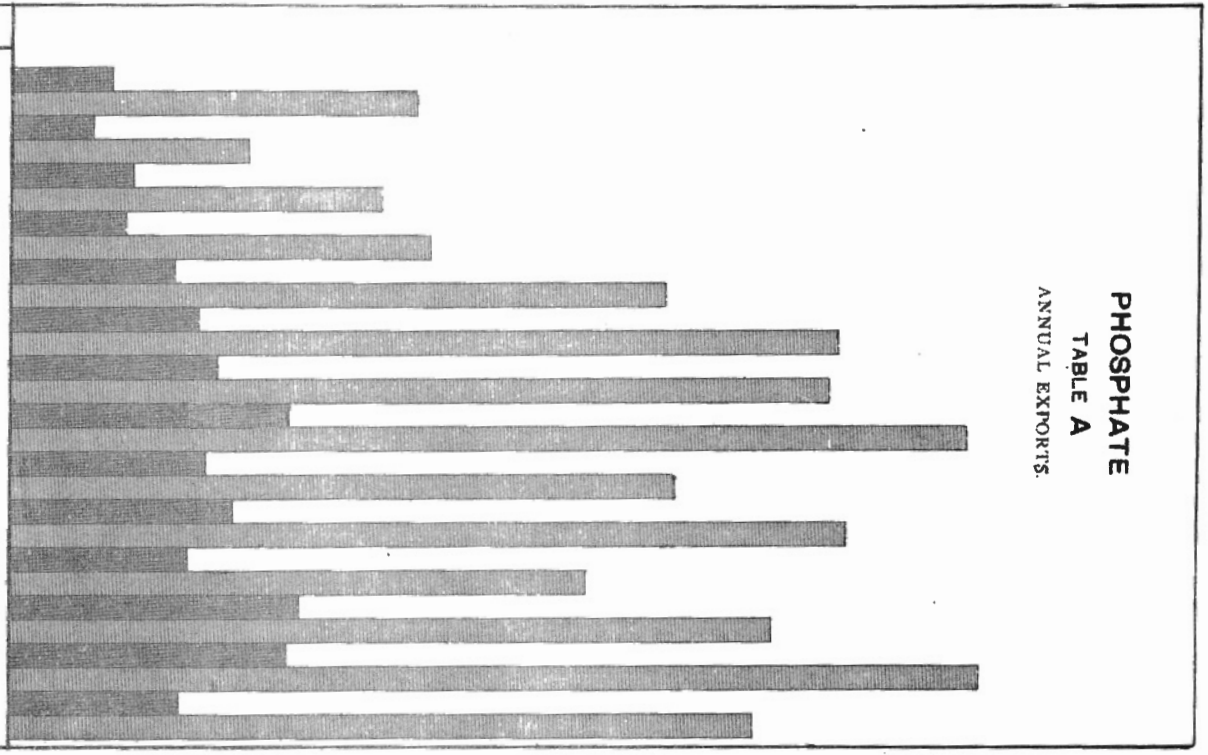
Year.	Canadian Apatite.		Total Phosphates.		Per cent of Value of Canadian Apatite to total Value.
	Long Tons — 2,240 lbs.	£ stg.	Long Tons — 2,240 lbs.	£ stg.	
1882.....	8,187	39,851	199,428	613,198	6·5 per cent.
1883.....	16,531	66,714	246,945	813,825	8·2 "
1884	15,716	52,370	219,225	643,851	8·1 "
1885....	21,484	76,179	238,572	628,027	12·1 "
1886.....	18,069	63,490	223,111	526,885	12·0 "
1887.....	19,194	65,974	283,415	614,088	10·7 "
1888.... .. .	12,423	42,291	257,886	544,919	7·7 "
1889...	23,123	71,037	304,953	703,704	10·1 "
1890..... .	21,089	65,420	343,501	849,452	7·8 "
1891.....	15,918	54,235	256,772	628,395	8·6 "

PHOSPHATE

TABLE A

ANNUAL EXPORTS.

Year	Quantity	Value
	Tons	$
1878	10,743	208,109
1879	8,446	122,035
1880	13,060	190,086
1881	11,968	218,456
1882	17,153	338,357
1883	19,716	427,668
1884	21,709	424,240
1885	28,969	496,293
1886	20,440	343,007
1887	23,152	433,217
1888	18,776	298,609
1889	29,987	394,768
1890	28,457	499,369
1891	17,271	384,661



THE PRECIOUS METALS.

GOLD.

The production of gold for 1891 was 51,303 oz., valued at $930,614, as compared with 64,046 oz. in 1890, valued at $1,149,776. The details of this production are given in Table 1, which, compared with the figures for last year, shows the following features.

Nova Scotia shows a falling off of 1,204 oz., and British Columbia of 3,801 oz., whilst the estimated quantity for the North-west Territories and Yukon district is less by 7,853 oz. Quebec and Ontario only register a slight increase of 115 oz. on their small production.

The alluvial gold product of British Columbia, added to that resulting from the mining of the auriferous lodes of Nova Scotia, constituted, as in the past, all but a small fraction of the production given above. The deficit in the former province is due to the continuation of the exhaustion of the shallower placer deposits which have hitherto furnished nearly all the gold. The falling off due to this cause is clearly shown in the graphic table A, showing an almost uninterrupted shrinking of the yield from almost four million dollars in 1863, till in 1891 it is but a little over one-tenth of that amount.

Of the other items in the below given Table No. 1, the amount credited to Ontario is due to the working of quartz; that credited to Quebec is a close estimate of the results of the gold washed from the gravels of the Chaudière district.

The amount credited to the North-west Territories, &c., comprises a close estimate of the gold washed out of the bars of the Saskatchewan River, together with the mean of several estimates of the gold washed on the Yukon River in Canadian territory.

GOLD.

TABLE 1.

PRODUCTION BY PROVINCES.

Provinces.	Ounces.	Value.	No. of Men.
Nova Scotia	23,154	$451,503	498
Quebec	90	1,800	
Ontario	100	2,000	19
North-west Territories (including Yukon District)	2,676	45,500	100
British Columbia	25,283	429,811	1,199
Total	51,303	930,614	1,816

THE PRECIOUS METALS. Gold—Production.

BRITISH COLUMBIA.—The statistical details regarding the gold-mining industry of this province, as supplied by the Provincial Department of Mines, have been compiled, and are given in Tables A, B, C and No. 2.

The amounts of gold reported by the banks of the province, as exported during the year, are as follows:—

Bank of British Columbia	$196,588
Messrs. Garesche, Green & Co	144,654
Bank of British North America	16,934
	$358,176
Add one-fifth; estimate of gold carried away in private hands	71,635
Production of gold as estimated by the provincial authorities	$429,811

GOLD.

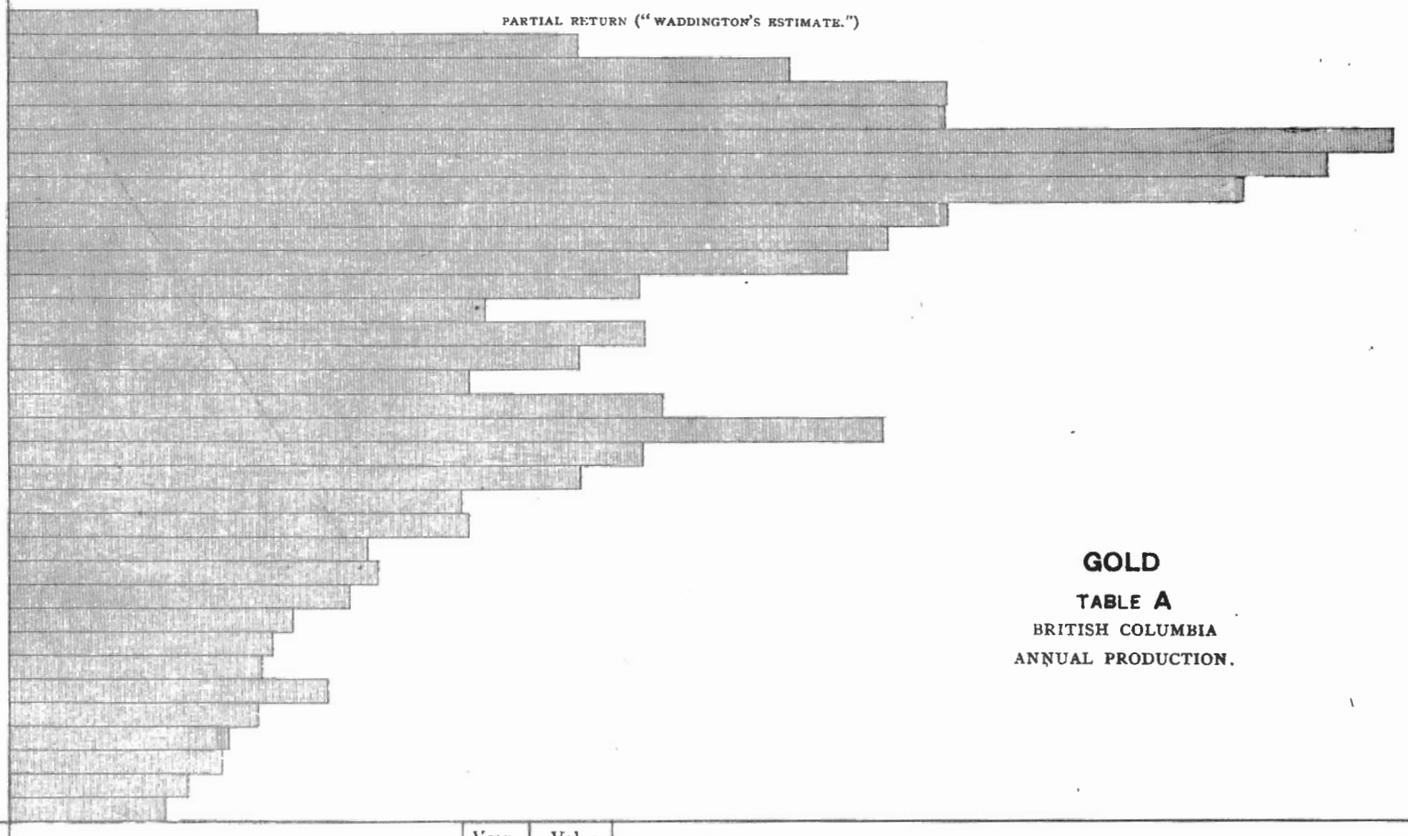
TABLE 2.

BRITISH COLUMBIA.

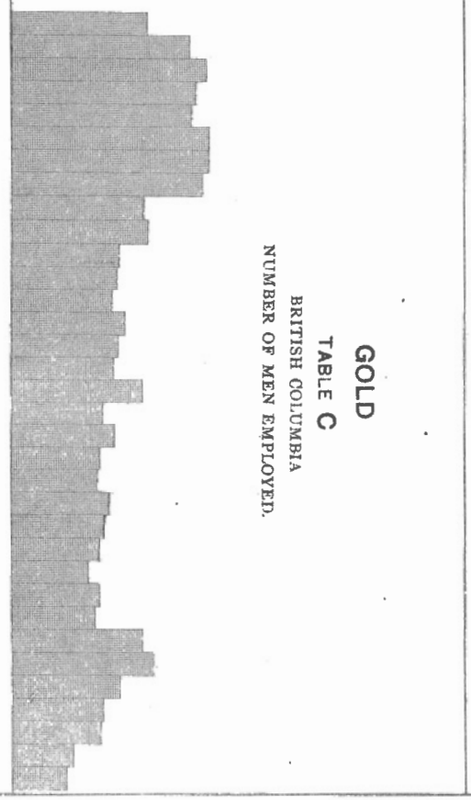
YIELD, ETC., BY DISTRICTS.

District.	Divisions.	Men Employed.		Yield of Gold by Divisions.	Total Yield by Districts.
		Whites.	Chinese.		
Cariboo	Barkerville	77	136	$63,450	
	Lightning Creek	26	111	33,850	
	Quesnelle Mouth	3	97	30,650	
	Keithley Creek	68	261	57,100	
		174	605		$185,050
Cassiar	Laketon			40,000	40,000
Kootenay	Western	35		13,000	
	Eastern	9	48	28,550	
		44	48		41,550
Lillooet		35	60	52,506	52,506
Yale	Osoyoos	62	45	11,000	
	Similkameen	58	68	21,100	
		155	173		32,100
					$351,206
	Total Whites	373			
	" Chinese		826		
	" employed	1,199			

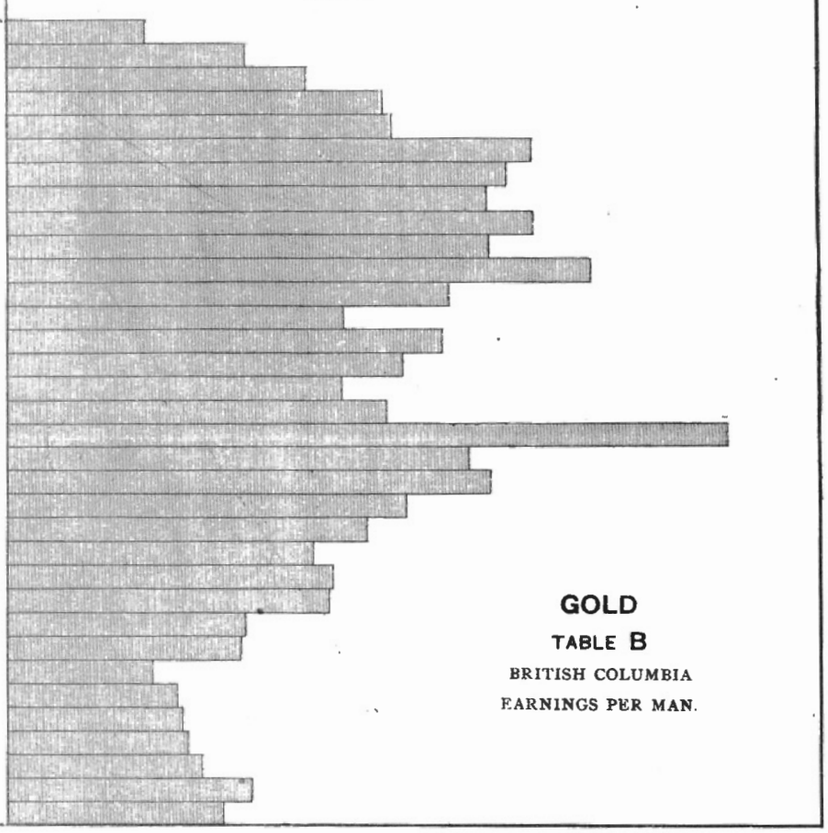
Year	Value
1858	$705,000
1859	1,615,072
1860	2,228,543
1861	2,666,118
1862	2,656,903
1863	3,913,563
1864	3,735,850
1865	3,491,205
1866	2,662,106
1867	2,480,868
1868	2,372,972
1869	1,774,978
1870	1,336,956
1871	1,799,440
1872	1,610,972
1873	1,305,749
1874	1,844,618
1875	2,474,904
1876	1,786,648
1877	1,608,182
1878	1,275,204
1879	1,290,058
1880	1,013,827
1881	1,046,737
1882	954,085
1883	794,252
1884	736,165
1885	713,738
1886	903,651
1887	693,709
1888	616,731
1889	588,923
1890	494,436
1891	429,811

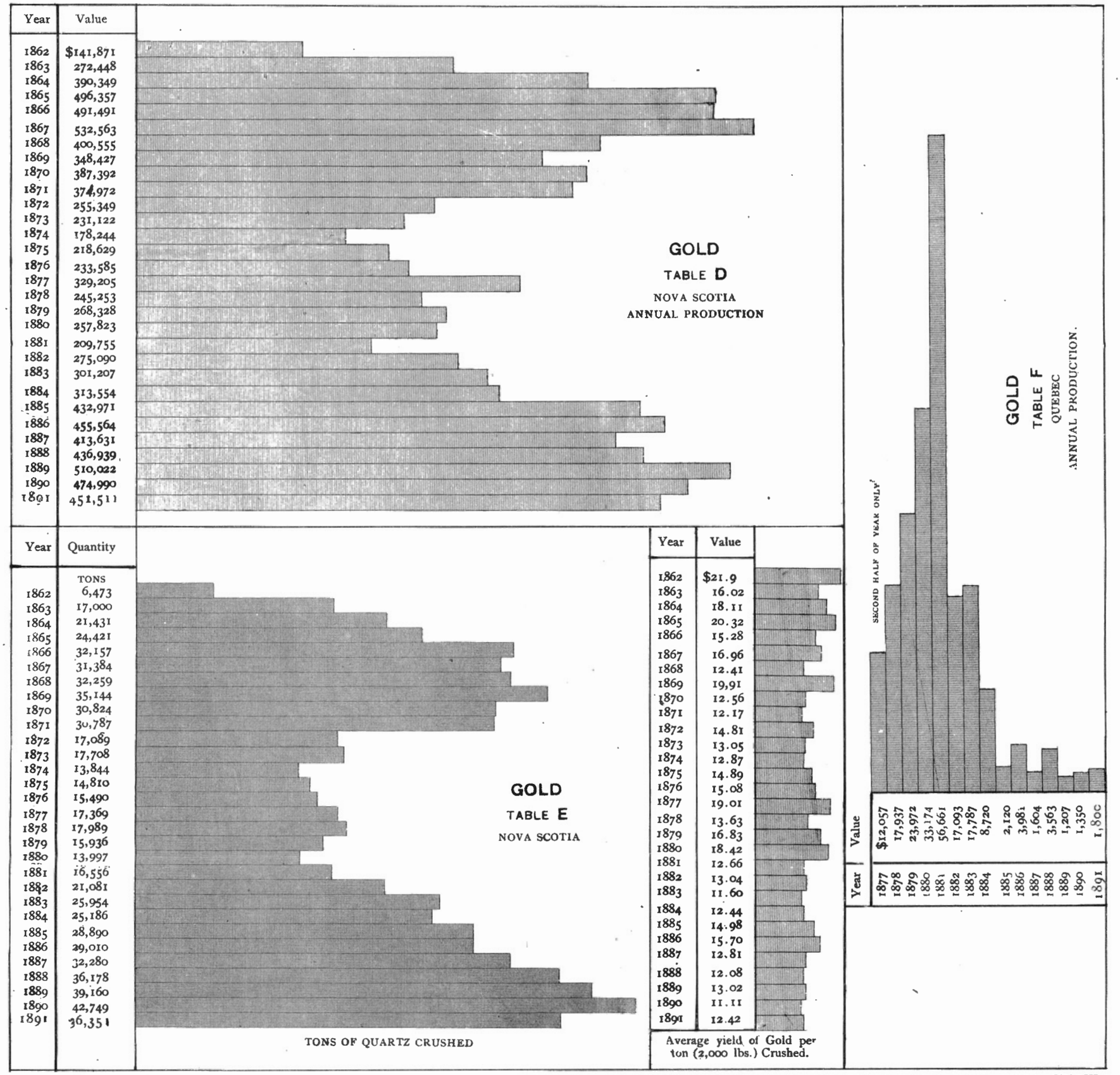


Year	Number
1858	3000
1859	4000
1860	4,400
1861	4,200
1862	4,100
1863	4,400
1864	4,400
1865	4,294
1866	2,982
1867	3,044
1868	2,309
1869	2,369
1870	2,348
1871	2,450
1872	2,400
1873	2,300
1874	2,868
1875	2,024
1876	2,282
1877	1,960
1878	1,883
1879	2,124
1880	1,955
1881	1,898
1882	1,738
1883	1,965
1884	1,858
1885	2,902
1886	3,147
1887	2,342
1888	2,007
1889	1,929
1890	1,342
1891	1,199



Year	Value
1858	$235
1859	403
1860	506
1861	634
1862	648
1863	889
1864	849
1865	813
1866	893
1867	814
1868	992
1869	749
1870	569
1871	734
1872	671
1873	567
1874	643
1875	1,223
1876	783
1877	820
1878	677
1879	607
1880	518
1881	551
1882	548
1883	404
1884	396
1885	246
1886	287
1887	296
1888	307
1889	330
1890	423
1891	358





Year	Value
1862	$141,871
1863	272,448
1864	390,349
1865	496,357
1866	491,491
1867	532,563
1868	400,555
1869	348,427
1870	387,392
1871	374,972
1872	255,349
1873	231,122
1874	178,244
1875	218,629
1876	233,585
1877	329,205
1878	245,253
1879	268,328
1880	257,823
1881	209,755
1882	275,090
1883	301,207
1884	313,554
1885	432,971
1886	455,564
1887	413,631
1888	436,939
1889	510,022
1890	474,990
1891	451,511

Year	Quantity
	TONS
1862	6,473
1863	17,000
1864	21,431
1865	24,421
1866	32,157
1867	31,384
1868	32,259
1869	35,144
1870	30,824
1871	30,787
1872	17,089
1873	17,708
1874	13,844
1875	14,810
1876	15,490
1877	17,369
1878	17,989
1879	15,936
1880	13,997
1881	16,556
1882	21,081
1883	25,954
1884	25,186
1885	28,890
1886	29,010
1887	32,280
1888	36,178
1889	39,160
1890	42,749
1891	36,351

Year	Value
1862	$21.9
1863	16.02
1864	18.11
1865	20.32
1866	15.28
1867	16.96
1868	12.41
1869	19,91
1870	12.56
1871	12.17
1872	14.81
1873	13.05
1874	12.87
1875	14.89
1876	15.08
1877	19.01
1878	13.63
1879	16.83
1880	18.42
1881	12.66
1882	13.04
1883	11.60
1884	12.44
1885	14.98
1886	15.70
1887	12.81
1888	12.08
1889	13.02
1890	11.11
1891	12.42

Average yield of Gold per ton (2,000 lbs.) Crushed.

Year	Value
1877	$12,957
1878	17,937
1879	23,972
1880	33,174
1881	56,661
1882	17,093
1883	17,787
1884	8,720
1885	2,120
1886	3,981
1887	1,604
1888	3,563
1889	1,207
1890	1,350
1891	1,800

THE PRECIOUS METALS. Gold—Production.

NOVA SCOTIA.—The statistical details regarding the gold-mining industry in this province are given in the accompanying tables, graphic D and E and Nos. 3 and 4, which are compiled from data collected by the Provincial Department of Mines. From these it is seen that whilst there is a decrease in the total yield of gold and the number of tons crushed, the yield of metal per ton milled shows a slight increase over last year.

GOLD.

TABLE 3.

NOVA SCOTIA.

PRODUCTION OF THE DIFFERENT DISTRICTS FROM 1862 TO 1891, INCLUSIVE.

Districts	Tons of Quartz Crushed.	Total Yield.				Average yield per ton of 2,000 lbs.
		Ozs.	Dwts.	Grs.	Value at $19.50 per oz.	
Caribou and Moose River	49,760	25,541	17	10	$ 498,066	$10·01
Montague	17,055	33,942	12	16	661,881	38·81
Oldham	40,166	44,151	16	16	860,960	21·43
Renfrew	46,071	31,814	13	2	620,385	13·46
Sherbrooke	166,295	119,767	9	2	2,335,465	14·04
Stormont	23,124	24,266	6	9	473,193	20·45
Tangier	29,492	19,198	8	6	374,369	12·69
Uniacke	39,207	24,896	2	8	485,474	12·38
Waverley	94,692	54,476	3	14	1,062,285	11·22
Salmon River	39,785	12,121	4	0	236,363	5·94
Brookfield	5,663	4,858	4	9	94,735	16·73
Whiteburn	5,875	9,281	2	20	180,981	30·83
Lake Catcha	6,459	7,430	19	3	144,913	22·44
Rawdon	11,389	9,060	14	4	176,683	15·51
Killag	379	354	6	16	6,909	18·23
Wine Harbour	41,798	28,639	6	1	558,466	13·36
Darr's Hill	39,909	18,715	19	19	364,962	9·14
Fifteen Mile Stream	13,363	7,547	2	5	147,168	11·01
Malaga	15,847	12,687	4	18	247,400	15·61
Unproclaimed, etc	53,178	40,950	15	21	798,540	15·01
Totals	739,507	529,702	9	7	10,329,198	13 97

THE PRECIOUS METALS.

Gold—Production.

GOLD.

TABLE 4.

NOVA SCOTIA.

DISTRICT DETAILS.

Districts.	Number of Mines.	Mills.	Tons of Quartz Crushed.	Yield of Gold per Ton.			Total Yield of Gold.		
				Ozs.	Dwts.	Grs.	Ozs.	Dwts.	Grs.
Tangier	2	1	370	0	3	21	71	12	12
Whiteburn	1	2	890	1	0	3	895	7	4
Central Rawdon	1	1	510	0	1	8	342	0	0
Killag	1	1	379	0	18	11	354	6	16
Oldham	2	2	2,019	1	9	0	2,909	10	13
Caribou / Moose River	3	4	5,801	0	5	23	1,723	5	21
Wine Harbour	1	1	1,823	0	7	15	698	9	0
Waverley	3	3	1,611	0	7	11	602	4	0
Lake Catcha	1	1	2,432	0	6	13	800	3	0
Fifteen Mile Stream	2	2	4,862	0	10	12	2,550	10	12
Uniacke	3	4	1,854	1	12	21	3,045	5	4
Montague	2	3	863	1	11	10	1,361	1	0
Stormont	2	4	888	2	1	21	1,025	12	4
Malaga	2	2	4,826	0	19	12	4,827	8	17
Salmon River	1	1	5,210	0	5	9	1,406	0	0
Sherbrooke	4	2	464	0	5	3	119	5	0
Unproclaimed, etc	3	5	1,549	0	5	11	421	18	4
Totals and averages	34	39	36,351	0	12	17	23,153	19	11

Graphic Table F shows the production of Quebec to remain at a very unsatisfactory point, but there is reason to hope for an increased yield for next year in view of the contemplated renewal of work on the Gilbert River under the management of Mr. Arthur Lockwood.

GOLD.

TABLE 5.

EXPORTS.

Gold—Exports.

Provinces.	1887.	1888.	1889.	1890.	1891.
	$	$	$	$	$
Ontario	6,650		2,660		1,000
Nova Scotia	321,379	163,412	191,671	304,521	
Manitoba		50	261		110
British Columbia	592,300	464,696	414,658	402,271	343,582
Totals	920,329	628,158	609,250	706,792	344,692

SILVER.

Silver—Production.

From information obtained directly by the Division, the production of silver in the Dominion during 1891 had a value of $406,233, which at the average market price for the year of 98 cts. =414,523 ozs. This amount represents the calculated silver contents of the argentiferous iron and copper pyrites mined in the Eastern Townships of Quebec, together with the production of the silver mines proper of the Thunder Bay district of Ontario, including also a small amount entered as exported from British Columbia, and the silver contents of a small amount of argentiferous galena mined in the province of Quebec. This amount shows an increase of 13,836 ozs. over the production of last year, but a decrease of $14,489 owing to the considerable depreciation in the value of the metal.

Table No. 1 below shows the progress of the industry for the past five years.

SILVER.

TABLE 1.

PRODUCTION OF SILVER.

YEAR.	ONTARIO.		QUEBEC.		BRITISH COLUMBIA.		TOTAL.	
	Ozs.	Value.	Ozs.	Value.	Ozs.	Value.	Ozs.	Value.
		$		$		$		$
1887.	190,495	190,495	146,898	146,898	11,937	11,937	349,330	349,330
1888.	208,064	208,064	149,388	149,388	37,925	37,925	395,377	395,377
1889. ...	181,609	162,309	148,517	133,666	53,192	47,873	383,318	343,848
1890.	158,715	166,652	171,545	180,122	70,427	73,948	400,687	420,722
1891.	225,633	221,120	185,584	181,872	3,306	3,241	414,523	406,233

Price.

Graphic Table A illustrates clearly the fluctuation in value of the metal during 1891 as per New York quotations, the general depreciation in value having continued almost uninterruptedly since the middle of August last when the metal was quoted as high as $1.19.

THE PRECIOUS METALS. Silver—Exports.

The exports of the ores of this metal as compiled from the books of the Customs Department are given in Table 2 following.

SILVER.

TABLE 2.

EXPORTS OF SILVER ORE.

Province.	1887.	1888.	1889.	1890.	1891.
Ontario	$184,763	$208,064	$203,871	$203,142	$222,071
Quebec	450	5	2,500	900	
Nova Scotia			50		
Manitoba	3,741		5		
British Columbia	17,331	10,939	5,737	100	3,241
Totals	$206,285	$219,008	$212,163	$204,142	$225,312

Discovery and development.—Gold and Silver.

DISCOVERY AND DEVELOPMENT.

GOLD AND SILVER.

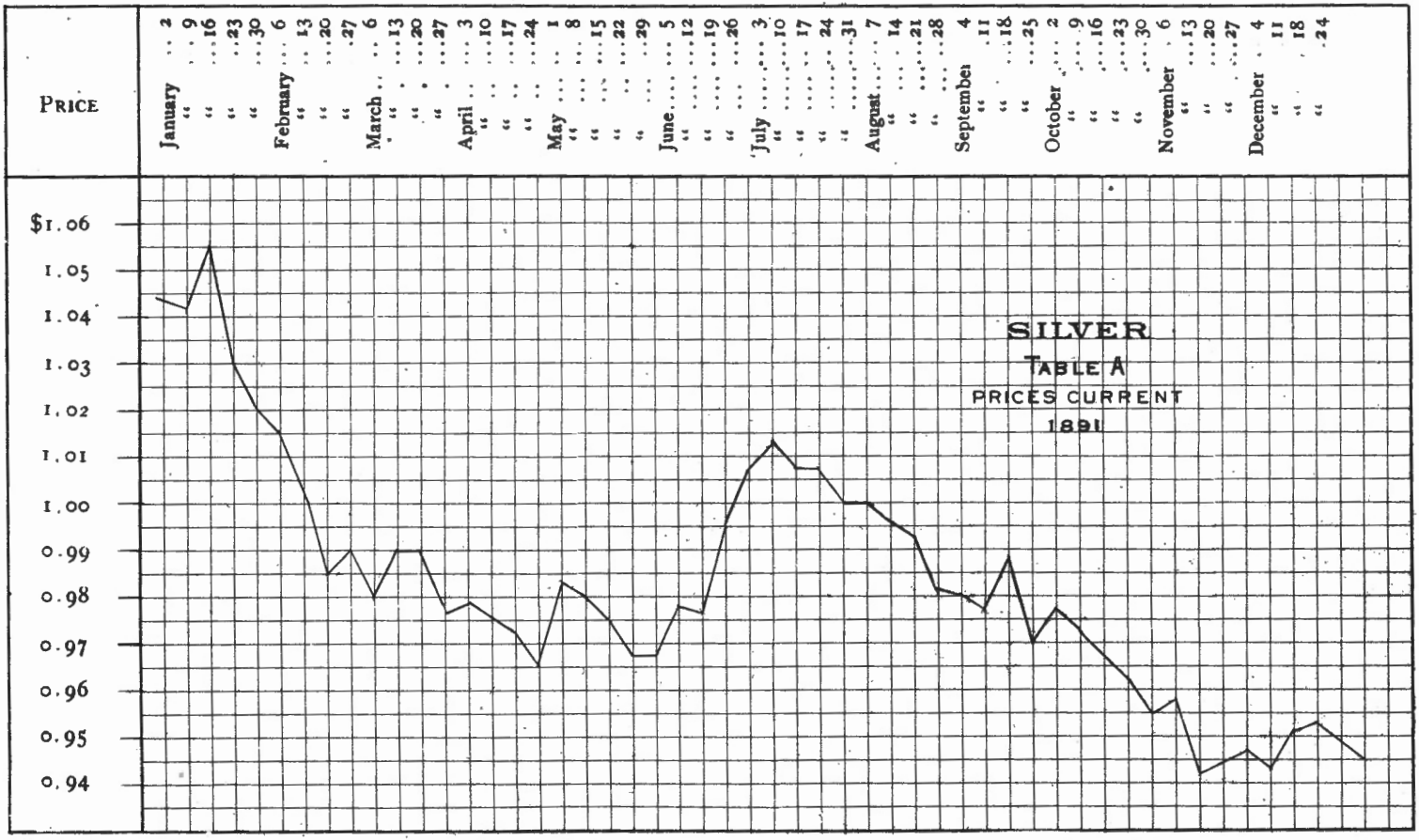
The progress of discovery and development of the mineral resources of the country in respect to gold and silver are best considered together.

Nova Scotia.

NOVA SCOTIA.—Beginning then on the eastern coast with the mining operations of Nova Scotia, operations were continued in developing the numerous gold-bearing quartz leads found in the Cambrian rocks of the Atlantic slope of the peninsular portion. Scattered all along this district, between the centre and the coast, are numerous sub-districts whose names are set forth in Gold table 3, which includes some thirty-four separate mines.

The details of this industry are given in the undermentioned extracts from the report of the inspector of mines for the province, from which it will be seen that mining still continues to be carried on mostly by comparatively small operators, employing forces of men numbering 50 or less, the mills ranging from ten to fifty heads of stamps.

"The various districts were visited by Mr. Maddin, deputy inspector, who reports the mines generally in fair order and safe. With respect to some mines, arrangements have been made for introducing better and safer ladders. The ephemeral system of gold mining which prevails in this province, makes it very difficult for the department to exercise anything like a close and regular supervision over the smaller


PRICE
January 2 9 16 23 30
February 6 13 20 27
March 6 13 20 27
April 3 10 17 24
May 1 8 15 22 29
June 5 12 19 26
July 3 10 17 24 31
August 7 14 21 28
September 4 11 18 25
October 2 9 16 23 30
November 6 13 20 27
December 4 11 18 24
$1.06
1.05
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
SILVER
TABLE A
PRICES CURRENT
1891

THE PRECIOUS METALS. Discovery and development. —Nova Scotia

mines. A small mine is rapidly opened out and abandoned within a few months. The work being tentative, little attention is paid to points which receive the attention of a manager in larger and more ambitious workings. The enforcement, in all gold mines, of a strict adherence to the letter of the Mines Regulation Act would require the services of a man specially devoted to the work. There should also be some system adopted of keeping a check on the work performed in the mills. At present the returns are received as made; and it is believed that there are annually considerable unaccounted for amounts of gold extracted from rich quartz by hand, on which no royalty is paid.

"At Wine Harbour, * * R. McNaughton was working, with Adam McGrath as under-manager. The middle lead was stripped and operations began on the Caledonia lead; twenty men were employed underground, and ten men overground. * * *

"At Goldenville, George Hirschfield was working in the McLean lead, employing four men taking out the roof quartz, allowing the waste to fall down the mine, and making an opening for water. The Sutherland and Chicago mines were idle, but the Blackie mine was at work, employing six men, and things appeared very dull in this mining camp. At Ecum Secum the mine was idle. There are very many complaints against so many trial pits being left open unguarded.

"At Dufferin Mine, Salmon River, South and North leads working, and down from 250 to 300 feet; thirty men are employed. A new twenty stamp mill has been erected, a self-feeding Blake's Rock Breaker is also used at this mill, and all the machinery is run by water power.

"Visited Tangier Mine, and found mining matters very dull. One of the old veteran miners, John Murphy, had four or five men employed on the Strawberry Hill lead, which was all the work that was being done in this vicinity.

"At Oxford Gold Mining Company, East Chezzetcook, J. M. Reade, manager, with thirty-one men employed. This mine is very well equipped with good machinery. Compressed air is utilized in doing a very large amount of the work. * * * John H. Anderson had six men employed erecting a new mill, and N. McMillan had four men employed opening up "Colman lead," or "Annand Mine."

"At Montague Mines, Alex. P. McQuarrie, manager, and W. Collins, under-manager, twenty-eight men employed. They were at work taking down the old mill and preparing to rebuild and put in a new battery, and from the appearance of the mine and the push of the management, with such a body of good practical men as are here, I

THE PRECIOUS METALS. Discovery and development. —Nova Scotia

should think we shall have good accounts of this mine in the near future. In this district there is also the Hay Mine, Wm. Skerry, manager, with fourteen men employed. Here they have had a difficult task to keep the water out, but I am glad to say that, at the date of my visit, Mr. Skerry had almost overcome this difficulty, and was getting his mine timbered and fixed up. T. M. Baker is also at work on the iron lead, so called, employing three men; and Mr. Pratt is working the Sutherland mine, on what is supposed to be the iron lead, employing three men.

"At Lake View Mining Co., Waverley, A. A. Hayward, manager, and Matt. Thompson, under-manager. This mine was idle at the time of my visit, but it is one of the best equipped that I saw. There are seven drills run by compressed air; one of Gates' Rock Breakers, self-feed; thirty stamp mill; boilers, 280 H.P.; mill engine, 230 H. P.; hoisting engine, 130 H.P.; pump engine, 25 H.P.; a compressor engine, 50 H.P.; shaft, 300 feet depth; self-dumping skips. This mine did employ fifty men. The water was out when I was there, affording an opportunity of travelling all through it.

"In this district there is also the West Waverley Mine, John Hardman, manager. Some thirty men employed. The mine was idle, but the men were employed erecting new mill and new hoist. Windsor Junction Mine, Capt. Geo. McDuff, manager. Some sinking has been done here.

"Renfrew Mine, R. S. Turnbull, manager, A. Manning, under-manager. Mine down 400 feet, and in good order and condition.

"At Gay's River Mine, R. R. McLeod, manager, with forty men employed. A fifty stamp mill has been erected; this mill was built by the Truro Foundry Co. The gold is obtained here chiefly from the surface.

"Moose River, Mr. Touquoy, manager; seventeen men employed. A fifteen stamp mill and three pumps run by water power, with plenty water to run as many more. In this district A. McGregor and Wm. Bruce are working on the Moose River property, with ten men employed.

"At Caribou district, L. L. Wordsworth, manager. This mine is down some 400 feet, and at the date visited was very poorly timbered. * * * In this district Mr. Dickson is doing a very good paying work, and his mine was in good shape.

"The mines which I have visited to this date* were all well ventilated and timbered, with one or two exceptions. I may, however, say

* Aug. 15, '91.

that instead of hanging ladders on the foot wall in those mines where the angle is so high, it would be much better to hang them lengthways on the lead—they would then have more slope. At present in many of the mines the ladders are nearly perpendicular, in distance ranging from 50 to 200 feet, and no means provided to save a man if he were accidentally to stumble and fall. I am pleased to say that very few accidents have occurred, but as the shafts are gradually becoming deeper, the time has arrived when such a preventive to accidents as I have suggested should be adopted.

THE PRECIOUS METALS. Discovery and development. —Nova Scotia

Queen's County.

"Whiteburn district, Rossignol Mine. This mine has been idle for some time, and is just getting fairly started. F. B. Murchy, Esq., manager, says he expects to do well this winter. There are 20 men employed, and have a ten stamp mill running, and everything looks well about the mine.

"Whiteburn Mine, — Partinger, manager, Michael Kelly, undermanager, with forty men employed. The shaft is 200 feet deep, and well timbered. Ten stamp mill. The perpendicular lead or mine is idle; the manager is prospecting close by the old shaft. Everything looks satisfactory around this mine.

"Malaga Gold Mining District, G. A. Wade, manager, John Thornholm, under-manager. Twenty-seven men employed, two shafts working: Main shaft 200 feet deep. The travelling way is the best I have seen; the ladders are at an easy angle, and stages every 20 feet. * * * North of this F. H. Ballou is working, employing some thirty men; his travelling way is very good. I may say all the travelling ways in this county are good. A little east of this, Charles McLeod is working in the Nine Bolder lead, so called, employing eight men. The Caledonia Mine is idle, their mill house was accidentally burned some time ago. The Parker Douglas is also idle, which makes business somewhat dull in this locality.

"I visited Brookfield Mine, G. A. Kenty, manager of the Philadelphia Gold Mining Company; they employ thirty men; three shafts working; the main shaft is down 200 feet. All the mines in this county are in good condition, but have not so many men employed in this district as were last year.

"I may say it has hitherto been the prevailing system in the gold mining industry in this province, when the work arrives at a distance of from 200 to 400 feet, to cease operations, the operator in many cases being unable to go deeper on account of the inadequacy of the machinery to go to any greater depth, and because of the fear that at

THE PRECIOUS METALS.
Discovery and development. — Nova Scotia

any "greater depth" gold ceased to be found. I have learned that at Goldenville, however, a shaft has been sunk to a depth of some 600 feet, and paid to the last inch. In my opinion there is very great room for the supposition that some of the most valuable properties in this province are being virtually lost, unless some means be adopted to encourage the operators to prospect some property at a depth of from 1,000 feet to 2,000 feet."

Mr. Faribault has been conducting some very interesting geological investigations for the Survey, which will throw much light upon the nature and geological affinities of these veins, and in his preliminary report on the subject makes the following remarks :—

"The section surveyed this season in Nova Scotia lies westward of that surveyed in 1889 and 1890, and extends along the sea-shore from Porter's Lake to Halifax harbour, and northerly to the Shubenacadie and St. Andrew's rivers, covering an area of 305 square miles in Halifax county and 70 square miles in Colchester county.

"The greater part of the region is occupied by the auriferous Lower Cambrian rocks cut by the western end of the belt of granite examined last year, which extends to within two miles east of Waverley, and also by a small granite mass three miles north of Waverley. In the northern portion, the gold-bearing rocks are overlain by the Lower Carboniferous formation along the valleys of the Shubenacadie, Gay's and St. Andrew's rivers and a few of their tributaries.

"Two or three beds of dolomitic limestone from six inches to four feet thick were found at various places at the bottom of the upper graphitic ferruginous slate group, between layers of greenish talcose slate. These beds may contain fossils, but search made for them has so far proved unsuccessful.

"The anticlinal axes were minutely examined and traced, as in former years, on account of their close relation to the auriferous belts. Within the region examined, the geological structure of the gold district of Lawrencetown, Montague, Waverley and Oldham was carefully studied. Lawrencetown has been but little worked.

"Special attention was given to the gold district of Oldham, it being a typical district, worked to a great extent and exposing to great advantage the quartz leads, all of which were prospected by means of surface trenches on account of the small thickness of the drift. A detailed geological map of this district, on a scale of 500 feet to one inch, with sections, was compiled on the ground. It shows the elliptical structure of the anticlinal fold, with all the known quartz veins, both interbedded and transverse; and also the numerous faults affecting them, and proves clearly that the richness of a lead depends altogether

on its position and relation to the structure of the elliptical dome of the fold to which it owes its origin. In this work I am specially indebted to Mr. J. E. Hardman, B.Sc., M.E., manager of gold-mining properties in Oldham and Waverley, for much valuable information which his great experience in gold-mining enabled him to give.

"Auriferous leads have also been prospected at Elmsdale, South-east Passage, and other places along anticlinal axes."

He points out that as the zones containing the rich portions of the veins hold a definite relationship to the structural features of the anticlinal folds of the inclosing rocks, the successful prosecution of deep mining calls for the study of these features in order to locate and trace out these rich zones. He further asserts that as the veins in their extension either in length or depth change their relationship to the axes of the anticlinals their richness is thereby affected. Continuing, he says: "In most of districts the zone of rich leads has the anticlinal axis for its centre, and it is probably the centre of the auriferous zone to a depth practically unlimited. Such is the case in the eastern part of the province, at Seal Harbour, Isaac's Harbour, Goldenville, Harrigan Cove, Salmon River, Fifteen Mile Stream, Killag, Mooseland, Moose River, Caribou, Gold River, Lawrencetown, Waverley and Oldham. In the few other districts where the auriferous zone is worked only on the north or south side of the anticlinal, the zone would, for the same reason, be parallel to the axis of the anticlinal to an inaccessible depth, as in Isaac's Harbour, Wine Harbour, Beaver Dam, Tangier and Lake Catcha.

"The gold district of Gay's River was reopened last spring by the Cole Stream Gold Mining Company, who put up an extensive fifty stamp steam mill and other large buildings. They sank a shaft immediately north of Daniel McDonald's old works, which gave the following section of the Lower Carboniferous:—

	Feet.
Surface drift	20
Conglomerate, containing gypsum, non-auriferous	35
Coarse sandstone	2
Auriferous, irregular conglomerate	8

"This lower auriferous conglomerate is wholly composed of debris of the adjacent Lower Cambrian rocks, apparently in an old river bed, and rests on the lower graphitic ferruginous slate group. Beds of conglomerate similarly situated along the northern boundary of the gold-bearing rocks may prove sufficiently rich to be worked, but the great excitement caused two years ago by exaggerated reports of dis-

THE PRECIOUS METALS.
Discovery and development —Nova Scotia

coveries of gold in various places, remote from the gold-bearing rocks, have led a great many to take up valueless ground." (See Summary Report for 1890, page 41.)

Dr. Selwyn expresses concurrence in these conclusions as follows:—

Personal observation enables me to concur in the opinion he expresses both as regards the correspondence of the Quebec gold-bearing rocks with those of Nova Scotia, and also as regards the position of the rich leads and their relation to axial folds. The latter, if correct, must prove of the greatest practical importance if intelligently applied in the further development of gold mining in Nova Scotia and also in directing prospecting for veins in the alluvial fields in Quebec.

New Brunswick.

NEW BRUNSWICK.—In New Brunswick the small amount of work done was altogether of the nature of test explorations. Several of these were visited by Mr. Brumell, who gleaned the following information:

"At the Britton Mine, near Woodstock, when visited on 17th August, it was found that operations were partly suspended owing to an accident to the pump.

"The shaft was down 150 feet, levels running off at 50 feet, 100 feet, 137 feet and 144 feet, the two latter running 25 feet to the north and south and 25 feet N.N.W. respectively.

"The manager claims to have a four-foot vein in the 144-foot level from which came the samples which were shown me. These together with those to be seen on the dump were very poor, containing but slight traces of mineral. Assays of ore said to be from this level are as follows:—

By W. A. Gould, Sussex, N.B.

Gold	3¼ dwts.	Ton 2,240 lbs.
Lead	283 lbs.	
Silver	4¼ ozs.	
Copper	9 lbs.	

By John McVicker, Salt Lake City, U.S.A.

Lead	11·4%	Ton 2,000 lbs.
Silver	$4.62	
Gold	0.58	

Another assay of ore not, however, from the same part of the mine as the above gave Mr. Gould the following result:—

Gold	4¼ dwts.	Ton 2,240 lbs.
Lead	23 lbs.	
Silver	trace.	
Copper	do	

THE PRECIOUS METALS.
Discovery and development —New Brunswick.

"At Nauwigewauk, prospecting operations were undertaken during the year by the New Brunswick Mineral Developing Company, of which Mr. J. DeWolfe Spurr, of St. John, is president, and Mr. G. Wetmore Merritt, secretary. The work was done with a view of testing the auriferous character of the Lower Carboniferous conglomerates of the district, and the results are said to have shown the more pebbly portions of the beds to carry as high as four pennyweights in gold to the ton. The gold is free and very fine, and apparently contained in the quartz pebbles which make up a considerable proportion of the rock. The conglomerate beds consist of interstratified coarse sandstones and pebble beds, the pebbles being of quartz, Lower Carboniferous shale and limestone, and have a general strike nearly east and west, the dip being about 80° to the north.

"In the work of prospecting, besides having assays made of many specimens collected at different points, the company drove a tunnel about fifteen feet across the beds with, it is said, encouraging results. The supply of rock is practically inexhaustible, timber plentiful, the situation favourable, being on the Intercolonial Railway, and water may be obtained from the Hammond River, which flows through the property. It is said that negotiations are pending with a New York Company who profess to be able to make the property pay if three pennyweights per ton are available.

"At Moore's Lake, near St. Stephen, Charlotte county, on the property mentioned in the article on nickel, is a vein of pure, white quartz, about two inches wide, striking N. 80° E., and dipping at an angle of 82° to the north, and which is said to carry gold, the ore assaying, it is said, from four to twenty dollars per ton in gold. The lead cuts rocks, which near the vein are dioritic, though they pass imperceptibly into rocks with a marked schistose character. The schistose rocks strike nearly north and south, and dip at an angle of 30° to the east.

"On Sawmill Creek, near Memel, prospecting was being carried on by J. F. Fraser, of St. John, *et al.*, on a band of altered mica-schist, which contains a considerable percentage of pyrites scattered through the mass. The rocks strike N. 70° W. and dip $<$ 55° N.

"At Peck's Creek, Albert county, about two miles west of the Albert mines, similar rocks are met with, and a small amount of prospecting done. These rocks strike N. 30° E. $<$ 55° N. The rock from these beds is said to have yielded as high as 8 dwts. per ton in a mill test.

"Assays of average specimens from both of these places were made by Mr. Hoffmann, of which he furnishes the following :—

THE PRECIOUS METALS.
Discovery and development —New Brunswick.

1. From Sawmill Creek, Albert county, N.B., a light gray felsite-schist, through which was disseminated numerous small grains of pyrite.

It contained neither gold nor silver.

2. From Peck's Creek, Albert county, N.B., a gray felsite-schist, through which was disseminated numerous small grains of pyrite.

It contained neither gold nor silver.

"Rocky Brook, Millstream River.—This property—one of several in the neighbourhood—is owned by Wm. R. Payne, of Newcastle, and is situated on Rocky Brook, a tributary of the Nepisiguit Millstream, and about 17 miles from Bathurst. The vein which is 17 ft. wide, shows strong in highly altered slate—'country' rock—strikes N. 70° E. < 65° S., running in from its first exposure on the east bank of Rocky Brook. It consists of a mixture of quartz and argillaceous material, carrying iron and copper pyrites, galena and a small proportion of calcite. Possibly the average of the entire width might be even too low to pay for milling, but through the width of the vein proper are several comparatively wide pay streaks, which consist almost entirely of fine-grained argentiferous galena. The location of the property is very favourable for operations, as water and timber are both plentiful and close to the vein. The developments are as yet but small in extent, and consist of a stripping on the bank of the brook and about 100 yards further east and on the vein, a shaft about 12 ft. deep. In both of these places, the vein shows strong, and between very distinct walls.

"A good trail has been cut in from the road above Ste. Thérèse, and every opportunity is afforded of making a good wagon road.

"The following assays have been made for Mr. Payne by J. T. Donald, of Montreal:—

From stripping on creek:

	Ozs.	Dwts.	Grs.
Gold	2	6	16
Silver	7	7	12
Gold	0	11	16
Silver	11	0	16
Gold	None.		
Silver	40	16	16
Gold	0	11	16
Silver	None.		

"From same (?) vein further east (which point was not visited, however):

	Ozs.	Dwts.	Grs.
Gold	1	15	0
Silver	57	15	0
Gold	1	19	0
Silver	32	14	0
Gold	Trace.		
Silver	60	1	16
Gold	1	10	0
Silver	37	6	16

"An assay made for W. R. Payne by the Geological Survey* gave results as follows:—

"From a vein between Mill Stream and Nigadoo River, parish of Beresford, Gloucester Co.:

Gold ..... trace.

Silver ..... 0·466 ozs. in 2,000 lbs.

"Mr. Ed. Jack, under date of 29th December, 1891, reports that Messrs. Cook & Son, of Newcastle-on-Tyne, made an assay of 100 lbs. sent to them, and found 37½ ozs. silver and 7 per cent lead per ton. They did not estimate the gold."

QUEBEC.—In the province of Quebec there has been but little done. Quebec.

The washing of the alluvials of the rivers tributary to the Chaudière River, in Beauce county, have been carried on irregularly by a few men with the small product already reported, and some little attention was paid to the quartz reefs of the district.

A small force was at work exploring veins carrying argentiferous galena in this vicinity, in speaking of which the report of the Provincial Government Mining Engineer gives the following assays of specimens:—

Armstrong Silver Mine, Marlow, Beauce:—

	Principal vein.	Transversal vein.	
Gold	Traces		Per ton of 2,000 lbs.
Silver	34·04 ozs.	21·46 ozs.	
Insoluble silicious residue	57·36 p.c.	51·80 p.c	

A specimen from the first vein analysed by Mr. Hoffmann, of the Geological Survey of Ottawa, gave:—

Silver ..... 34·757 ozs. per ton.

*Annual Report Geological Survey Dept., vol. IV., 1888-89, p. 29 R.

THE PRECIOUS METALS.

Discovery and development —Quebec.

Mr. Faribault visited the Ditton gold district and gives his opinion, in which the Director concurs, that the auriferous rocks of that district are of the same age as those with which his field work has rendered him familiar in Nova Scotia.

"The Little Ditton rocks, like those of Nova Scotia, may be divided into two distinct groups, a lower or quartzite group, and an upper or graphitic ferruginous slate group. They present the same lithological character as the two groups in Nova Scotia, and there are good reasons to believe that the gold of the Ditton alluvial deposits is derived as in Nova Scotia from numerous quartz veins which run along the sharp anticlinal axes into which these rocks have been folded."

Samples were collected by Mr. Giroux from the supposed gold veins of "La Barrière" in the township of Courcelles, county of Joliette, which were alluded to in the last report of the Division* as having been said to have yielded specimens which, assayed by Messrs. Ledoux & Co., of New York, yielded, gold 1·83 ozs. and silver 2 65 ozs. The assays made of Mr. Giroux's specimens, however, by Mr. Hoffmann, chemist to the Survey, showed only a trace of gold and no silver.

The only other production of the precious metals in the province is represented in the silver contents of the shipments of sulphuretted copper ores from the Capelton group of mines, and of the galena of the Temiscamingue mine, already alluded to under the heads of lead and copper.

Ontario.

ONTARIO.—In the Madoc and Marmora gold district more or less work has been done of an exploratory nature, about which Mr. Brumell, who visited the district, gleaned the following information:—

"The Belmont gold mine, located on the E. ½ lot 20, con. I., Belmont, was operated during the summer by the South African General and Exploring Co., and was not visited owing to lack of time; the following information was, however, kindly furnished by Mr. A. W. Carscallen, of Marmora:—

"On the property are several shafts and test pits, the deepest and most important being the Carscallen shaft with a depth of 37 feet. The vein on which this shaft is sunk has widened very materially in descending and has, in the bottom of the shaft, a width of eleven feet six inches and dips to the south-west at an angle of about 80°. The vein throughout shows sulphurets and free gold, an average sample taken from the bottom of the shaft affording $19.11 in gold to the ton of 2,000 lbs. About 500 yards south-east of the above is located the O'Neill shaft with a depth of 14 feet sunk, and a vein running north

*Report Geol. Surv. of Canada, vol. V., part S, pp. 65 and 66.

and south and probably a continuation of the vein exposed in the Carscallen shaft.

THE PRECIOUS METALS. Discovery and development —Ontario.

"The other shafts are the Strickland, East and West, sunk 16 and 12 feet respectively, on a six-foot vein running east and west and dipping about vertically, and the Lingham shaft sunk eight feet on the same vein as that in the Carscallen, and distant about seventy yards to the south-east of that shaft.

"The country rock is a syenitic granite in which the veins are very clearly defined. The ore contains no arsenic, and has assayed as high as $573 in gold to the ton of 2,000 lbs. During November, 1891, thirty men were employed. In the fall a commencement was made to erect a plant of a capacity of fifteen tons per day, which it is expected will be finished early in 1892 ready to treat the ore.

"At the 'Fiegle Mine,' lots 16 and 17, con. XI., Marmora, Ont., the Crescent Gold Mining Co. continued active operations in development and erection of suitable buildings. The mining operations consisted in continuing the old shaft to a depth of 80 feet and the sinking of several test pits and open cuts. During the year they also erected a ten stamp mill, which was in operation up to the end of the year. Thirty men were employed in mining and milling.

"A small amount of development work was done at the 'Demarse Mine' on lot 24, range V. of Marmora township, by Emory Demarse, who sank several test pits on veins in the north-west corner of the lot. Encouraging results were obtained, as the veins afforded rich gold-bearing arsenical pyrites and a small proportion of free gold."

Reports of a number of finds of gold-bearing veins come from the district around Sudbury, but of these no further details are available. Mr. A. E. Barlow visited some of the veins in the township of Creighton and collected specimens, which, however, on being assayed in the laboratory of the Survey, were found to contain neither gold nor silver.

Further west, in the Thunder Bay district, the mines opened some years ago on the silver-bearing veins proper, have been operated during the year. Chief among these are the Beaver, the Badger, the Porcupine, the Shuaniah Weachu or East End Silver Mountain, and the West End Silver Mountain mines, all of which made shipments of silver ore and concentrates. Development work was also conducted on the following properties, viz.: The Palisades; Silver Centre; R. 83; Augusta; Murillo; Y. 5; Gopher; Silver Weasel; Silver Bluff; Silver Martin; Lily of the Valley, and others along the range extending W.S.W. from Port Arthur through the Rabbit Mountain groups to the vicinity of Whitefish Lake.

THE PRECIOUS METALS.

Discovery and development —Ontario.

Some prospecting work was also done on Arrow Lake further west and also down the coast south from Port Arthur in the neighbourhood of Cloud Bay and Cloud Lake.

In the Black Bay region development work has been recommenced on the vein of argentiferous galena which was discovered years ago by Mr. Duncan McEachren.*

It would be unnecessary to go into the details of developments made on these various properties, as there is nothing outside of the ordinary course of opening up by test shafts, drifts and tunnels to record. On seven of the principal of these prospects there were expended over $35,000, and several operators have gone so far as to bring machinery to their aid for hoisting and pumping.

A correspondent, writing from Port Arthur, says:

"By far the most important find was that of the Lily of the Valley in Paipoonge. The discoverer, Henry Parsons, had taken up the property as a homestead and got some residents of Port Arthur to find money to make good his title to mineral rights, &c., by conceding them a half interest. The surface showing of native silver was wonderful, and is still, after development, though this silver changed to argentite at ten feet in depth, which is quite to be expected. The vein is four feet wide, and is in the slate formation. It reminds one of Rabbit Mountain vein, from having swamp land on each side, so that one cannot trace it far. The location is lot 19, concession II. in Paipoonge township. The vein has been found in exploration in lot 20 by F. Guerard and F. E. Gibbs."

The producing mines have employed forces ranging between ten and sixty men, amounting in all, according to the returns, to 154, exclusive, of course, of a large number indirectly connected with these activities.

About the methods of opening up the mines and the extraction of ore, there is nothing novel. The veins not being, as a rule, wide, the drifts take in the entire vein and stoping is done where the ground warrants it. The most extensively exploited and completely equipped mines are the Beaver and Badger, which are the only ones having the shafts fitted with cages running on tracks. The ore is carried in cars direct from the shutes, run into the cage and hoisted to the surface. The other mines hoist simply with a bucket running on skids.

The present system of treatment of the ore is by wet concentration. The ore, as it comes from the stamps, is graded by separators into three grades, coarse, fine and slimes. These three grades pass over

* For map of district see part H, vol. III., Annual Reports, Geological Survey of Canada.

three "Frue" vanners, and thence over three "Hooper" tables, which have a canvas belt twice the width of the rubber belts of the "Frue" vanners, differing also from them in having neither side nor end shake, the necessity for which is got over by an ingenious method of perfect distribution of water and pulp. The pitch of the travelling belt can be readily altered and the machine is said to do excellent work, the cost of treating a ton of ore having been largely reduced by its adoption. The inventor of these tables is Mr. Thomas Hooper, manager of the Beaver Mine, and they are in use both in that mill and in that of the Badger Mine. Besides the six vanners there is also another "Hooper" vanner to treat the slimes very rich in argentite which pass the separators and come direct from the stamps. This does very effective work and the concentrates obtained are very rich.* Though there is much native silver it cannot be economically handled by amalgamation, and there is, therefore, no necessity for pans and settlers such as were first tried in the district. The native silver is all found in the concentrates from the vanner which receives from the coarse separator. The capacity of the mill at the Beaver Mine is twenty to twenty-five tons per day. The product of the mines is shipped in the condition of concentrates produced as above, except a proportion of rich ore requiring no treatment previous to shipment, which, according to returns, amounted this year to from thirty-eight to forty per cent of the whole shipments. Most of this was sold to the smelters in Newark, N.J., a small percentage going to Omaha, Neb.

As to the cost of production, no very close figures can be obtained. The mining cost will, of course, vary with the particular conditions of the various mines, and especially in those veins where the ore is so apt to run in bunches, and where the amount of drifting and sinking to open up any body of ore, varies so much. The cost of concentration is said to be about 90 cents per ton, smelting charges, $12 to $15 per ton of concentrates, and freight of same to Newark, N.J., $14 per ton. From the Rabbit Mountain group of mines to the Canadian Pacific Railway at Murillo costs about $3.75 for cartage. It is said that ore assaying $8 per ton will pay.

The gold-bearing veins of the Thunder Bay district have received but little attention. Discoveries were reported from the Aticokan district. Mr. Smith, of the Geological Survey, during his field work, visited the gold location on the lake west of Manitou Lake and collected some specimens from the veins, of which he says:—

* We are indebted to Mr. Arthur McEwen, Assoc. R. S. M. and manager of the Shuniah Weachu mine, for much useful information about the latest developments in the Port Arthur silver districts about the method of concentrating as at present carried on.

THE PRECIOUS METALS.

Discovery and development —N.W. Territories.

"The field appearance is very encouraging; one vein in particular seems to be a very strong one, and in some places is as wide as ten feet, of promising looking quartz, associated with soft, soapy talc schist, in soft chlorite schist."

NORTH-WEST TERRITORIES, &c.—The gold credited to the North-west Territories, &c., resulted from the washing of the gravels of the Saskatchewan River and the Yukon River districts.

For information regarding the former we are indebted to Superintendent A. H. Griesbach, in command of the North-west Mounted Police at Fort Saskatchewan. Some seventeen miners were engaged at times during the three summer months washing the gravels of the River Saskatchewan, between Fort Saskatchewan and Edmonton, and for some distance above and below these two places. There being no means of getting actual figures owing to the desultory nature of the work, a close estimate was obtained by inquiry among the miners and striking an average.

With regard to the Yukon district the same remarks apply. Several estimates were available, and by comparing these, the figures adopted have been arrived at, which, of course, represent only that proportion which there is reason to believe was obtained on Canadian territory, and ignoring that which was obtained from the same river and its tributaries, but over the Alaskan border.

British Columbia.

BRITISH COLUMBIA.—In British Columbia the work of developing the various classes of deposits of the precious metals continued throughout the year in the several districts with varying success.

The yield of gold from shallow placer mining continues to fall off, but more attention is being paid to hydraulic mining of old river channel gravels and prospecting for and working veins.

The chief field of this latter activity is still found in the districts of East and West Kootenay, in the south-east corner of the province, where the numerous discoveries of the last two years, of veins of argentiferous and auriferous galena and copper sulphurets continue to receive attention.

Development work on the claims of the older mining camps such as Toad Mountain, Ainsworth, Trail River, &c., has been continued, and important and promising new discoveries have been made in the district between the Kootenay and Slocan lakes, constituting the new Kaslo-Slocan districts.

Altogether the prospects of these two districts are very bright, the only drawback being the want of a really good railroad and local markets for the ores.

Following the policy adopted in the past, the record of development and discovery is completed by reproducing below, the details given in the report of the Minister of Mines for the province.

THE PRECIOUS METALS.
Discovery and development —British Columbia.

Cariboo—(Mr. Bowron's Report.)

"In view of the fact that there has been an actual decrease in the number of men employed, and that several projects of considerable magnitude have been inaugurated, which naturally absorb a portion of the available labour supply, it is satisfactory to note that there has been no decrease in the total gold output of the district for the season.

"Several enterprises of magnitude have been entered upon during the season, from some of which great expectations are anticipated, and, I think, justly so. A visit to the hydraulic claims of the South Fork of the Quesnelle River (to which discovery I referred in my last report) but confirms the impression already expressed, that the finding of a large blind river channel in the hill is one of, if not the most important discovery ever made in placer mining in the province.

"I found the South Fork Company, which is composed principally of working miners, had their large ditch cut some five miles, a large reservoir constructed; also a No. 1 monitor, and some 400 feet of steel pipe (fifteen inches diameter) on the ground, and were prosecuting their work with vigour. Having expended $20,000 in preparation during the summer the company will be ready for piping next season.

"I speak of this company thus particularly to show the confidence reposed in these mines by representative miners.

"I found here also, although unavoidably prevented from visiting personally their mines, that the Victoria Hydraulic Company, under Mr. J. Hepburn's management, had constructed a ditch (having a capacity of 1,500 inches) a distance of seven miles, bringing the water from Spanish Lake to their mines near the South Fork Lake, having during the year expended, including the purchase of plant for saw-mill, $30,000. This company will also be in readiness to commence operations next season. The other companies holding leases of mining ground in this vicinity have so far done but little work, presumably from lack of sufficient capital, although efforts are now being made to secure this necessary acquisition. The new road from the 150-Mile House into the Forks will be a great factor in the development of these mines, as a large quantity of machinery is now lying at the 150 ready to be brought in.

"I am pleased to report the probability of the deep ground on lower Williams Creek being worked next season on an extensive scale, with

THE PRECIOUS METALS.

the latest and most approved appliances, by which the gravel will be raised into flumes by hydraulic pressure.

Discovery and development —British Columbia.

"A London syndicate, at the instance of Mr. A. D. Whittier, of Victoria (who had obtained a lease of ground), sent this spring an expert to examine the property, and whose report appears to have been satisfactory, as Mr. Whittier has since bonded a number of the claims adjoining his leased ground, and is now in England making final arrangements to commence operations.

"The company represented by Mr. Chas. Ramos, who last season obtained a lease of mining ground on Slough Creek, has not as yet commenced operations on the ground.

"It is reported that boring machinery, by which means it is intended to prospect the ground, has been purchased by this company, and is now on its way to Cariboo.

"The introduction of boring apparatus will be a new feature in Cariboo, and one which, it is believed by many who are acquainted with the operating of such appliances, will prove an important factor in the development of our deep diggings.

"Our district was visited this fall by a Monsieur Sampson, at present of Vancouver, but recently from Eastern Canada, the patentee of a machine for saving fine gold. His *modus operandi* is to immerse the appliance in a strong current and allow the sand and gravel containing fine particles of gold to pass over it, the machine catching the gold in transit. Mr. Sampson is very sanguine that there is a "bonanza" in Cariboo for him, but it was too late in the season for him to make a practical test, so he returned to Vancouver for the winter, intending to revisit Cariboo in the spring. Mr. Sampson appears to have good backing, and should his apparatus do half he claims for it, the millions existing in the sand bars and benches of our numerous small streams, to say nothing of the bars of the Fraser, will become a known factor in the general output of the district.

"In the Williams Creek polling division there is but little of especial interest, if I except the proposed working of lower Williams Creek by hydraulic pressure above referred to. At the upper end of Williams Creek, above the old works, Messrs. Taylor and Boyce have opened up a new hydraulic claim, which I understand presents most favourable indications for developing a channel in the hill.

"The Waverly Company, of Grouse Creek, are much gratified at the result of their season's work, the claim having yielded about twice the amount of any previous year, which shows that they are now coming into the paying gravel that the company has so long struggled

THE PRECIOUS METALS.

Discovery and development —British Columbia.

to reach, and there can be no doubt that this claim will give good returns for the next quarter of a century.

"Messrs. Knott, Dibby & Co. obtained a lease of ground on lower Antler Creek, with the purpose in view of again attempting to bottom the deep ground, but so far they have not succeeded in enlisting sufficient interest in the undertaking to warrant them in making a start, but hope to do so during the winter.

"On Lightning Creek a lease of mining ground (which includes within its limits the ground formerly owned by the old South Wales Co.) was obtained by a company of local miners, who have been prosecuting the work of development uninterruptedly during the season.

"Mr. St. Laurent, of Quesnelle, reports the discovery this season of gold in paying quantities, by a party of Chinese miners, on a large creek, a tributary of Quesnelle River, which flows into that stream some 20 miles from its mouth on the north side. The creek is from 20 to 30 miles in length, and five Chinese, working about five miles from its mouth, took out about $2,000 during the season. As this creek has not been visited by whites since this discovery of gold, I cannot speak definitely as to the importance of the find.

"The Blue Lead Hydraulic Mining Company, of Hixon Creek, have prosecuted their works of development during the season, but from last accounts had not reached the bottom of the deep channel in the hill.

"The total gold product of the district, exclusive of Omineca, for the year, I estimate at $195,000, distributed as follows :—

"Barkerville polling division, to 15th Nov., per statistics..	$ 63,450
"Lightning Creek " " " ..	33,850
"Quesnelle mouth " " " ..	30,600
"Keithley Creek " " " ..	57,100
"Estimated product from 15th Nov. to 31st Dec....	10,000
Total..... ... .$195,000	

"Quartz mining during the season has remained almost in *statu quo*. Indeed, a fatality seems to follow every effort made to develop this most important branch of our mining industry in Cariboo. That we have numberless valuable gold-bearing lodes traversing the district in all directions, none, I think, who are acquainted with recent development, will be inclined to doubt; but it now would appear to have become a settled fact that until better means of communication are provided with the outer world, and consequent improved facilities for the reduction of our ores, little real progress will be made.

"A number of instances might be cited where foreign capitalists about to invest largely in our mines, upon learning that they were

THE PRECIOUS METALS.

Discovery and development —British Columbia.

situated some 300 miles from railway or steam-boat communication, at once abandoned the project. The erection of test works by the Government, in this district, it was hoped would be sufficient to give an impetus to quartz mining, and that these works have met expectations in so far as the treatment of ore is concerned, none will deny. Then why have those wealthy persons and companies, non-residents of the district, who hold valuable mineral claims in Cariboo, ceased development work and left it to a few impecunious miners (who have spent their all, perhaps, in the effort) to develop this industry? Because they are awaiting railway connection, when the further development of their mines will be less expensive. This is the only reasonable conclusion when we consider that three companies now hold charters for the construction of railways to or passing through this district. It is, therefore, important that the Government and Legislature, in considering any project affecting the building of a railway to Cariboo, will make construction at the earliest possible moment a *sine qua non* to any concessions granted.

"The Black Jack Quartz Mining Company is the only company which has during the season done anything to further develop our mineral resources. This company has sunk to the depth of 125 feet, and after running 75 feet of a drive through exceedingly hard rock, finally struck the ledge again, but too late in the fall to fully prove its value at the depth mentioned. The vein here, as far as developed, is about five feet in width. As the work during the season was all in bed-rock, their small mill was not started. Having proved the continuance of the ledge downwards, it is probable this company will, in the spring, start on the 70-foot level to take out and work the ore in their small mill, and have the sulphurets worked at the Government test works.

"Messrs. Martin, McArthur & Co. located and worked a mine on Island Mountain this fall, which is likely to prove valuable. The ledge is about 12 feet in width, assays $25 per ton, and is nearly all free gold. The vein has been traced several hundred feet.

"Mr. Perkins, on Burnes Mountain, continues to work his man-power arrastra, and manages to make his living from it while prospecting the mine.

(Mr. Stephenson's Report.)

"The estimated yield of gold for Keithly, Alexandria, and Williams Lake Polling Divisions, Cariboo District, during 1891, is a little less than last year, which can easily be accounted for when we take into consideration the amount of work that has been carried on in this

vicinity in the way of digging ditches, and other work where miners or others, whether whites or Chinese, could get employment at good wages. These works, to my certain knowledge, absorbed a considerable number of the Chinese miners in this section. Also, owing to a light snowfall last winter, the hydraulic claims had a shorter season than usual; still, for other kinds of mining, the low stage of water was advantageous in many cases in this section.

"Our old mines in the creek bottoms and along the shallow benches are getting about worked out, and it is to hydraulic mining that we will chiefly have to look for our output of gold in placer mining for the future, and there is every reason to believe that the immense gravel deposits which are to be found along the rivers and creeks in this section of Cariboo will amply repay those who have the capital and enterprise to invest in hydraulic mining. So far, every hydraulic mine that has been opened in this section has proved good paying property.

"On the South Fork of the Quesnelle River, there are two companies—the Victoria Hydraulic Mining Company and the South Fork Hydraulic Mining Company—which, during the past season, have been pushing their works ahead as fast as it was possible for them to do, in the way of digging ditches and other work necessary to the opening up of their hydraulic mines, and, owing to the nature of the country they are operating in, both companies have certainly done a great deal of work for the season. The Victoria company has now something over seven miles of ditch, five feet wide on the bottom, seven feet wide on top, by twenty-four inches deep. This ditch brings the water from Spanish Lake upon the ground they are going to work, on Coquet Lake, at the lower end of Quesnelle Lake. This company has other locations, which they intend opening as soon as it is possible to get the necessary work done. During the season they have employed, upon an average, a force of ten whites and fifty Chinese. Their works are well advanced, and early next season they expect to be in full operation. The South Fork company have about five miles of their ditch completed. Their ditch is four feet wide in bottom, six feeet on top, by twenty-two inches deep. This part of their ditch is through a very rough country, a great deal of blasting and rock cutting having been done to avoid fluming. They have also completed a large reservoir, which will enable them to use their hydraulic pipe ten hours out of the twenty-four just as soon as they can get ready. This they expect to be able to do during the coming season. This company, dur ing the season has employed, upon an average, ten whites and thirty-five Chinese, and will continue to push their work as fast as possible

THE PRECIOUS METALS. Discovery and development —British Columbia.

until they get their mine opened. Both these companies will have an ample supply of water during the whole mining season when their ditches are completed and in working order.

"On Keithley Creek, two Chinese companies have hydraulic claims which are paying them well, although they are only just getting them opened. Two other Chinese companies on the same creek are also preparing for hydraulic workings, thus showing that the banks and benches on Keithley Creek will well pay for hydraulic mining.

"On Snowshoe Creek there are now two good hydraulic claims, the well-known Anderson & Smith claim and the Hayward Company claim, which is principally owned by Messrs. Veith & Borland, on Keithley and Snowshoe creeks. There are still several claims working in the bed of the creek by wing-damming, and getting to the bed-rock at a low stage of water.

"On Snowshoe Creek, there has been a company of whites at work for a year past in trying to get to the bottom of the creek. They have sunk an eighty-foot deep shaft in the bed-rock, and the last time I heard from them they had drifted from the bottom of their shaft one hundred feet in the bed-rock towards the channel, but had not yet broken through. It is to be hoped they will find enough gold to repay them well for the work done. Over this channel lies a great depth of slum, and all attempts to sink a shaft through it have proved failures, but the company now going through the bed-rock will, in all probability, succeed in getting to the bottom of the channel.

"Harvey Creek is now abandoned by white men; the last company left lately, after having worked out what paying ground they could find. There are now three Chinese companies on the creek, working over old ground.

"The company of whites (three) on Spanish Creek still continue to drive their tunnel ahead. They are getting a little gold, but have not yet reached the old channel where they expect to find good pay.

"On the North Fork of Quesnelle River there is very little mining being done at present, only one white man working on the river and a few Chinese. The former is driving a tunnel, and the latter working along the river.

"Kangaroo Creek empties into the North Fork about two miles above the Forks of the Quesnelle. This creek, in former years, paid well on the surface for a distance of two miles up from the river, but it has never yet been bottomed in the deep ground, although several parties have tried to sink shafts upon it. Last year, Mr. Theodore Thermahlon obtained a lease of one-half mile of the creek. He tried

THE PRECIOUS METALS. Discovery and development —British Columbia.

to sink a shaft, but was driven back by water. He then started a tunnel, and is now in about three hundred feet, and he thinks he will probably have to go three hundred feet more to find bottom. Two men have been employed at this work for over a year. On the main branch of the Quesnelle River, from the Forks down, nothing of any importance is being done; there are only a few Chinese miners scattered along the river engaged in desultory mining.

"On the South Fork River, outside of the two companies previously mentioned (the Victoria and South Fork), there is nothing new to report. The two Chinese hydraulic claims have done as well as usual, considering the very poor supply of water during the season. They depend for their water supply upon the small streams upon which they are located. Other work done on the river has been by Chinese during very low water in the winter and early spring, when they get as far out in the river bottom as they possibly can, sometimes by wing-damming. They also work from a raft, with very long handled shovels, bringing up what little dirt they can and rocking it out upon the raft. Very little work of this kind has been done for the last two years; it is evident they cannot make it pay now, or they would not abandon it.

"On the Horsefly River, in the Harper claim, now worked by Mr. R. T. Ward, some very good paying ground has been discovered during the season, and they have good prospects for the future, but the company will be put to considerable expense to get the ground in working order. Five miles further down the river from the Harper claim the Discovery Company have been operating their hydraulic claim with fair results, although their supply of water was light during the summer. At this place, two other companies have been driving in tunnels to reach the old channel, but have not yet got through the rim-rock.

"Along the Fraser River, in my section, there is nothing new to report for the season. The few hydraulic claims (four) keep working, while the desultory mining has been carried on about as usual.

"As to quartz mining, or even prospecting, I have nothing to report, as there has been nothing whatever done anywhere in this section that I am aware of."

West Kootenay—(Mr. Fitzstubbs's Report).

"The mining industries of West Kootenay district, consisting chiefly of quartz mining, have progressed satisfactorily during the past season, and well-grounded hopes exist of continuous improvement.

THE PRECIOUS METALS. Discovery and development —British Columbia.

"The following statement of records shows the transactions in the respective divisions :—

"*Revelstoke Division*—

Locations	73
Assessment certificates	25

"*Nelson Division*—

Locations	416
Assessment certificates	75
Transfers	251

"*Trail Creek Division*—

Locations	87
Assessment certificates	33
Transfers	46

"*Ainsworth Division*—

Locations	363
Assessment certificates	113
Transfers	179

"*Goat River Division*—

Locations	
Assessment certificates	
Transfers	

[Not obtainable.]

"*Summary*—

Locations	939
Assessment certificates	246
Transfers	476

"From the above statement it appears that prospecting has been prosecuted vigorously, chiefly in the Nelson and Ainsworth divisions.

"About 200 of the above location records are in portions of the district, namely, on the Slocan and Kaslo streams, which heretofore have been visited only by stray prospectors.

"The above statement shows, also, a satisfactory proportion (considerably larger, I believe, than hitherto) between the number of locations made and the number of assessment certificates issued; and further, that buyers of mineral claim prospects have been unusually active.

"Development work, in the sense of work to prove and not merely to hold the mine, has not been lacking, though no mine in the district is, as yet, fully worked with adequate capital and labour invested in the hope of realizing dividends, but the high offers made, and high prices paid, or agreed to be paid, for promising prospects, together with the steady work undertaken by claim owners, on their own well known

THE PRECIOUS METALS.

Discovery and development —British Columbia.

claims, in the Toad Mountain, Ainsworth, Trail, Goat River, and Illecillewaet camps, indicate that there soon will be in the district mines worked systematically on a large scale, some of which, no doubt, will become dividend-paying properties.

"I regret that I am unable to report any considerable exports of mineral products from the district, though there is a good deal of ore on the dumps. Various circumstances connected with the principal high grade 'shipping ore' claims have prevented the export of their products during the past season.

"Silver lead ore of medium grade constitutes a large proportion of the mines in West Kootenay, and for this class of ore it has been found difficult to obtain a profitable market. The high freight rates and difficulties of transportation, together with the duty of $30 per ton on lead ores, recently imposed by the United States, make unprofitable the shipment of any lead ore that averages less—so the opinion seems to be at Ainsworth—than about $80 per ton. Claim holders, nevertheless, and mining men generally, believe strongly in the future, and have not been slow in spending their money in support of their opinions. There will probably soon be a home market for the above class of ores.

"The lead smelter already existing at Revelstoke, in the northern part of the district, is to be supplemented by the erection in the southern part of an 80-ton smelting and refining plant, with a concentrator of 100 tons a day capacity. These works are now in course of erection at Pilot Bay, on Kootenay Lake. They are owned by a wealthy American company, which already has large mining property in Kootenay. The enterprise will, undoubtedly, have a most beneficial effect on the lead mining of the section. The promoters have planned so as to permit the increase of capacity, and the treatment of all kinds of ores in the works, when required.

"Some of the companies whose claims are what miners call 'concentrating propositions,' propose, in the coming season, to erect concentrators at their mines, to prepare the ore for shipment.

"The above gives a general view of the condition of mining in the district. I have now to state, more particularly, what is being done at the different camps.

"The quartz leads at Big Bend are at present neglected. Two placer companies are at work there, one on French Creek, with four men, and one on the west shore of the Columbia River, above Smith Creek, with five men. Both pay good wages.

"At Illecillewaet, the only continuous work is upon the Lanark claim, which is the property of the Lanark Consolidated Mining and Smelting Company. Their work, it is confidently expected, will be

THE PRECIOUS METALS.
Discovery and development —British Columbia.

successful, and have the effect of aiding the progress of this valuable well placed camp, towards which attention is again directed. Several claims have been located along the upper waters of Fish Creek, above the Falls. Some of the prospectors who have been across the divide, in the neighbourhood of Trout Lake, express themselves in favourable terms as to the mineral appearance of parts of that country. It is a part of the Revelstoke division which may repay further prospecting.

"No important find has been made in the country along the Arrow Lakes during the past season.

"Several mineral claims have been located at Sproat, which have yielded gold and silver, but the assays, so far, have not been very attractive.

"The camp at Trail has advanced this year in public favour. The principal leads are of silver-bearing copper ore, yielding also gold. There is also silver-bearing galena ore. The leads are very extensive, and the quality proves to be higher than was at first supposed. About 30 men have been at work in this camp. The Le Roi Mining Company, an active Spokane concern, has an 82-feet shaft, and a tunnel 130 feet. Assessment, and also some development work, has been done on other claims. The size of the leads and the presence of quantities of ore that will pay to 'matte,' are encouraging facts. Assays and returns have been satisfactory. The return from a ten ton shipment averaged $86 per ton.

"In what is known as the 'free gold belt,' in this camp, several claims yield fine specimens of free gold, and the owners believe that further work will disclose defined ledges of paying gold ore. The supposed superior attractions of Slocan as a newer field, may draw men thither during the coming season, but the camp at Trail, no doubt, has an assured future. On the upper waters of Sheep Creek, which flows southerly across the boundary, several gold-bearing quartz claims have been recorded.

"The prospecting of the 'Whitewater' gold mine, near Rover Creek (south of the River Kootenay, about half-way between Nelson and Robson), has been satisfactory to the owners, and will be continued with more suitable appliances.

"The stamp mill on the 'Poorman' group of gold claims, near 49 Creek has not been actively at work lately, for reasons not adverse, it is believed, to the character of the claims. Assessment, and in some cases additional work, has been done on other gold claims in that neighbourhood. The extensive copper deposit on the north side of the River Kootenay, in this quarter, continues to attract attention.

"On Toad Mountain, prospecting, also assessment and developing work, have progressed steadily. Ordinary prospect claims have been in demand, generally, at fair prices.

THE PRECIOUS METALS. Discovery and development —British Columbia.

"A high price—it is said over a million dollars—was offered during the autumn for the well known group of claims owned by the Kootenay Bonanza Company, but was not accepted. On one of these claims, the 'Silver King,' the tunnel is now in over 700 feet, and cross-cuts show abundance of fine ore. There appears to be about 500 tons of picked ore, probably worth several hundred dollars a ton, on the dump at this mine. The development work undertaken on the adjacent promising groups of claims, owned respectively by the Stadacona Mining Co. and the Helena and 'Frisco Mining Co., has been steadily prosecuted, I believe, to the satisfaction of these important companies, which are prepared to work their mining properties on an extensive scale, as soon as their value has been thoroughly proved. On a number of claims owned by individuals and private companies, the necessary assessment work, and also developing work, has been done. Confidence in the future of this established camp has been much strengthened during the past season.

"In the Salmon Valley, between Toad Mountain and the boundary, several promising leads exist, on which sufficient work has been done to warrant good hopes for the future.

"I am pleased to be able to report, further, that several gold placer claims on Hall Creek, in the above locality, have yielded, during the summer, good wages to the locators, who propose to continue to work.

"The Ainsworth, or Hot Springs camp, which is essentially a silver lead camp, has much more than maintained its repute. Comparatively few claims have been allowed to lapse, and on nineteen well known claims considerable development work has been done in excess of the required annual expenditure. The transfers represent over a quarter of a million dollars. The Pilot Bay Smelting Works, already mentioned, will help this camp importantly, by affording a needed local market for ores. The largest amount of development work, during the past season, has been done on the properties of the Revelstoke Mining Co., McCune Co., of Salt Lake City, Ashworth & Jevons, of Billings, Montana, Howe & Co., of Duluth, and Dr. Coe, of Seattle. More than 2,000 feet of shafts, tunnels, etc., have been sunk or run during the past season in this camp.

"A shipment of 200 tons of ore produced an average of $150 a ton at Helena, Montana; and another shipment of ten tons realized $600 a ton at Tacoma. Pumping and hoisting plants, chiefly of American manufacture, have been erected at four of the mines. In one case, a

THE PRECIOUS METALS. Discovery and development —British Columbia.

30-horse power plant was procured in Toronto, with the exception of the pump, which, I am informed, could not be obtained in Canada. It is proposed to erect concentrators at several of these mines during the coming season. There are over 3,000 tons of ore on the dumps, some of it of very high grade.

"The extensive and valuable claims in the Hendryx camp, on Kootenay Lake, opposite Ainsworth, where about seventy claims are located, on some of which a great deal of development work has been done during the past season, will be greatly enhanced in value by the effect of the Pilot Bay Smelting Works, now in course of erection by Dr. Hendryx and his associates.

"Considerable attention has been directed to the twenty or thirty mineral claims which have been located in the vicinity of Goat River and Duck Creek, tributaries to Kootenay River, in the Goat River District. The ore, so far, does not appear to be high grade, but is in sufficient quantity to be regarded as promising. An American company proposes to undertake development work on some of their claims in this locality during the ensuing season.

"About sixteen and twenty-five miles, respectively, north of Ainsworth, on the west side of Kootenay Lake, on Kaslo and Schroeder creeks, valuable discoveries of lead and copper ore have lately been made, and eighty locations recorded. Owing to the lateness of the season, at the altitude of these discoveries, little development work has been done as yet on any of the claims, but the assays generally give a very high percentage of silver. The last advices confirm the existence of large bodies of silver, lead, and copper ores, in this section.

"Some of the prospectors on the Kaslo River, who proceeded westerly across the divide, made further very important discoveries of mineral claims on the Slocan slope, toward the close of the season. These lie, for the most part, from ten to fifteen miles easterly from the Slocan Lake, but claims have been located on the eastern margin of the lake. The existence of minerals in this region has been known for some years. The mines appear to be in the limestone belt, which Dr. Dawson noticed as running south-easterly from about the foot of Upper Arrow Lake. The discoveries were made so late in the fall that I was unable to visit the locality. The ores, so far as known, consist chiefly of silver-bearing galena and carbonates, but some of the ores have copper for a base. The assays on an average run high. Twenty assays ranged from low grade to 2,000 ozs. per ton, the average being about $175 a ton. As the prospectors had only a few weeks available before winter set in, it is difficult for any one at present to give a complete account of these discoveries. No work, of course, has been done on the claims. The

prospectors, however, judging from surface showings, express a very favourable opinion as to the mineral character of the region. They say that large bodies of ore exist, and that access to the region, and the natural mining conditions, are favourable.

THE PRECIOUS METALS. Discovery and development—British Columbia.

"That this opinion is generally entertained by prospectors, and by mining men generally, is attested by the number of records made, and the number of claims which, without any work being done on them, have been bought by investors. About fifty men, it is said, are wintering in Slocan. Storekeepers, packers, and steam-boat men, have arranged their business for a large influx of persons into the Slocan country in the spring. The people of Nelson have cut out a twenty-five-mile trail from the Columbia and Kootenay Railway to Slocan Lake. The probability is that a large number—possibly a very large number—of miners and others will be attracted to West Kootenay in the early part of the year, by these Slocan discoveries.

"So far as I can judge of a population, which as in all mining districts, is liable to much fluctuation, it probably somewhat exceeds 2,000, nearly all engaged in or dependent on mining. A considerable number of families have settled in the district."

East Kootenay—(Mr. Cummins's Report).

Placer Mining.—"The total value of gold derived from placer mining during 1891 amounted to $28,500.

"The creeks from which the gold was taken all lie in the southern portion of the district.

"The hydraulic workings of Mr. David Griffith on Wild Horse Creek, which yielded last year about $9,000, have, I understand, not been in continuous operation this year, pending negotiations respecting the sale of the property to an English company.

"I am glad to be able to state that it is proposed to test the deep ground on Wild Horse Creek. Some efforts were made in this direction over twenty years ago without success. The scheme has, however, been thought well of by good authorities on placer mining, and there is every reason to suppose that the ground is rich. A lease of one and a half miles of the bed of the creek has been granted to a company of ample means to carry on the work in a most efficient manner.

"The greater part of the placer gold derived from the various creeks, as will be seen by the tabular statement, was taken out by Chinese companies."

Quartz Mining.—"Mineral development in this district has, during 1891, been carried on with more energy than heretofore. Capital de-

THE PRECIOUS METALS. Discovery and development —British Columbia.

rived from outside sources has been invested in the district, and is being expended in the development of some good prospects, under competent direction, in various localities. Work is going on steadily this winter on several properties, and satisfactory results may be looked for before spring. Assessment work has also been done with greater regularity and intelligence than heretofore. The possibility of now bonding or selling mineral claims has also led the discoverers to make greater individual effort in prospecting their claims. It may now, I hope, be fairly said that mineral development has commenced, and that progress will be more rapid during next year. Search for new discoveries has not been so active, most of the prospectors having been engaged in working on their claims. A few good prospects have, however, been found, especially in the southern portion of the district.

"Another feature to be mentioned is that the assays of mineral obtained from claims throughout the district show a marked increase in richness. As erroneous ideas have in some cases been formed, due to the results published in some of the reports of the Geological Survey, of specimens which happen to have reached Ottawa from time to time,* I add, at the conclusion of this report, a list of assays obtained through the courtesy of Mr. Harvey, of Golden, which are perfectly reliable, and which confirm the fact that the ores of the district are mainly high grade in character, and in some instances run very high in both gold and silver.

"The trails and roads have been kept in a state of efficiency, owing to the liberal appropriations devoted to their improvement and repair last session.

"It is to be regretted that no funds were available during the summer for the collection of samples from the ore deposits of East Kootenay, as a very handsome exhibit could have been collected, at a moderate cost, to represent the mineral of the district for exhibition, the effect produced by the very fine exhibits of West Kootenay having resulted in great advantage to that district, and having been a credit to all concerned.

"The 'Bobby Burns' claim, situated near the head of the Middle Fork of the Spillemechene or McMurdo Creek, mentioned on page 373 of the Report of the Minister of Mines for 1890, has attracted much attention during the season. A five-stamp gold quartz mill was erected on the ground last summer. The water power was, unfortunately, not got into working order before the coming on of the winter. It is, however, expected to be in operation early next season.

*The results so given are accurate, for the *specimens* received by the Survey, but unless these are collected by competent and reliable persons, nothing can be guaranteed as to how far they represent the *average* of the ore body from which they come.

THE PRECIOUS METALS. Discovery and development —British Columbia.

"Some development done on the lead since the date of last year's report established the existence of a considerable quantity of free milling gold quartz on the surface, the quantity in sight justifying the erection of machinery, To what depth the lead will maintain its free milling qualities has not yet been conclusively tested. It is considered that at a depth a large quantity of gold will be contained in sulphurets, in which case it is assumed that additional plant will be needed. It seems highly probable that the enterprise, with experienced and practical management, will pay handsomely, and prove the forerunner of similar undertakings in the near future on other gold ledges which exist in the immediate neighbourhood.

"Development prosecuted, for a time on a considerable scale, on the property of Messrs. Rand Bros.' Syndicate, on Carbonate Mountain, on the right bank of McMurdo Creek, has been temporarily suspended whilst organizing a larger company, which has lately been registered as the Carbonate Mountain Mining Company, Limited.. It is understood that the company will prosecute development vigorously in the spring. As mentioned in last report, this property was reported on favourably in 1889 by Mr. Giffard, the expert, well known in connection with the undertakings of Messrs. John Taylor & Son, of London.

"On the opposite side of the creek, directly to the north-west of Carbonate Mountain, little more than assessment work has been done. Some of the claims are, however, reported to be showing very favourably.

"But little work has been done on the Copper Creek claims.

"Further to the south-east, on the left bank of Vermont Creek, a tributary of the South Fork of the Spillemechene River, three claims were bonded last autumn to the management of the Golden Smelting and Mining Company. A contract was let in the beginning of the winter to the owners of the claims for two hundred feet of tunnelling and cross-cutting. According to the last information received, a tunnel had been run into the face of the mountain in a north-westerly direction for one hundred feet, and a cross-cut to the right commenced.

"The Vermont claim, one of a block of claims situated on the southern side of Vermont Creek, mentioned on page 374 of last year's report, has been steadily worked all this winter. The greater portion of the ground included in this block was bonded to Messrs. Osler & Hammond, of Toronto, last summer, after being examined in their interests by Mr. George Attwood, the expert and mining engineer, on whose report, and according to whose directions, the present work is being carried on, under the charge of a qualified mining engineer.

THE PRECIOUS METALS.
Discovery and development —British Columbia.

"As stated in last year's report, this property contains a number of veins of silver-bearing galena and grey copper ore on the surface, ten of which, varying from six inches to twenty inches in width, are confined to a comparatively small area on the Vermont claim. A tunnel is being driven to cut those veins in the mountains, at a depth of about two hundred feet from the surface, to test their permanence, and ascertain to what degree they converge or run together to form larger veins at that depth. The tunnel has been driven in three hundred feet up to the date of last reports. At two hundred feet a vein was cut which does not appear in the face of the mountain. It was expected to cut some of the principal veins in the early part of January, and news is now shortly expected.*

"It has been estimated, from the surface showings of the veins, that their strike is about N. 65° W. and S. 65° E., with a dip varying from 50° to 80° southward. The veins all cut the formation in dip, and gain in strength as they attain depth in the mountain, generally pinching as they approach Vermont Creek. Some cannot be traced in the face of the bluff.

"The average of eighteen samples taken indifferently from the surface of the veins by Mr. Attwood, assayed silver, 86.013 ounces; lead, 41.83%; whilst many high assays have been obtained at various times by the owners of the claims, the highest of which I am aware giving 1,169 ounces of silver to the ton.

"The claims on the south-eastern side of the divide between Vermont Creek and Crystal Creek would appear to contain extensions of the Vermont Creek veins. A tunnel of forty feet has been driven this winter on one of these claims, and good concentrating ore found in a vein of some size, which has all the characteristics of a true fissure.

"The mineral claims lying further south in this belt, many of which were noticed in last year's report, have not been developed to any extent beyond doing assessment work last season. There are, however, some promising prospects on Bugaboo Creek, Horse Thief Creek and Toby Creek, which will, it is hoped, attract the attention of those possessing the capital to develop them in the near future, should ventures going on in neighbouring localities prove successful.

"The claims on Jubilee and Spillemechene Mountains, lying near the foot of the Selkirks in the Columbia Valley, near the mouth of the Spillemechene River, have not been worked this year beyond the usual assessment work. Crown grants have been obtained for several claims,

* "Since the above was written, news of a very favourable kind has been received. At about three hundred and twenty feet in the tunnel, a vein reported to be three feet in thickness was cut. This is probably the first of the veins showing on the surface. The assays of the ore are stated to be most satisfactory.

and the issuing of grants for others, delayed through litigation, now happily overcome. It is understood that a considerable amount of capital would be needed to develop the mineral of this locality effectively. Most of the properties are, however, with reason, considered valuable.

THE PRECIOUS METALS. Discovery and development —British Columbia.

"The work which was being carried out last winter on the Spillemechene claim, alluded to in last year's report, brought to light some fine bodies of galena ore, which were considered to be of too low grade in silver to be profitably worked in the existing state of the lead market. It may, however, be reasonably expected that higher grade ore will be met with, as good assays have been obtained from the same lead.

"Thunder Hill is a large butte situated in the foot-hills of the Selkirk Range, near Findlay Creek, and within about one and a half miles of the Upper Columbia Lake, on which a number of claims have been located.

"This discovery was made by Mr. James Brady, M.E., in 1884. Until this winter, but little development work was done on any of the claims. The work done from year to year was confined mainly to cutting trenches across the butte at various places, in order to locate the lead, which was, to a great extent, covered with soil.

"During the latter part of last summer, Mr. Brady formed a company, registered as the Thunder Hill Mining Company, Limited, of Victoria, to test and operate his claims. Work has been prosecuted in a most energetic manner this winter. The lead is of exceedingly large dimensions, running in a northerly and southerly direction. The country rock of the locality appears to be generally Cambrian slate.

"I have not had the advantage of examining the property since last fall, when the operations of the company were about to commence. The following particulars have, however, been obtained from several reliable sources:—

"The work done this winter consists of an open cut, about one hundred and fifty feet in length, running across the lead. The top width is about twenty feet, the average depth about eighteen feet. This cut has disclosed large quantities of concentrating ore, silver and gold-bearing galena, with some gray copper. The quartz, in some instances, contains a small quantity of free gold. The ore taken out of the cut has been stored for future treatment.

"It is understood that, should developments continue as promising, the proprietors intend to put up concentrating works on a very large scale, as, to judge from present showing, the supply of ore would seem to be almost unlimited.

"The mine is exceptionally situated for operating at an exceedingly low cost. A tramway, not more than two miles in length, will connect

THE PRECIOUS METALS. Discovery and development —British Columbia.

with the Upper Columbia Lake, and the transportation facilities of the Upper Columbia Navigation and Tramway Co. The mill site would probably be located on or near the lake.

"On Windermere Mountain, situated about four miles north of Windermere, on the Lower Columbia Lake, work has not progressed as rapidly as was anticipated last spring. A ten-ton lot of ore taken from the principal claim was sold in the early part of the summer for $50 a ton to complete a shipment from elsewhere. The Windermere Mining Co., Ltd., was organized at Spokane to work this claim, and a contract for 50 feet of drifting was let last fall.

"The Canal claim, on the east side of the Upper Columbia Lake, has been recently sold for $3,000, but little work had been done on the claim. It is understood to be a very good prospect.

"In the valley of the Kootenay River, and in the adjacent Hughes' Range of the Rockies, a number of claims have been recorded. From reports received, there are sufficient grounds to look forward to this locality receiving more attention in the future.

"On Wild Horse Creek, some claims have been staked on old discoveries in the neighbourhood of the Old Camp.

"The Pass claim, on the mountain above Wild Horse, is, I understand, showing favourably. In the vicinity of this lead a small stringer was discovered last summer. A little pocket in this seam, which is situated on the mountain, far above the action of water, contained over $100 worth of gold. The remainder of the seam, as far as it was explored was barren. This would tend to confirm Dr. Dawson's opinion as to the origin of the Wild Horse placers.

"In last year's report the discovery of a new district was alluded to, on Lost Creek, in the Rockies, about eleven miles in a south-easterly direction from Fort Steele, from whence some high grade samples of ore were obtained. About two miles further down the creek two leads were discovered last summer, containing peacock copper ore of remarkably beautiful appearance. When I visited the claims there was a very fine display of ore in the face of the workings on one of the leads.

"The original discoveries, further up the creek, from which assays of 800 ounces to the ton in silver and $46.60 in gold were obtained, have not been prospected sufficiently yet to determine the permanence of the veins, which are small at the surface. There is, however, a probability that further discoveries will be made in the locality, as the formation is very favourable, and larger leads should exist.

"The Monarch mine, which was being actively worked during the beginning of the year, has closed down for the present. I am not acquainted with the exact reasons which led to this. The other claims near Field have only had the necessary assessment work done this year.

"Some new discoveries, which are stated to be of importance, have been made up the Ottertail Creek. The claims nearer the Canadian Pacific Railway track have not been worked. THE PRECIOUS METALS. Discovery and development —British Columbia.

"Howse Pass.—Discoveries were made in the early part of the season in the neighbourhood of the head waters of the Bow River. Doubts exist if they are in British Columbia or the North-west Territories.

"The Golden Smelting Works are now in complete order, and I understand the management intends to make an effort to obtain sufficient ore for a run shortly.

"The following is a statement of a number of assays obtained from claims in different localities in the East Kootenay District previously referred to :—

"LIST OF ASSAYS OBTAINED FROM EAST KOOTENAY ORES IN 1891.*

Date.	Locality.	Mineral.	Assays to the Ton (2,000 lbs.)
1891.			
September.	McMurdo Creek.....	Quartz.	Gold $326.70.
June .. .	do	do	Gold 15.43 oz.
do	do	do	Gold $546.30.
do ...	do	do	Gold $34.35.
do	do . ..	Galena... ..	Silver 41.45 oz., lead 79%.
do	do	do	Silver 177.29 oz., lead 74%.
July.....	Copper Creek.....	do	Silver 102.9 oz., lead 69%.
do	Vermont Creek.. .	Grey copper.	Silver 1169.33 oz.
do	do	.....	Silver 242.39 oz., gold $5.38.
do	do (average of 18 samples from surface of various leads.)	Galena and antimonial copper.	Silver 86.01 oz., lead 41.83%.
do	Crystal Creek.....	.. ..	Silver 50.05 oz.
do	do	.. ..	Silver 1,113 oz.
do	Bugaboo Creek.....	.....	Silver 249.66 oz.
do	do	... ...	Silver 61.97 oz., gold nil.
do	Jubilee Mountain. ...	Copper ores...	Silver 129.91 oz., gold nil.
do . ..	Howse Pass.....	.. . .	Copper 12.7%, silver 38.23 oz., gold 19 dwt.
June	Windermere..	... .	Lead 46.7%, silver 38.75 oz., gold $23.
May.	Ottertail..	. .....	Silver 19.25 oz., gold $3.25, lead 60%.
do	East Kootenay.....	.....	Silver 111.28 oz., gold $35.15.
do	do	.. ..	Silver 107.79 oz., gold $1.25.
do	North-west of Golden.	Antimonial c'r	Silver 72.01 oz., gold $14.62.
do . .	East Kootenay..	.....-..	Silver 80 oz., gold $50.
do	Windermere..	. . ..	Silver 43.99 oz., gold $1.
do	Lost Creek..	....	Silver 71.16 oz., gold $46.60.
November.	do	Grey copper..	Silver 610.58 oz., gold $7.
do ..	do	do ..	Silver 800.18 oz., gold $19.62.
do ..	Skookum Chuck	Antimonial ore	Silver 523.52 oz.
do ..	Hughes' Range.....	....	Silver 44.50 oz., gold $1.
do ..	North-west of Donald.	Copper ore....	Silver 243.95 oz.

*It is not clear whether the assays made were of picked "*specimens*, of material taken hap-hazard, or of carefully selected *samples* representing the average of some definite ore body. The usefulness of the results as illustrating the mineral capabilities of the district are thus greatly lessened.

THE PRECIOUS METALS. Discovery and development —British Columbia.

"In conclusion, I beg to state that 253 free miners' certificates have been issued during the year, the number of new claims recorded being 138."

Lillooet—(Mr. Soues's Report.)

"The total yield of gold for the year (ascertained from reliable sources only) is $52,506.

"This shows a decrease of nearly $19,000 as compared with the ascertained yield of last year.

"This decrease does not infer by any means that the sources of supply are exhausted, but is attributable simply to the fact that the Chinese miners, for reasons best known to themselves, have almost deserted this district for the past two years.

"Considering the few miners there are in the district, and with the knowledge that several of the white miners, this year at least, have been non-producers, and the fact that there has been no new or rich strikes, I must confess to being surprised that the returns are so large.

"The various gentlemen to whom I am indebted for courteous information as to the amounts of gold dust bought by them during the year, kept a correct business account of their gold-buying transactions, and knowing them all for many years, I have every confidence that their statements to me are absolutely correct.

"The aggregate of their figures give the above-named total. I make no calculations or allowances from any other source of information.

"Mr. Phair, Mining Recorder at Lillooet, reports to me under date 26th inst.: 'The yield of gold for the season for 1891 in this part of the district is $39,091. This amount was shipped to San Francisco, through the Bank of British Columbia, by the following, viz.:—

'A. W. Smith	$22,399
'C. A. Phair	10,500
'A. McDonald	6,192
	$39,091

"'You will observe the yield is smaller than usual, owing entirely to the departure of nearly all the Chinese to work on the railroad and on the mining ditches on the South Fork of Quesnelle River. The amount taken out by the Lillooet Hydraulic Mining Company, viz., $6,192, is good considering the fact that two months of the working season were lost while enlarging ditches and flumes and opening out a new cut, otherwise they would have taken out considerably more.

The company intend during next season to dig a new ditch four and a half miles to the 4-Mile Creek, and, when completed, it will give them double the water they now have. This mine is splendidly equipped for working by the superintendent, Mr. A. McDonald.

"'This company has also a lease on the South Fork of Bridge River which prospects exceedingly well. They commenced mining this season with a large force of men, but their wing-dam, unfortunately, was carried off by high water. They are replacing it this winter. The Mina Company, on Tyaugton Creek, have completed their flume and ditch and will commence mining in the spring. Their ground shows good prospects. Mr. Jensen, representing a Victoria company, intends to commence active operations under their mining lease on Cadwallader Creek as soon as the season opens.

"'The Vancouver Enterprise Mining Company, on Cayoosh Creek, have their tunnel in now over 500 feet, and expect to have it finished in three months.

"'A scheme is being developed for bringing water from Cayoosh Creek upon the benches on both sides of the Fraser River at Lillooet. If this were accomplished it would add greatly to our prosperity.'

"With regard to the scheme to which Mr. Phair refers, viz., bringing in water for hydraulic mining purposes from Cayoosh Creek, two mining leases have been granted and three more applied for, all dependent on water from this creek. The supply is more than ample for all, and available at all seasons. For hydraulic mining, possibly during the months of December, January and February, at intervals on account of frost, it might be necessary to shut off the water, otherwise work would be continuous, and there is no question as to the results. Were proof wanting as to the mineral value of the various benches in the immediate neighbourhood of Lillooet, we have it in the returns from the Lillooet Hydraulic Mining Company and Messrs, Peters & Ward's mining leases. With a most inadequate supply both of these enterprises are doing very well, and at least settle the question as to what could be done with a powerful and well managed supply of water. Cayoosh Creek is the only source from which this supply can be had, and to bring it in sufficiently high to cover all the available benches will be a most costly undertaking, and I can only trust that the parties interested will carry out the scheme as they propose on a large and substantial plan. Hydraulic mining with any of the other small creeks in that neighbourhood is only time lost, for the inevitable small returns.

"In view of probable extensive hydraulic mining on the various benches of the Fraser River in this district in the near future it is,

THE PRECIOUS METALS. Discovery and development —British Columbia.

perhaps, not out of place here to refer to a similar method of mining in other lands, notably on the Feather, Yuba and Sacramento rivers in the State of California, where legislative action was invoked to put a final stop to it on account of filling up the rivers named with silt, and the practical destruction and flooding of unnumbered acres of, probably, the best alluvial lands in that state.

"From personal observation, I am clear in saying the same conditions do not exist here, and capitalists investing largely in substantial, permanent works for the conveyance of water for hydraulic mining purposes, in this district at least, need not take into consideration the probability in the near or remote future of being met with legislative enactments or judicial injunctions compelling them to stop work.

"Of the leases issued last year, so far there are no returns, bringing in a sufficient supply of water, being the great and expensive barrier in every case."

Quartz Mining.—"In quartz mining I regret to say that I have absolutely nothing new to report.

"A number of mineral claims recorded in 1889 and 1890 have been practically abandoned, no work or prospecting having been done on them in the past year. On Cayoosh Creek sufficient work was done on the Bonanza Company's property in the early part of the year in compliance with the latter part of clause 73, 'Mineral Act, 1884.' Negotiations for bonding the above-named property, and two other locations on the same creek, by English capitalists have been in progress for some time, but up to the present no satisfactory terms have been concluded.

"Prospecting work on most of the locations on the North Thompson has been done during the year, notably by Messrs. Allingham, Craven and McDonald. The whole of the miners in this part of the district are heavily handicapped by the innumerable natural obstacles in their way—remoteness from all centres of supply, total absence of roads or trails, and dangerous and rapid rivers to cross, all in combination with a very short season.

"The scheme for working Big Bar on the Fraser River, under water, by machinery, referred to in my report of last year, came to an abrupt ending early in the season. The large scow for carrying the dredging plant was jammed in the ice and carried off before any practical work was done.

"I understand the company propose building another scow this winter to be ready for active work at lowest water in the early spring.

Yale—Kamloops Division—(Mr. Tunstall's Report).

THE PRECIOUS METALS. Discovery and development —British Columbia.

"After giving particulars of work and discovery in iron and copper deposits, Mr. Tunstall says:—'Placer mining on the Tranquille River is pursued on so small a scale as not to be worthy of mention, and, I regret to add, I cannot report any operations in the gold or silver-bearing veins in this division of this district.'"

Yale—Yale Division—(Mr. Dodd's Report).

"A few of the bars on Fraser River, from Hope to Foster's Bar, have been worked by Chinese in a desultory manner. It is, however, impossible to obtain any reliable data as to their success, as most of their earnings (presumably small) are sold in small quantities to the various traders in the district.

"An English syndicate commenced operations on Hill's Bar Flats in April last, by washing the banks by means of a powerful Merriweather hydraulic pump, and continued work until the end of September, when, expectations not having been realized, work was discontinued for the season, after a large outlay for machinery and labour.

"Yale Creek.—The owners of the Queen Mine have been actively at work all the season. Operations at this mine commenced in 1878, and up to the present time nearly 2,500 feet of tunnels have been driven, the last 100 feet giving indications of a very favourable character.

"Siwash Creek.—Placer Mines.—Rodney & Co. have wing-dammed the creek, laid a flume 450 feet long, 4 feet wide and 2 feet deep. They have also run a race, having expended during the past season, $1,800. They have not reached bed-rock, but are washing a fine body of gravel 16 to 18 feet deep, out of which was washed 20 oz. of gold, including one piece valued at $45.

"Siwash Creek syndicate, composed of a few of the leading men of Vancouver, obtained a lease of the lower end of the creek, and began work in a practical manner about two months ago by constructing a dam and sluice gate across the creek, laying a flume 135 feet long, 5 feet wide and 2 feet deep, blasting down two falls and sluicing to a depth of 22 feet. Very encouraging prospects have been found and I trust to be in a position in a few months to report that very good pay has been discovered.

"Roddick & Co. have also obtained a lease of a portion of the creek near the Forks, on which active operations will be under way as soon as the spring opens.

THE PRECIOUS METALS. Discovery and development —British Columbia.

"About 20 quartz claims are located on Siwash Creek, on a large portion of which assessment work has been performed, with the exception of the Montrose and Roddick. On the latter several thousand dollars have been expended in driving tunnels, discovering such encouraging prospects of free gold, that a Crown grant has been applied for. This mine will be thoroughly tested by a company of Vancouver capitalists.

"Two leases have been applied for adjoining the Boston Bar farm by the side of the old wagon road. So far, the lessees are busy testing the ground by sinking a series of prospecting shafts on the land.

"Before closing my report I would respectfully submit, for the consideration of the Government, the urgent necessity of constructing a pack trail into Siwash Creek, as the only mode of transporting tools and supplies is packing by Indians, at a cost of four cents per pound. This, of course, would be greatly reduced in the event of a suitable pack trail being constructed."

Yale—Okanagan Division—(Mr. Dewdney's Report).

"Two whites and a few Chinese are still prospecting Cherry Creek, and the Chinese are taking out small wages from the abandoned claims.

"Mr. John Merritt, foreman of the Cherry Creek Mining Company, is still persevering in trying to find the old channel. The tunnel now extends about 800 to 850 feet, with very good indications ahead. He showed me from 4 to 6 oz. of coarse gold, which he took out from his last two or three sets of timbers.

"Mr. L. W. Riske and Donald McIntyre have during the summer been working their quartz mines on the Monashee Mountain, with good results, until compelled to shut down for want of water. They now intend to bring water, as proposed last year, a distance of two and a half miles, by ditch and flume, which will give them an ample quantity to operate the mill during the summer months.

"A very little prospecting on Rock Creek, and at the quartz mines, has been done during the summer, and until better facilities are offered for getting machinery into the province there will still remain a deadlock in mining enterprises.

"The placer and hydraulic mines at the mouth of Rock Creek have not done so well this past season, the output of gold reaching only from $5,000 to $6,000.

"Very encouraging reports come from Fairview Camp, and I am informed that it is a most promising camp, several claims having already

been bonded for large sums, but, for lack of machinery, they have not been thoroughly tested. THE PRECIOUS METALS. Discovery and development —British Columbia.

"There are one or two hill claims on Siwash Creek, the owners of which are developing their prospects by tunnelling."

Yale—Similkameen Division—(Mr. Hunter's Report).

"The yield of gold still continues to decrease, although the yield of platinum has increased considerably, both in quantity and value.

"On Granite Creek the yield of gold has increased, five companies are on fair pay, averaging about $6.50 per day.

"On Newton Creek very little work has been done, the water having given out, although while it lasted fair wages were made.

"On Slate Creek a large amount of work was done, considering the few miners there. In most cases fair wages were obtained. This creek has proved to be rich, though only a small portion of it has been worked, on account of the ground being so deep and miners not being in possession of funds to prospect it.

"On Boulder Creek there is only one Chinese company, and they have obtained small wages.

"On the Tulameen River a large amount of work has been performed, principally mining for platinum, the price of which has increased, making it an object to mine solely for that metal.

"An hydraulic company has been started on the Tulameen, about fifteen miles north-west of Granite Creek. The work is being pushed forward with all speed. A saw-mill, with a capacity of 25,000 feet per day, has been erected on the ground. The company expects to have the machinery in working order this fall, so as to be able to start up in the spring.

"About twenty Indians were mining on this river, with rockers, and obtained small wages.

"On the Similkameen, mining operations have been limited this year, the late season having kept the river high, and a scarcity of hands obliged Mr. Allison to shut down on his claim.

"On Whipsaw Creek very little work was done, on account of the small wages obtained.

"Considerable work has been done this year in quartz mining.

"About nine miles from Princeton, and about five from Friday Creek, a claim has been located, although little work has been done on it as yet.

"On the Bonanza Queen and Nevada, situated on the Tulameen River above Granite Creek, the owners have satisfied themselves with merely performing the necessary work to hold the location."

PYRITES.

PYRITES. Production, etc.

The amount of pyrites or sulphur ore produced in Canada during 1891 was 67,731 tons, valued at $203,193. This was all used in the manufacture of acid. As this ore runs from 35 to 40 per cent of sulphur, it will represent about 25,542 tons of sulphur.

QUEBEC.—As formerly, the whole of the pyrites produced is the result of the working of the Capelton group of mines near Sherbrooke. Of the operations at these points there is nothing new to add to the description given in last year's report.

Messrs. Nichols & Co. have continued to use part of their ore on the spot in the manufacture of sulphuric acid, shipping the bulk of it, however, in the raw state for similar use in their acid works at Laurel Hill. The remainder was also shipped to United States to acid manufacturers, the much enhanced price of sulphur causing a demand for pyrites to replace the more expensive article.

The effect of this demand is visible in the figures of production, which as compared with last year's, viz., 49,227 tons, show a great increase.

There being as yet slight demand for sulphuric acid in Canada the value of the country's resources in the way of pyritous sulphur ores varies with the fluctuations in the price of the competing material, viz., sulphur, and is closely connected with supply and demand in the American markets for this material.

The main feature of the American market would seem to be that the great increase in the price of sulphur has forced upon many acid makers the necessity of altering their works, and replacing their sulphur burners by furnaces suitable for burning pyrites. The effects of this movement will affect also the future policy of those acid makers who have previously adhered to the use of sulphur, even possibly at some disadvantage, rather than go to the great expense of constructing the much more elaborate plant for using pyrites. These, however, having once incurred this expense will for that very reason continue to be users of the pyritous ores.

It must be remembered, however, that whilst these changes will affect the *relative* values of all Canada's pyrite deposits, many will yet be without the pale of profitable working, on account of their inaccessibility and lack of cheap means of transport to the consumers and must await the improvement of these conditions or the creation of a local demand by the erection of acid works in their vicinity.

In regard to this latter point the needs of the phosphate industry may at some future time lead to the manufacture of acid in those min-

ing districts themselves and to a consequent demand for pyritous de- PYRITES.
posits within a reasonable distance.

The subjoined table shows that the home market for sulphur increases slightly but steadily year by year :—

PYRITES.

TABLE 1. Imports of Sulphur.

IMPORTS : BRIMSTONE OR CRUDE SULPHUR.

Fiscal Year.	Pounds.	Value.
1880	1,775,489	$27,401
1881	2,118,720	33,956
1882	2,375,821	40,329
1883	2,336,085	36,737
1884	2,195,735	37,463
1885	2,248,986	35,043
1886	2,922,043	43,651
1887	3,103,644	38,750
1888	2,048,812	25,318
1889	2,427,510	34,006
1890	4,440,799	44,276
1891	3,601,748	46,351

SALT. SALT.

PRODUCTION.

During 1891 there were 45,021 tons of salt sold, valued at $161,179 ; Production, etc.
this production is altogether that of the provinces of Ontario and New Brunswick, and the result of operations carried on by the following producers :—

Courtwright ..... Courtwright Salt Company.
Parkhill ..... Hutchins & Company.
Port Franks ..... Jos. Williams.
Exter ..... Exeter Salt Works Company.
Hensall ..... Geo. McEwen.
Clinton ..... R. & J. Ransford.
" ..... John McGarva.
Goderich ..... N. A. Chemical Company.
" ..... Ogilvies & Hutchison.
" ..... Peter McEwen.
" ..... Jos. Kidd, jr.
" ..... John S. Platt.
Warwick ..... Elarton Salt Works Co.
Wingham ..... Grey, Young & Sparling Co.
Blyth ..... " "

SALT.
Production, etc.

Kincardine.....L. Rightmeyer.
" .....Ontario People's Salt Co.
Brussels .....T. T. Coleman.
Sarnia .....Sarnia Salt Co.

The quantity of salt produced this year is 1,267 tons in excess of last year, while the value has decreased $37,718. According to returns annually received at this office the production for the past five years has been as follows :—

1886—62,359	tons,	valued at.....	$227,195
1887—60,173	"	"	166,394
1888—59,070	"	"	185,460
1889—32,832	"	"	128,547
1890—43,754	"	"	198,897

There is nothing new to report in the industry, beyond the fact that a new company, the Sarnia Salt Company, began operations at a new block erected in Sarnia.

Exports and Imports.

The following tables, 1, 2 and 3, and graphic table A, illustrate the exports and imports during this and previous years, and explain themselves :—

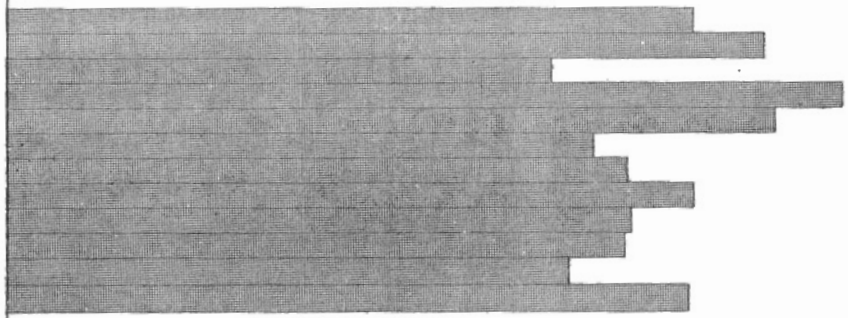
SALT.

TABLE 1.

EXPORTS.

Year.	Bushels.	Value.
1880	467,641	$46,211
1881.	343,208	44,627
1882.....	181,758	18,350
1883.	199,733	19,492
1884.....	167,029	15,291
1885.....	246,794	18,756
1886	224,943	16,886
1887.....	154,045	11,526
1888.	15,251	3,987
1889.....	8,557	2,390
1890.....	6,605	1,667
1891.....	5,290	1,277

Fiscal Year	Tons
1880	106,720
1881	117,115
1882	84,932
1883	129,442
1884	119,081
1885	90,984
1886	96,236
1887	106,728
1888	97,338
1889	96,019
1890	86,813
1891	105,316



SALT

TABLE A

IMPORTS OF SALT: ALL SORTS.

SALT.

SALT.
Exports and Imports

TABLE 2.

IMPORTS: SALT PAYING DUTY.

Fiscal Year.	Pounds.	Value.
1880.....	726,640	$ 3,916
1881.....	2,588,465	6,355
1882.....	3,679,415	12,318
1883.....	12,136,968	36,223
1884.....	12,770,950	38,949
1885.....	10,397,761	31,726
1886.....	12,266,021	39,181
1887.....	10,413,258	35,670
1888.....	10,509,799	32,136
1889.....	11,190,088	38,968
1890.....	15,135,109	57,549
1891.....	15,140,827	59,311

SALT.

TABLE 3.

IMPORTS: SALT NOT PAYING DUTY.

Fiscal Year.	Pounds.	Value.
1880.....	212,714,747	$400,167
1881.....	231,640,610	488,278
1882.....	166,183,962	311,489
1883.....	246,747,113	386,144
1884.....	225,390,121	321,243
1885.....	171,571,209	255,719
1886.....	180,205,949	255,359
1887.....	203,042,332	285,455
1888.....	184,166,986	220,975
1889.....	180,847,800	253,009
1890.....	158,490,075	252,291
1891.....	195,491,410	321,239

STRUCTURAL MATERIALS.

STRUCTURAL MATERIALS.

Building Stone

Building Stone.—According to direct returns received at this office, and estimated to constitute about four-fifths of the total production, there were 187,685 cubic yards produced, having a net value at the quarries of $708,736, showing a decrease, compared with 1890, of $256,047. The production, as returned to this office for the year, by provinces, is shown in the following table:—

STRUCTURAL MATERIALS.
Building Stone.

STRUCTURAL MATERIALS.

TABLE 1.

PRODUCTION OF BUILDING STONE DURING 1891.

Province.	No. of Returns	Cub. Yds.	Value.
Ontario	55	127,548	$426,908
Quebec	26	45,353	202,319
Nova Scotia	10	2,650	28,037
New Brunswick	7	8,767	41,838
British Columbia	1	150	1,600
Manitoba	1	44	600
North-west Territories	3	3,173	7,434
Totals	103	187,685	$708,736

Returns received in a similar manner show the production for the past five years to have been as follows:—

1886—165,777 cubic yards $642,509
1887—262,592 " 552,267
1888—411,570 " 641,712
1889—341,337 " 913,691
1890—382,563 " 964,783

Of the operations throughout the Dominion, but little need be said, as work was carried on on lines very similar to those of last year. Of the work in New Brunswick, Mr. H. P. Brumell reports on two of the largest quarries there as follows:—

"The Dorchester Union Freestone Co. are carrying on active operations at Rockland, Westmoreland Co., N.B., where they are turning out very large dimension stone. The stone is olive-coloured and the section in the quarry shows about thirty-five feet of red sandstone, breaking into small blocks on account of the jointing. Beneath this is found the olive stone sought for, having a thickness of thirteen feet. This lower bed is very solid and free from fractures or mud planes. All shipments are made by water and about two-thirds the output goes to the United States. Prices are:—Small and random blocks, $4 per ton, F.O.B.; large dimension stone, $8.50 to $9, F.O.B.

"The New York Freestone Quarrying Co. are operating at Wood Point, and from the quarry opened there about five years ago, they obtain a micaceous sandstone which on drying, becomes almost grey, with a reddish tint. The quarry face shows the following section: thin upper beds, three to ten feet in all; lower bed thirty feet, between mud planes. The equipment at the quarry is very complete, consisting of steam drills and hoisting gear and cable tramway to landing,

from whence the stone is taken on scows to Sackville for transportation by rail. STRUCTURAL MATERIALS. Building Stone.

"This and all the larger quarries of New Brunswick are being operated on the 'notch' system, thus ensuring cleaner blocks and less actual dead work."

The following tables of exports and imports explain themselves:—

STRUCTURAL MATERIALS.

TABLE 2.

EXPORTS OF STONE AND MARBLE, WROUGHT AND UNWROUGHT.

Province.	1890.		1891.	
	Wrought.	Unwrought.	Wrought.	Unwrought.
Ontario	$ 7,284	$ 6,474	$1,804	$23,311
Quebec	53	1,613	.....	.....
Nova Scotia	252	16,821	300	12,793
New Brunswick	13,649	11,275	9,105	9,323
Manitoba	.....	9	.....	.....
British Columbia	487	7,419	2,189	735
Totals	$21,725	$43,611	$13,398	$46,162

STRUCTURAL MATERIALS.

TABLE 3.

IMPORTS OF BUILDING STONE.

Fiscal Year.	Value.
1880	$ 35,970
1881	58,149
1882	33,623
1883	35,061
1884	51,088
1885	30,491
1886	41,675
1887	54,368
1888	86,373
1889	100,314
1890	132,155
1891	170,890

STRUCTURAL MATERIALS.
Building Stone.

STRUCTURAL MATERIALS.

TABLE 4.

IMPORTS OF MANUFACTURES OF STONE OR GRANITE, N.E.S.

Fiscal Year.	Value.
1880	$29,408
1881	36,877
1882	37,267
1883	45,636
1884	45,290
1885	39,867
1886	41,984
1887	41,829
1888	47,487
1889	61,341
1890	84,396
1891	61,051

During 1891 Canada afforded a market for about $880,000 worth of building stone, as follows:—

Production	$708,736	
Imports, building stone	170,890	
Imports, stone and granite	61,051	
		$940,677
Less—Exports, wrought stone	13,398	
Exports, unwrought stone	46,162	
		59,560
		$881,117

Marble.

Marble.—The production of marble for 1891 shows a considerable falling off when compared with the year previous, as the amount produced was only 240 tons, valued at $1,752, a decrease of 540 tons. The following figures show the production for the past five years:—

1886—501 tons, valued at		$9,900
1887—242	"	6,224
1888—191	"	3,100
1889— 83	"	980
1890—780	"	10,776

No new developments have come within the knowledge of the Division; the production is that of quarries which have been operated for many years.

The following table 5 shows the imports for the past twelve years and explains itself:— STRUCTURAL MATERIALS. Marble.

STRUCTURAL MATERIALS.

TABLE 5.

IMPORTS OF MARBLE.

Fiscal Year.	Value.
1880	$ 63,015
1881	85,977
1882	109,505
1883	128,520
1884	108,771
1885	102,835
1886	117,752
1887	104,250
1888	94,681
1889	118,421
1890	99,353
1891	107,661

Granite.—There is a slight increase shown in the figures of production of granite, the amount quarried and sold this year being 13,637 tons, valued at $70,056, as against 13,307 tons, valued at $65,985 for 1890. Granite

By provinces the production was as follows:—

Ontario,	3,842	tons	$ 9,451
Quebec,	4,425	"	17,390
Nova Scotia,	1,130	"	3,415
New Brunswick,	4,240	"	39,800

The annual production for the past five years is shown below:—

1886—6,062	tons, valued at		$ 63,309
1887—21,217	"		142,506
1888—21,352	"		147,305
1889—10,197	"		79,624
1890—13,307	"		65,985

STRUCTURAL MATERIALS. Slate.

Slate.—Only one slate quarry was in operation during the year, viz., that owned by the New Rockland Slate Company, whose return on account of its confidential character, is withheld. The only figures available, therefore, are those of exports and imports given below :—

STRUCTURAL MATERIALS.

TABLE 6.

EXPORTS OF SLATE.

Year.	Tons.	Value.
1884	539	$6,845
1885	346	5,274
1886	34	495
1887	27	373
1888	22	475
1889	26	3,303
1890	12	153
1891	15	195

STRUCTURAL MATERIALS.

TABLE 7.

IMPORTS OF SLATE.

Fiscal Year.	Value.
1880	$21,431
1881	22,184
1882	24,543
1883	24,968
1884	28,816
1885	28,169
1886	27,852
1887	27,845
1888	23,151
1889	41,370
1890	22,871
1891	46,104

Flagstones

Flagstones.—The production of flagstones for 1891 amounted to 27,300 square feet, valued at $2,721, an increase over 1890 of 9,435 square feet and $1,078. The production is altogether that of quarries in Wolfe and Richmond counties, in the province of Quebec.

During the past five years the production has been as follows :—

1886—	70,000 (?) feet	$ 7,895
1887—	116,000 "	11,600
1888—	64,800 "	6,580
1889—	14,000 "	1,400
1890—	17,865 "	1,643

No exports of flagstones, as such, were reported. The imports are given in the following table :—

STRUCTURAL MATERIALS.

TABLE 8.

IMPORTS OF FLAGSTONES.

Fiscal Year.	Tons.	Value.
1881	23	$ 241
1882	90	848
1883	10	99
1884	137	1,158
1885	205	1,756
1886	1,602	9,443
1887	1,316	10,966
1888	2,642	21,077
1889	1,669	15,451
1890	5,665	48,995
1891	3,770	36,348

Cement.—The total production of hydraulic cement of all kinds during 1891, was 93,473 barrels, having a value of $108,561, showing in quantity a decrease of 8,743 barrels while the value increased $16,156. Cement.

For the past four years the production has been as follows :—

1887—	69,843 brls	$81,909
1888—	50,668 "	35,593
1889—	90,474 "	69,790
1890—	102,216 "	92,405

But little can be said of the industry beyond that to be found in last year's report of this division. The operators during the year were as follows :—

Imperial Portland Cement Co	Montreal,	Que.
Thos. M. Morgan	"	"
T. A. Gauvreau & Co	Quebec	"
C. B. Wright & Co	Hull	"

STRUCTURAL MATERIALS.
Cement.

Napanee Cement Works Co	Napanee Mills, Ont.
Jas. Marshall	Rymal "
Toronto Lime Co	Limehouse "
John Battle	Thorold "
Isaac Usher & Sons	" "
Irwin, Hopper & Co	Marlbank "
North American Chemical, Mining and Manufacturing Co	Owen Sound, Ont.
Geo. Reid	Hannon "

Regarding some operations in Ontario and Quebec, Mr. H. P. Brumell reports as follows:—

"Messrs. Irwin, Hopper & Co., of Montreal, have during the year erected a plant for the manufacture of Portland cement at Cementville Siding, near Marlbank, Hastings county, Ont. The cement will be produced from marl and clay obtained in the immediate vicinity of the works, which have a capacity of thirty-five tons per day. Careful experiments and trials have been made, with the result that the company feel confident that during the coming year they will place upon the market a very superior and strong cement. Tests made —one hour in air and seven days in water—run as high as 550 pounds. It is the intention to ship the product in cotton bags instead of barrels, by which means it is expected the strength of the cement will be better guarded.

"The North American Chemical Mining and Manufacturing Co., of Owen Sound, have erected a plant for the manufacture of Portland cement, at a lake a short distance from Owen Sound, Ont. Two kilns have been erected and put into commission with a capacity of forty-two tons of clinker per kiln per week.

"The lake has an area of about 600 acres, and is in the fall of the year comparatively dry. A section of the lake deposit shows: Marl, two feet; mixed marl and clay, four feet. The materials in proper proportions are first mixed by means of a 'mixer' or puddler, after which the 'mud' is pumped to wet stones and ground, and from thence pumped to dry pans where the waste heat and gases from the attached kilns dry it. After roasting to clinker, the cement is ground in the usual way.

"Works for the production of Portland cement were erected during 1891 by the Imperial Portland Cement Co. at Pointe Claire, Que. Three kilns were erected, and active operations under the management of Mr. Gordon Kingan, at once begun. The materials used in the manufacture of the cement are found in the immediate vicinity of the works and consist of ordinary blue limestone and clay. The propor-

tions of these requisite for the making of a strong cement have been very carefully worked out with the result that the company are now turning out a very superior quality of cement." Structural Materials. Cement.

The following tables, 9, 10 and 11, illustrate the imports of cement; the exports are included with those of lime in table 14 :—

Structural Materials.

Table 9.

Imports of Cement in Bulk or Bags.

Fiscal Year.	Bushels.	Value.
1880	65	$ 28
1881	579	298
1882	386	86
1883	1,759	548
1884	4,626	1,236
1885	4,598	1,315
1886	6,808	1,851
1887	5,421	1,419
1888	23,919	5,787
1889	32,818	10,668
1890	21,055	5,443
1891	11,281	2,890

Structural Materials.

Table 10.

Imports of Hydraulic Cement.

Fiscal Year.	Barrels.	Value
1880	10,034	$ 10,306
1881	7,812	7,821
1882	11,945	13,410
1883	11,659	13,755
1884	8,606	9,514
1885	5,613	5,396
1886	6,164	6,028
1887	6,160	8,784
1888	5,636	7,522
1889	5,835	7,467
1890	5,440	9,048
1891	3,515	6,152

Structural Materials. Cement.

STRUCTURAL MATERIALS.

TABLE 11.

IMPORTS OF PORTLAND CEMENT.

Fiscal Year.	Barrels.	Value.
1880		$ 55,774
1881		45,646
1882		66,579
1883		102,537
1884		102,857
1885		111,521
1886		120,398
1887	102,750	148,054
1888	122,402	177,158
1889	122,273	179,406
1890	192,322	313,572
1891	183,728	304,648

Roofing Cement.

Roofing Cement.—During the year there was a production of roofing cement of 1,020 tons, valued at $4,810, showing a decrease, when compared with last year, of 151 tons and $1,692.

Lime.

Lime.—The production of lime during 1891 shows a slight decrease when compared with the year previous, the quantity being 1,829,894 bushels, valued at $251,215. Full data cannot be obtained, though all the principal producers are thought to have made returns and it is supposed that the above represents four-fifths of the total production.

The production, by provinces, as well as the totals for the past five years, are given in the following tables:—

STRUCTURAL MATERIALS.

TABLE 12.

PRODUCTION OF LIME DURING 1891.

Province.	No. of Returns	Bushels.	Value.
Ontario	63	1,227,681	$152,286
Quebec	9	506,700	77,462
Nova Scotia			
New Brunswick	6	67,430	15,285
Prince Edward Island	2	6,150	1,482
North-west Territories	3	21,933	4,700
Totals	83	1,829,894	$251,215

STRUCTURAL MATERIALS.

STRUCTURAL MATERIALS. Lime.

TABLE 13.

ANNUAL PRODUCTION OF LIME.

Year.	No. of Returns	Bushels.	Value.
1886	87	1,535,950	$283,755
1887	133	2,269,087	394,859
1888	93	2,216,764	339,951
1889	106	2,948,249	362,848
1890	93	2,501,079	412,308

The exports of lime and cement and the imports of lime are given in the following tables :—

STRUCTURAL MATERIALS.

TABLE 14.

EXPORTS OF LIME AND CEMENT.

Province.	1887.	1888.	1889.	1890.	1891.
Ontario	$ 4,269	$ 12,262	$ 12,877	$17,341	$ 21,924
Quebec	83	398	71	.....	25,729
Nova Scotia	142	278	11,017	17,137	15,451
New Brunswick	77,518	97,318	135,222	130,180	59,318
Prince Edward Island	4	.....	2	5	12
Manitoba	241	.....	2,060	.....	.....
British Columbia	4	.....	.....	4,141	300
Totals	$82,261	$110,256	$161,249	$168,804	$122,734

STRUCTURAL MATERIALS.

TABLE 15.

IMPORTS OF LIME.

Fiscal Year.	Barrels.	Value.
1880	6,100	$ 6,013
1881	5,796	4,177
1882	5,064	5,365
1883	7,623	9,224
1884	10,804	11,200
1885	12,072	11,503
1886	11,021	9,347
1887	10,835	8,524
1888	10,142	7,537
1889	13,079	9,363
1890	8,149	5,360
1891	6,259	4,273

STRUCTURAL MATERIALS. Building Bricks.

Building Bricks.—The production of building bricks during the year and according to direct returns was 176,533 thousand, valued at $1,061,536, a slight decrease from figures obtained in the same way for the year previous. These returns are not complete but are supposed to represent about four-fifths of the total production.

The production by provinces is as follows :—

STRUCTURAL MATERIALS.

TABLE 16.

PRODUCTION OF BRICKS DURING 1891.

Province.	No. of Returns.	Thousands.	Value.
Ontario	225	166,415	$675,719
Quebec	33	35,536	204,192
Nova Scotia	11	8,825	54,755
New Brunswick	11	5,145	35,725
Prince Edward Island	4	830	5,720
Manitoba	2	650	6,100
North-west Territories	5	2,050	23,000
British Columbia	7	7,082	56,325
Totals	298	176,533	1,061,536

The total yearly production for the past five years, as returned to this office, is as follows :—

1886—139,345 M., valued at	$	873,600
1887—181,581 M. "		986,689
1888—165,818 M. "		1,036,746
1889—200,561 M. "		1,273,884
1890—211,727 M. "		1,266,982

The exports of bricks amounted to 246,000 thousand, valued at $1,163, as follows :—

Ontario, 229 thousand	$1,039
Nova Scotia, 14 thousand	94
Prince Edward Island, 3 thousand	30

The following table illustrates the imports of bricks for the past twelve years:— Structural Materials. Building Bricks.

Structural Materials.

Table 17.

Imports of Building Brick.

Fiscal Year.	Value.
1880	$ 2,067
1881	4,281
1882	24,572
1883	14,234
1884	20,258
1885	14,632
1886	5,929
1887	2,440
1888	20,720
1889	24,585
1890	12,500
1891	9,744

Terra Cotta.—There was a production of terra cotta during the year amounting to $113,103, an increase over the year previous of $23,103. Comparisons with years prior to 1890 cannot be made as returns were not made nor asked for. Terra Cotta.

Drain Tiles.—According to returns made to this office, and supposed to represent about two-thirds of the total output, there were produced in 1891, 11,839 thousand drain tiles, valued at $141,399, an increase over the year previous of 1,318 thousand and $522. Drain Tiles.

The production by provinces is shown in the following table 18:—

Structural Materials.

Table 18.

Production of Tiles during 1891.

Province.	Number of Returns.	Thousand.	Value.
Ontario	91	11,597	$136,388
Quebec	1	111	1,665
Nova Scotia			
New Brunswick	4	98	1,346
British Columbia	1	33	2,000
Totals	97	11,839	$141,399

STRUCTURAL MATERIALS.

Drain Tiles.

For the past five years the annual production has been as follows :—

1886—12,416 M,	valued at	$142,617
1887—14,658 M	"	230,068
1888— 7,518 M	"	114,057
1889—10,526 M	"	134,265
1890—10,521 M	"	140,877

The imports, if any, are included with those of sewer pipes in table 19. No exports are reported.

Sewer Pipes.

Sewer Pipes.—The production of sewer pipes during 1891 was $227-300, a decrease, when compared with 1890, of $120,700. No further statistics beyond those of imports are available :—

STRUCTURAL MATERIALS.

TABLE 19.

IMPORTS OF DRAIN TILES AND SEWER PIPES.

Fiscal Year.	Value.
1880	$ 33,796
1881	37,368
1882	70,065
1883	70,699
1884	71,755
1885	69,589
1886	57,953
1887	71,203
1888	101,257
1889	83,215
1890	77,434
1891	87,195

Pottery.

Pottery.—Returns made direct to this office show that there was a production of pottery of all kinds, and earthenware, amounting to $258,844, an increase over last year of $63,602. The returns made to this office are supposed to represent about four-fifths of the total production.

The following table shows the imports for the past twelve years. There were no exports reported :— Structural Materials. Earthenware.

Structural Materials.

Table 20.

Imports of Earthenware.

Fiscal Year.	Value.
1880	$322,333
1881	439,029
1882	646,734
1883	657,886
1884	544,586
1885	511,853
1886	599,269
1887	750,691
1888	697,082
1889	697,949
1890	695,206
1891	634,907

Sand and Gravel.—No returns were asked for nor received, bearing upon the production of sand and gravel in Canada ; the only statistical data available, therefore, are the following tables of exports :— Sand and Gravel.

Structural Materials.

Table 21.

Exports of Sand and Gravel.

Province.	1890.		1891.	
	Tons.	Value.	Tons.	Value.
Ontario	341,656	$64,398	243,294	$58,283
Nova Scotia	170	750	230	805
New Brunswick	210	290	200	400
Manitoba	122	80		
British Columbia				13
Totals	342,158	$65,518	243,724	$59,501

STRUCTURAL MATERIALS.

TABLE 22.

EXPORTS OF SAND AND GRAVEL.

Year.	Tons.	Value.	Year.	Tons.	Value.
1877.....	11,998	$ 2,151	1885.....	110,661	$ 22,878
1878.....	50,140	8,381	1886.....	124,865	24,226
1879..... . .	46,999	9,438	1887...	180,860	30,307
1880.....	53,951	11,177	1888.....	260,929	38,398
1881.... , ...	58,693	15,129	1889.....	283,044	52,647
1882.	60.158	16,218	1890...	342,158	65,518
1883..... ...	55,346	14,065	1891.....	243,724	59,501
1884.....	73,741	19,978			

TABLE OF CONTENTS.

	PAGE.
EXPLANATORY NOTES	2
LETTER OF TRANSMITTAL	3
TABLE OF MINERAL PRODUCTION, 1886-1891, facing.	4
EXPORTS OF MINERALS, 1891	5
do DESTINATIONS, 1891	5
IMPORTS OF MINERALS, &c., 1891	6
ABRASIVE MATERIALS	6-10
Grindstones	6
Tripoli	7
Pumice	7
Emery	7
Buhrstone	7
Exports and Imports	8
ANTIMONY	10-11
Production	10
Exports and Imports	10
ARSENIC	11-12
Production	11
Imports	12
ASBESTUS	12-23
Production	12
Present conditions of Industry	12
Mode of occurrence	13
Characteristics	14
Companies Working	15
Mining	15
Dressing	18
Cost of Mining	21
Growth of Industry	22
Prices and Markets	22
Exports and Imports	23
COAL	24-65
Production	24
Exports and Imports	25
Home Consumption	27
Markets	28
Nova Scotia	28
Statistical Tables	28
Discovery and development	30
North-west Territories	44
British Columbia	45
Statistical Tables	46
Markets	47
Discovery and development	48
Nicola Valley	61
Crow's Nest Pass	61
Coke	64
COPPER	65-70
Production	65
Discovery and development	66
Nova Scotia	66
Quebec	67
New Brunswick	67
Ontario	68
British Columbia	68
Markets and Prices	69
Exports and Imports	69
GRAPHITE	70-74
Production	71
Development and discovery	71
New Brunswick	71
GRAPHITE—*Continued.*	PAGE.
Quebec	72
Exports and Imports	73
GYPSUM	74-77
Production	75
Discovery and development	75
Exports and Imports	76
Home Consumption	77
IRON	78-88
Production	78
Exports and Imports	79
Discovery and development	79
Nova Scotia	79
New Brunswick	81
Quebec	82
Ontario	83
British Columbia	85
Pig Iron and Steel	86
Production	86
Exports and Imports	87
LEAD	88-90
Production	88
Discovery and development	89
Imports	89
MANGANESE	90-92
Production	90
Exports and Imports	91
Discovery and development	92
MICA	93
Production	93
Exports	93
MINERAL PIGMENTS	93-96
Ochres	93
Baryta	95
Litharge	96
MINERAL WATERS	96-97
Production	96
Imports	97
MISCELLANEOUS	98-102
Production	98
Felspar	98
Platinum	98
Precious Stones	99
Whiting and Chalk	99
Mercury	100
Tin	101
Zinc	101
NATURAL GAS	102-110
Development, discovery, &c	102
Ontario	102
Quebec	109
N.W. Territories and Manitoba	109
British Columbia	110
NICKEL	110-119
Production	110
Values, &c	111
Discovery and development	112
New Brunswick	112
Quebec	114
Ontario	115
PETROLEUM	120-133
Stocks, Prices, Sales, &c	120
Discovery and development	122

	PAGE.
PETROLEUM—*Continued.*	
Ontario	122
Quebec	123
N. W. Territories	123
British Columbia	125
Statistics, Exports and Imports	127
PHOSPHATE	133-134
Production	133
Exports, &c	134
THE PRECIOUS METALS	135-179
Gold	135
Production	135
British Columbia	136
Nova Scotia	137
Exports	138
Silver	139
Production	139
Exports	140
Discovery and development	140
Nova Scotia	140
New Brunswick	146
Quebec	149
Ontario	150
N. W. Territories	154
Silver—*Continued.*	
British Columbia	154
PYRITES	180-181
Production, &c	180
Imports of Sulphur	181
SALT	181-183
Production, &c	181
Exports and Imports	182
STRUCTURAL MATERIALS	183-198
Building Stone	183
Marble	186
Granite	187
Slate	188
Flagstones	188
Cement	189
Roofing Cement	192
Lime	192
Building Bricks	194
Terra Cotta	195
Drain Tiles	195
Sewer Pipes	196
Pottery	196
Earthenware	197
Sand and Gravel	197

INDEX—VOL. V.

(NEW SERIES.)

ABBREVIATIONS.

Al.	District of Alberta.	N.S.	Nova Scotia.
Ath.	District of Athabasca.	N.W.T.	North-west Territory.
B.C.	British Columbia.	O.	Province of Ontario.
Ma.	Province of Manitoba.	Q.	Province of Quebec.
N.B.	New Brunswick.	Sk.	District of Saskatchewan.

	PAGE
Abercrombie, N.S., Permian....	121 P
Abrasive materials, statistics....	9 S, 6 SS
Acadia, N.S., coal mining	38 S
Accommodation, insufficient for library*...	91 *a*
for botanical work.....	87 *a*
Act relating to Geological Survey, 1890.....	3 *a*
Adams, F. D., work by.....	35, 39 *a*
Adams, W. C., work by.	59 *a*
Agassiz, ancient Lake, highest level of	99 E
delta of.....	102 E
coast cliff of.....	119 E
shore lines of.....31 A,	218 E
Agnes Lake, Hunters Island ...	11, 13 G
Laurentian..... .....27, 29,	31, 33 G
Coutchiching.	50 G
Keewatin	69 G
hornblende rock...	69 G
Agnes Lake route	16 G
Agricultural lands, Ath.....	8 D
north-western Ma.....	24 E
Fisher River....	24 *a*
east of Lake Winnipeg.....	32 A
Hunters Island region.....	74 G
N.B. .... .56 A,	50 *a*
northern N.S. 5,	169 P
Ailsa Craig, O., borings.....	53 Q
Akamina Brook, B.C., petroleum	11 A
Akamina Camp, U.S. boundary cairn	10 *a*
Albert copper mine, Capelton...	51 S
Albert Cañon, Illicillewaet.....	15 *a*
Albert County, N.B., work in....48,	62 *a*
Alberta, district of, work in.....	18 *a*
Albertite, northern N.S.....	174 P
Algoma district, O., iron..	83 S
Algoma Mills, O., ore, assay....	53 R
Almon, W. B., work by..... 52 A,	3 P
Altitudes, Athabasca district.... 7,	26 D
Lake Manitoba...	34 E
Lake Winnipegosis.....	47 E
Swan Lake.....	75 E
of lakes, Hunters Island....	10 G
of lakes, Sudbury district...	82 F
on main Pacific railway line.	84 F
Alum, imports... ..... 8 S,	6 SS
"Amber" deposits, Cedar Lake. 30 A, 225 E,	14 S
examination of.	225 E
Ami, H. M., work by.....73 A,	78 *a*
Ami Island, Lake Winnipegosis.	153 E
Amphibolite, Murray mine, described.	73 F
Analyses and assays in laboratory.....	1-72 R
Anderdon, O., boring..... ...	79 Q
Angling Lakes, Duck Mountain.	128 E
Ankerite, northern N.S.....	175 P
Anorthosite, north of lower St. Lawrence River.....8, 9,	22 L
examined 23, 76, 80,	81 L
use of the term.....	73 L
Anthracite, semi-, Red Deer River	70 R
Anticlines, Cambro-Silurian, eastern Q.....	29 L
connection of, with auriferous leads, N.S..	56 A
Antimony, statistics..6, 7, 8, 16 S, 6,	11 SS
ore, production..... 4,	10 SS
Apatite, statistics.....	153 S
characteristics of Canadian..	158 S
minerals in.....	68 R
Apahagin, N.B., mineral water (analysis).....	108 S

* In the present index, (A) placed after the numbers of the pages refers to Part A for 1890, and (*a*) to Part A for 1891, both in this volume.

	PAGE
Archæan rocks, Hunters Island.	17-38 G
area, north of lower St. Lawrence	7-26 L
Arches, natural, Minas basin	72 P
Argenteuil county, Q., work in	37 A
Argillite, South Manitou Island	168 E
cliff, Red Deer River	187 E
northern N.S., Cambro-Silurian	8 P
Devonian	20-73 P
Argillites, Silurian, St. John R.	9 M
Argynnis Atlantis	87 F
Arkona, O., boring	65 Q
Arkose, Sturgeon River, described	61 F
Maple Mountain, "	62 F
Lake Temiscaming, "	63 F
upper Wahnapitæ, "	65 F
Montreal River, "	67 F
Lady Evelyn Lake, "	68 F
Copper Cliff Mine, "	74 F
Armitt River, Red Deer River	121 E
Arrow Lake, Upper, B.C., hot spring, water analysis	24 R
quartz, assay	58 R
East arm, silver mining	171 S
Arsenic, statistics 6, 8, 17 S, 4, 6, 11 SS	
Arsenopyrite, Graham, analysis.	45 R
Artesian well boring, Deloraine.	9 A, 7 *a*
Asbestus, statistics. 6, 7, 8, 30 S, 4, 5, 6, 12, 23 SS	
deposits	19 S
industry 46 A, 12 SS	
Ascot, Q., ore, assay	50 R
Ashes, imports 8 S, 6 SS	
Asphalt, on generation of	16 Q
imports 8 S, 6 SS	
Assays, gold and silver	48 R
Sudbury district	52, 54 F
Assessipi, Shell River 129, 133 E	
Assiniboia, report on eastern	1-234 E
Assiniboine Lake, ancient	137 E
Assiniboine River, Lake Winnipeg 27 A, 23, 135-143 E	
Athabasca, district of, N.W.T., report on	1-67 D
petroleum	24 A
tar sands (analysis)	144 S
Athabasca Lake 22 A, 50, 51 D	
Athabasca River, Mackenzie River 22 A, 22, 27-36 D	
Athabasca sandstone, Lake Athabasca 22 A, 51 D	
Aticokan River, O.	30 *a*
iron deposits	85 S, 84 SS
magnetite, analysis	38 R, 86 S
Bailey, J. W., work by	3 M
Bailey, Prof. L. W., work by	9, 56 A, 59 *a*
report by	1-28 M
on gold in N.S.	64 S
Bailey's Bridge, Waugh River	155 P
Bainsville, O., borings for oil	21 Q
Baker Brook, St. John River	12 M
Balfour Brook, N.S., Devonian.	51 P
Banff, Al., plants and birds collected at	86 *a*
museum, preparation of specimens for	86, 87 *a*
Barachois Harbour, N.S., pyrrhotite, analysis	39 R
Barclay Sound, B. C., ilvaite, analysis	11 R
pyrrhotite, analysis	46 R
native mercury	65 R
cinnabar	66 R
Barley, S., work by	5 E
Barlow, A. E., work by 41 A, 31 *a*, 5 F	
on ore deposits at Sudbury	122 S
Barnardo farm, Ma	143 E
Barrens, northern N.S.	168 P
Barrie, O., borings	28 Q
Barton, O., boring	32 Q
Baryte, statistics 6, 7, 8, 105 S, 4, 95 SS	
northern N.S. 177, 191 P	
Bass Lake, Vermilion River	22 F
Bass River, Big, N.S., Devonian	64 P
Bass River, Little, N.S., "	65 P
coal	172 P
Bastard, O., hematite, analysis	39 R
Basswood Lake, Rainy River.	17, 27 G
origin of name	12 G
Bathurst, N.B., silver ore	62 *a*
Bay Lake, Montreal River, sandstone, described	67 F
Batiscan River, Q.	45 *a*
Beaches, lake, ancient, Lake Winnipeg	24 *a*
new and old, Lake Winnipegosis	53, 56 E
raised, northern N.S.	147 P
Bear Lake, Bear River	19 D
Bear River, Wabiscaw River	11 D
Bear River, N.S., ores, assay	49 R
Bear's Head Creek, Swan River.	115 E
Beardy Island, L. Winnipegosis.	176 E
Beauce district, Q., gold	64 S
Beaumé's hydrometer, table of gravities	87 Q
Beauport, Q., fault	32 L
Trenton	38 L
Post-pliocene fossils	56 L
terraces	65 L
Beauport Lake, Q., Trenton	39 L
Loraine (fossils)	44 L
quarries	70 L
Beauport River, Q., fossiliferous sands	56 L
Beaver Creek, Pelican Lake	10 D
Beaver Lake, Sananagons Lake.	60 G
Beaver mine, Thunder Bay district, harmotome, analysis	16 R
Beccaguimic River, N.B.	14 M
Beeton, O., boring	28 Q
Belisle River, Q., Trenton	35 L
Bell, Dr. R., work by 41 A, 31 *a*	
work in the North-west (1874)	17 E
report by	1-54 F
referred to	9 G
Bell River, Lake Winnipegosis	60, 120 E
Belmont, O., gold mining 63 *a*, 150 SS	
Belmont, N S., Devonian	60 P
Triassic	142 P
Benton formation 199, 210 E	
Benton shales, Vermilion River.	87 E
North Pine River	101 E
Swan River	112 E

PAGE

Benton shales—*Con.*
Armitt River ..... 121 E
Beren's River..... 20 *a*
Berlin, O., boring ..... 42 Q
Berthelot, on formation of carbides of hydrogen ..... 10 Q
Bertie, O., boring for gas..... 36 Q
Bibliography on geology of northwestern Ma..... 19 E
of Hunters Island. . ..... 8 G
of botany of northern N.S.. 169 P
on hydrocarbons of Canada. 91 Q
Bic, Q., Cambrian . ... 23, 26 M
Big Bass River, N.S .... 64 P
Big Brook, N.S., Devonian..... 36 P
Big Rock Lake, Hunters Island.. 62 G
Big Sandy Point, Lake Manitoba44, 196 E
Big Slide mine, Fraser River, ore, assay ..... 63 R
Big Turtle River, O., iron ore... 29 *a*
Bigsby, Dr. J. J., referred to... 8 G
Birch Hills, N.S., Devonian boss 64 P
iron ore ....64, 178 P
Birch Island, Lake Winnipegosis.67, 168 E
Birch Lake, Hunters Island .... 62 G
Birch Mountain, Moose Lake.21 A, 7, 25 D
a plateau... .... 44 D
Birch River, Lake Claire.....21 A, 7 D
Birch River, Swan Lake . ..... 118 E
Birds, catalogue of Canadian, published ..... 85 *a*
Bird Tail Creek, Ma ..... 143 E
Bitumen in tar sands, Ath ... 24 A, 65 D
Black Island, Lake Winnipeg... 35 A
Black Lake, Black River, Q... 41 *a*
Black Lake, Q., asbestus mines. 22, 25 S
Black River, Lake Winnipeg... 22 *a*
Black River, L'Assomption River 41 *a*
Black River, Q., gneiss..... 9 L
Black River, Big, St. John River. 10 M
Black River, Little, St. John R. 9 M
Black Jack Quartz Mining Co., B.C., gold . ... 69 S
Black Sturgeon Lake, O., hematite, analysis..... ... 39 R
Blacklead, statistics.....76 S, 74 SS
Blackrock, N.S., Carboniferous . 95 P
limonite .... 176 P
Black Water River, B.C., tripolite... ..... 20 R
Blanchard iron mine, N.S., rocks 12 P
Blanchard Brook, N.S., Cambro-Silurian..... ..... 10 P
igneous rocks. .... 148 P
red hematite.... .... 181 P
Blende, Mosquito Flat .... 18 *a*
Blenheim, O., boring..... 74 Q
Blezard mine, Sudbury .... 52 F
gabbro, described. ..... 77 F
Blue Mountain, N.S., igneous rocks .... 147 P
search for coal .... 174 P
Blue River, Q.. ... . 18 M
Blue Sack, N.S., Devonian.. ... 70 P
Blue Water Lake, O ... . 28 F
Blue Water River, O..... 30 F
Blyth, O., boring..... 57 Q
Blytheswood, O., boring..... 84 Q

PAGE

Boggy Creek, Big, Assiniboine River ..... 134, 138 E
Boggy Creek, Little, Assiniboine River..... .....134, 136 E
Boiler Rapid, Athabasca River.. 32 D
Bonanza location, Lillooet, rock, assay .... 63 R
Bonaparte Lake and River, B.C. 18 A
Bonaparte River, B.C., rock, assay..... . ... 61 R
Bonhomme Mountain, Q., gneiss. 18 L
terraces .... 63 L
Borax, imports .. . . 8, S., 6 SS
Bore, Swan River (1875) ..... 18 E
Ochre River..... ..... 82 E
Boring, Athabasca River .....26 A, 145 S
Vermilion River..... ... 86 E
Deloraine ... . 9 A, 7 *a*
Turtle Mountain ..... 10 A
Morden..... 29 A
for gas and oil, O ..... 21 Q
Welland county. .... 118 S
Oxford, O .... 119 S
Goderich..... ..... 162 S
Bosanquet, O., borings..... 64 Q
Boston Mining Co., N.S ..... 61 S
Botanical collection, additions to .... 81 A, 88 *a*
collections supplied.....82 A, 88 *a*
work, progress of .....81 A, 85 *a*
Boucher's mine, Lake Wahnapitæ ore, assay..... 53 F
Boucherville, J. B., work by.... 45 *a*
Boularderie Island, N.S., manganese ore (analysis).... 99 S
Boulder, sandstone, Assiniboine River.....27 A, 136 E
pavements, Assiniboine R.. 28 A
granite, Sturgeon River .... 74 G
in limestone, Jacques Cartier River..... ..... 27 L
Boulders, Lake Manitoba ... 40, 42 E
L. Winnipegosis..50, 52, 63, 68, 153 E
ridges of, Lake Winnipegosis 65, 67 E
forming rapids, Mossy River 73 E
sandstone, Red Deer River.. 124 E
striated, pavement of, Assiniboine River..... 139 E
limestone, Grand Rapids ... 146 E
bank of, Spanish River..... 31 F
north of lower St. Lawrence. 52 L
Kent County, N.B..... 54 A
northern N.S..... 146 P
St. John River..... . 9 M
Boulder clay, Peace River . .. 47 D
Athabasca River..... 60 D
See also Till.
Bourbon, Fort, old, Cedar Lake. 79 E
Bourg Louis, Q., swamp..... 66 L
Bow River, Al., coal . ... 18 *a*
Bowen Island, B.C., ores, assays 64 R
Bowron, Mr., on gold in Cariboo district..... 66 S
Brabant, Point, L. Winnipegosis 50 E
fossils in dolomite..... 159 E
Brantford, O., borings.. .... . 43 Q
Bras, Sault à la Puce, Q., anorthosite, examined..... 76 L

PAGE

Brass, imports ..... 8 S, 6 SS
Breccia, black, Sudbury district. 43 A
Breccias, fissure, Wilkins Point. 183 E
Brechin, O., mineral water (analysis) ..... 109 S
Brent Lake, Hunters Island, Laurentian..... 24, 27, 31 G
Coutchiching..... 42 G
hornblende rock..... 70 G
Bricks, statistics 6, 7, 194 S, 4, 5, 6, 194 SS
northern N.S..... 190 P
Bridgeville, N.S., Cambro-Silurian..... 8 P
Devonian..... 34 P
gypsum..... 87 P
Brine springs, north-western Ma 219 E
Brines from Ma. and Sk. (analyses)..... 27-34 R
from north-western Ma. (analyses)..... 222 E
Bristol, Q., iron ore..... 83 SS
British Columbia, progress of work in..... 11 A, 16 *a*
ores, assays..... 55 R
coal mining..... 44 S, 45 SS
gold production..... 56 S
gold mining ..... 66 S
silver..... 169 S, 154 SS
copper..... 68 SS
iron..... 86 SS
natural gas..... 102 SS
petroleum..... 125 SS
Broadbent, R. L., work by..... 67 A, 66 *a*
Brock, R. W., work by..... 31 *a*
Brompton Lake, Q., millerite.... 47 R
asbestus mines..... 27 S
Brooke, O., borings..... 43 Q
Brookfield, N. S., iron mine, Devonian..... 41 P
Carboniferous..... 76 P
limestone quarries ..... 94 P
limonite, baryte..... 177, 192 P
gold field, ore, assay..... 49 R
gold mining..... 61 A, 61 S
Brookville, N.S., Devonian..... 72 P
coal ..... 173 P
Broom, Loch, N.S., Permian.... 122 P
Broughton Lake, Q., asbestus... 26 S
Brown's Brook N.S., Devonian.. 52 P
Bruce Mine, Lake Huron, diabase (described)..... 79 F
Brulé Point, N.S., Permian .... 135 P
Brulée, Pointe, Athabasca River, section (fig.) ..... 30 D
Brumell, H. P. H., work by.... 64 A, 60 *a*, 4 S, 4 SS
report by..... 1-94 Q
Brunswick Manganese Co., N.B. (analysis)..... 95 S
Brussels, O., boring..... 56 Q
Bucke, M. A., work by..... 61 *a*
Buckingham, Q., graphite .... 72 SS
Buctouche Harbour, N.S., bog iron ore..... 51 *a*
Buffalo Lake, Birch Mountain .. 15 D
Buffalo Head Hills, Ma..... 7, 15, 41 D
a plateau..... 43 D
Buhrstones, imports..... 8, 11 S, 6 SS

PAGE

Building stones, statistics..... 8, 182 S, 4, 5, 6, 183 SS
Burgessville, O., boring..... 47 Q
Burk Lake, Hunters Island..... 69 G
Burnt Rapids, Athabasca River. 23, 31 D
Burnt River, Red River ..... 16 D
Burrard Inlet, B.C., sphalerite.. 66 R
Byassan, H., on origin of petroleum..... 11 Q
Byers Brook, N.S., drift ..... 145 P
igneous rocks ..... 156 P

Cabano River, Lake Temiscouata 16, 17 M
Cache Bay, Sananaga Lake..... 61 G
Calciferous, Argenteuil county.. 37 *a*
Caledonia, N.S., gold field, assay 9 A, 48 R
gold mine..... 61 S
coal mine ..... 40 SS
Caledonia Springs, O., gas spring 22 Q
Calgary, Al., well water (anal.).. 25 R
California, coal imports..... 47 SS
Calvary Brook, N.S., Devonian . 21, 39 P
specular iron ..... 183 P
Cambrian, Athabasca Lake.. ... 51 D
B.C., petroleum in..... 13 *a*
Temiscouata county..... 14 M
Lower, auriferous, Halifax county..... 56 *a*
Cambro-Silurian, Malbaie..... 44 *a*
north of lower St. Lawrence 48 A, 5, 26-47 L
mineral springs in Charlevoix county ..... 52 A
Temiscouata county..... 14 M
northern N.S ..... 6, 8-10 P
associated with igneous rocks 8 P
Camden, O., boring. ..... 72 Q
Cameron, A., work by..... 62 A, 59 *a*, 3 P
Cameron, A. M., work by..... 31 *a*
Cameron Bay, Lake Winnipegosis 171 E
Cameron Falls brook, B.C., petroleum ..... 11 *a*
Cameron's Bar, Fraser River, ore, assay..... 64 R
Cameron's, Sam, brook, N.S., Silurian ..... 13 P
Devonian..... 47 P
Carboniferous..... 89, 104 P
igneous rock..... 148 P
Camp Island, Vermilion River.. 20 F
Campbell, A. M., work by..... 31 *a*, 5 F
Campbell Lake, Vermilion Lake. 20 F
Camping Island, Lake Winnipegosis ..... 67 E
Canmore, B.C., coal mines.... 15 A
Cape Breton, N.S., manganese deposits..... 98 S
coal mining..... 37 SS
Capelton, Q., copper mining.... 51 S
pyrites. ..... 180 SS
Carbides of hydrogen, on formation of..... 10 Q
Carbonate Mountain, B.C., silver 178 S
Carboniferous formation, northern N.S .....6, 73-108 P
conglomerate..... 73-85 P

PAGE

Carboniferous—*Con.*
limestone ... 85-102 P
Cobequid Bay ... 53 *a*
Millstone Grit. ... 102-105 P
coal measures ... 105-108 P
Cariboo district, B.C., gold mining ... 66, 68 S, 155 SS
Cariboo Company, B.C., silver mine ... 170 S
Cariboo, N.S., gold mining ... 59 S
Cariboo Cove, N.S., coal mining 43 SS
Cariboo Island, Big, N.S., permian ... 135 P
borings, sections ... 139 P
coal ... 140, 171 P
Cariboo River, N.S., Permian ... 135 P
Carpmael, Prof. C., meteorological observations ... 28 33 E
Cascade, N.W.T., coal basin ... 44 SS
Cascade Range, B.C., explorations ... 17 A
Cascade Rapids, Athabasca River 33 D
Catcha Lake, N.S., gold mining. 59 S
Cathcart, O., boring. ... 45 Q
Cave, vertical, Lake Manitoba ... 195 E
Caves, northern N.S. ... 169 P
Cayoosh Creek, Lillooet, rocks, assays ... 65 R
gold ... 175 SS
Cayuga, O., natural gas ... 106 SS
Cedar Lake, Saskatchewan River ... 79, 151, 202 E
"amber" ... 30 A, 225 E, 19 S
Cement, statistics .6, 8, 190 S, 4, 5, 6, 189 SS
Portland, statistics ... 8, 192 S
roofing, statistics ... 7, 192 S, 4, 192 SS
Centredale, N.S., Devonian ... 35 P
Chalcopyrite, Sudbury district ... 48 F, 128 S
Chalk, statistics ... 8, 114 S, 6, 100 SS
Chalmers, R., work by ... 53 A, 48 *a*
Chambord, Q., spring water, analysis ... 26 R
Champlain, Q., fault ... 30 L
Champlain formation, north-western Ma ... 199 E
Champlain epoch, valleys of ... 128 E
Chandos, O., ores, assays ... 52 R
Charing Cross, O., boring ... 73 Q
Charlesbourg, Q., section ... 30 L
Trenton ... 38 L
Loraine (fossils) ... 44 L
Charlevoix, county of, work in ... 48, 51 A
Charlie Island, Lake Winnipegosis ... 162 E
Château Richer, Q., gneisses ... 21 L
described ... 80, 81 L
felspar (analysis) ... 26 L
anticline ... 33 L
quarries ... 70 L
anorthosite, described ... 78, 80, 81 L
Chatham, O., borings ... 72, 73 L
Chatterton Lake, Hunters Island mica schists ... 11 G
Chemahawin, Saskatchewan R. ... 49 G
Chemawinite, Cedar Lake ... 152 E
Chemical contributions to the geology of Canada ... 225 E
Chemical work, progress of ... 1-72 R
Cherry Bluff, B.C., ore, assay ... 66 A, 64 *a*

PAGE

Cherry Creek, B.C., gold ... 58 R
Cherry Creek Bluff, B.C., iron mining ... 72 S, 178 SS
Cherry Island, Lake Manitoba ... 85 SS
Chert, nodules of, Lake Winnipegosis ... 44, 196 E
Cheverie, N.S., manganese ore, analysis ... 155 E
Chevrotière, Q., limestone quarries ... 98 S
Chicago limestone, oleiferous ... 69 L
Chiganois River, N.S., Devonian 16 Q
Carboniferous ... 28 P
igneous rocks. ... 79 P
soil poor ... 137 R
coal ... 169 P
Chignecto coal mine, N.S. ... 177 P
Chignecto, isthmus of, glaciation 37 SS
Chipped flints, Valley River ... 49 *a*
Christie's, Henry, Millbrook, N.S., Devonian ... 95 E
Churchbridge, Ma. ... 45 P
Chute, Lac à la, L'Assomption R. 142 E
Cinnabar, Barclay Sound. ... 42 *a*
Claire, Lake, Lake Athabasca ... 66 R
Clarendon, O., pyrrhotite, anal. 21 A, 8 D
talc. ... 45 R
Clarendon, Q., pyrrhotite, anal. 67 R
pyrite, analysis ... 40 R
Clarke Head, N.S., Carboniferous ... 114 SS
Clastic rocks, metamorphism ... 72, 98, 100 P
Clay, east of Lake Winnipeg ... 56 F
brick, north of lower St. Lawrence ... 32 A
brick, Kent county., N.B. ... 68 L
Westmoreland county ... 56 A
Shubenacadie River ... 51 *a*
fire, production ... 59 *a*
See also Boulder clay. ... 6 S, 4 SS
Clay products, statistics ... 6 S, 4, 5 SS
Clays, imports ... 8 S, 6 SS
northern N.S ... 189 P
Clay slates, origin of, Sudbury district ... 42 F
Clearwater River, Athabasca R. 39 D
Clearwater shale, Athabasca R. 30, 57 D
Cliffs, coast, ancient, Porcupine River ... 119 E
Clifford's Brook, N.S., Devonian 45 P
Carboniferous ... 91 P
Clifton, N.B., grindstones, section ... 12 S
Clifton, N.S., Carboniferous, limonite ... 95, 178 P
Climate, north-western Ma ... 25 E
Clinton, B.C., rocks, assays ... 62 R
Clinton, O., boring ... 57 Q
Clinton formation, northern N.S. 12 P
Coal, statistics .6, 7, 8, 31 S, 4, 5, 6, 24, 46 SS
mining ... 36 S, 31 SS
Kamloops ... 18 A
Crow's Nest Pass ... 13 *a*
mines, Canmore ... 15 A
Bow River ... 18 *a*
north-western Ma ... 228 E
Turtle Mountain ... 9 A
measures, northern N.S ... 105-108 P
occurrences, northern N.S ... 170 P

PAGE

Coal—*Con.*
Cobequid Bay .... 53 *a*
Coalmine Brook .... 78 P
Kennet Cook River .... 97 P
in Permian formation .... 120 P
reported, central N.S. .... 60 A
Coal River, O., quartz sand .... 70 R
"Coal oil." *See* Petroleum.
Coalmine Brook, North River, Devonian .... 60 P
Carboniferous .... 78 P
Coalmine Brook, Debert River, Carboniferous .... 81 P
Cobalt ores, analyses .... 39 R
Cobequid Bay, N.S., shores of .. 52 *a*
Devonian .... 56 P
Cobequid Hills, N.S. .... 5 P
southern slope of, Carboniferous .... 77 P
structure of .... 151 P
Cochrane, A. S., work by .... 44 A
Cœnonympha inornata .... 87 F
Coke, statistics .... 6, 7, 8, 50 s, 4, 6, 64 ss
Colchester, O., borings .... 80 Q
Colchester county, N.S., work in. 52 *a*, 1-193 P
search for gold .... 62 S
Coldwell, Prof., work by .... 52 *a*, 3 P
Coldwell, F. A., work by .... 52 *a*, 3 P
Cole, A. A., work by .... 45 *a*
Cole Point, N.S., Permian .... 134 P
Coleraine, Q., asbestus mines .... 20, 26 S
Collection, botanical, additions to .... 81 A, 88 *a*
conchological, additions to .. 99 A
entomological, " .. 80 A
ethnological, " 77 A, 81-84 *a*
mineralogical, " 67 A, 67 *a*
palæontological, " 74 A, 82-87 *a*
zoological, " 72, 75 A, 77, 81-85 *a*
Collections supplied, botanical. 82 A, 88 *a*
of fossils .... 74 A, 79 *a*
of minerals .... 69 A, 71 *a*
Collingwood, O., borings for gas. 80 Q
shale distilling works .... 27 Q
Colorado beds, Peace River .... 55 D
Athabasca River .... 57 D
fossils, list of .... 58 D
Commis, Mount, Q., Cambrian . 27 M
Commissaires, Lake, Q. .... 51 A
Comox, B. C., coal mining .... 48 S, 57 SS
Conchological collection, additions to .... 99 A
Concord Mills, N.S., Devonian .. 49 P
Conglomerate, Crooked Rapids .. 33, 52 D
greywacke, Lake Wahnapitæ, described .... 58 F
Spanish River .... 30 F
Geneva Lake .... 38 F
slate, Sudbury district .... 42 F
Lake Maskinongéwagaming. 66 F
metamorphosed, Copper Cliff mine, described .... 69 F
upper Wahnapitæ River, described .... 65 F
Montreal River, described .. 67 F
Lady Evelyn Lake, " .. 68 F
Copper cliff mine, " .. 74 F
Cache Bay .... 61 G

PAGE

Conglomerate—*Con.*
Cambrian, Temiscouata Co .. 23, 25 M
Carboniferous, northern N.S. 73-85 P
New Glasgow .... 109-120 P
auriferous, Gay River .... 58 *a*
Conmee, Lake, Hunters Island, Laurentian .... 31 G
Coutchiching .... 43 G
Contact, Laurentian and Coutchiching .... 40, 55, 61 G
Laurentian and Keewatin .. 56, 61 G
Laurentian and Huronian .... 61 G
Trenton and Archæan .... 27 L
Loraine and Sillery .... 43 L
Devonian and Triassic .... 70, 142 P
Silurian and Carboniferous .. 87 P
Devonian and Carboniferous. 91, 99 P
Carboniferous and Permian . 110 P
Cookeite, Wait-a-bit Creek .... 67 R
Cook's Brook, N.S., Devonian .. 62 P
Cope, Prof. E. D., obligations to. 5 *a*
work by .... 72 *a*
Copper, statistics 6, 7, 8, 53 s, 4, 5, 6, 65 ss
mining .... 51 s, 66 ss
and nickel, Sudbury district. 46 F
mines, Eastern Townships .. 46 A
native, Minas Basin .... 186 P
ores, northern N.S .... 185 P
Copper Creek, B.C., silver ore, assay .... 55 R
Copper Cliff, O., roasting yard .. 132 S
smelting .... 135 S
copper and nickel mine, output .... 51 F
ore (fig.) .... 48 F
gabbro, described .... 60 F
felsites, " .... 61, 64 F
gneiss, " .... 67 F
conglomerate, described .. 69 F
chlorite schist, " .. 69 F
arkose, " .. 74 F
Copperas, imports .... 8 s, 6 ss
Cormorants, Lake Manitoba .... 44 E
Cormorant Islands, Lake Winnipegosis .... 66, 170 E
Cornwall's, Thompson River, quartzite, assays .... 60 R
Correspondence .... 92 *a*
Corrimony, N.S., igneous rocks .. 148 P
Corunna, O., boring .... 67 Q
Courtright, O., boring .... 68 Q
Coutchiching Lake, O., wolframite .... 21 R
Coutchiching series, Hunters Island region .... 17, 39-55 G
thickness of .... 50 G
rocks, character of .... 47 G
eroded by glaciers .... 72 G
Coxheath, N.S., copper mining 52 s, 66 ss
Cranberry Lake, N.S. .... 166 P
Crane River, Lake Manitoba .... 43 E
Crane River Narrows, Lake Manitoba .... 42 E
Creighton, O .... 24, 53, 54 F
pyrite, blende .... 51 F
ore, assay .... 53 F
pyrrhotite, analysis .... 44 R
Cretaceous, shales, Lion Lake .. 41 D

PAGE

Cretaceous—*Con.*
section Athabasca River.... 25 A
Buffalo Head Hills. ..... 44 D
Peace Athabaska region.... 52 D
Swan River.....108, 110 E
formation, Ma....144, 199, 209-215 E
Crimore Manganese Co., N.B., analysis.:..... 96 S
Croix, Lac la, Rainy River, Coutchiching.....41, 48, 53 G
Crooked Rapid, Arthabasca Piver 32 D
Cross Brook, N.S., igneous rocks 12 P
Devonian ... . 36 P
Cross Lake, Saskatchewan River 151 E
Cross Lake Rapids, Saskatchewan River..... ... 150, 202 E
Crow's Nest Pass, coalfield. ...14*a*, 61 SS
Crowe Brook, N.S., Carboniferous..... . .. . 85 P
Cruikshanks, J. M., work by ..62 A, 59 *a*
Crystalline rocks derived from clastics... ..... 57 F
Cullen's, N.S., Devonian..... 19 P
Cumberland county, N.S., work in..... ..... 52 *a*
coal..... . . . . 31 SS
Cumberland's Brook, N.S., Devonian..... ... . 63 P
Carboniferous..... 84 P
Cunard Swamp, N.S., gypsum land..... .... 94 P
Cunningham, G. C., work in the North-west (1874). ..... 18 E
Currie, Rev. H., work by..... 77 A
Cut-bank River, Lake Claire ... 21 A
Cypress Lake, Hunters Island .. 10, 63 G
Cyrtographus..... ..... 15 P

Dakota age of tar sands..... ... 58 D
Dakota formation, north-western Ma..... .. .. .190, 209 E
fossils... . ..... 209 E
sandstone, Kettle Hill..... 76 E
Vermilion River..... 87 E
Swan River..... ..... 110, 113 E
Red Deer River..... 125 E
Dawson Bay..... .... 184 E
Dalhousie, Mount, N.S., Devonian..... 55 P
Dana, Prof. J. D., on origin of petroleum..... 20 Q
Danaite, Graham, analysis..... 19 R
Dancing Bill Creek, B.C., gold mining .... 67 S
Danville, Q., asbestus..... . ... 21, 26 S
Darkey Lake, Hunters Island, Laurentian..... ..... 22, 35 G
Coutchiching..... .. . 42 G
Darkey Lake route..... .... 16 G
Darling, O., ores, assays..... 51 R
Dauphin, old Fort, Lake Dauphin..... ..... 70 E
Dauphin, Lake, Mossy River... 69-73 E
Dauphin Road, Ma. .... 35 A
David Lake, Rainy River. ..... 40 G
Davis Point, Lake Manitoba....41, 195 E
Dawn, O., borings.. ... . 66 Q

PAGE

Dawson, Dr. G. M., work by..16 A, 16 *a*
Dawson, S. J., in the North-west (1858)..... ..... 14 E
Dawson, Sir W., work by..... 11 E
Dawson Bay, Lake Winnipegosis..... .. ..59, 172-186 E
saline springs, water, anal.. 26-29 R
Dawson route, *via* Rainy Lake.. 15 G
Deadman's Point, Sananagons Lake .... 58, 65 G
Debert River, N.S., Devonian.. 29 P
Carboniferous..... .. 80, 98 P
Triassic .... 143 P
igneous rocks. ..... 157 P
coal .... 171 P
Deeks, W. E., work by. .. 45, 48 A, 35 *a*
De Geer, Baron G., work by ... 49 *a*
Deloraine, Ma., artesian well boring..... .. .. 9 A, 7 *a*
Delphi, O., boring.. ..... 29 Q
Delta, ancient, Valley River.... 93 E
Swan River .... 114 E
Rolling River..... 117 E
Red Deer River..... .... 123 E
Demi-charge Rapids, Saskatchewan River..... ..... 151 E
Denbigh, O., graphite..... 67 R
Denison, O., copper pyrite..... 51 F
pyrrhotite, analysis..... 53 F, 42 R
gersdorffite, " . ..... 22, 45 R
nickel ores, " .... 44 R
niccolite, " ..... 45 R
Deposits, delta, Athabasca .... 61 D
superficial, north of lower St. Lawrence .... 47 L
in ancient valleys.. ..... . 52 L
Dereham, O., boring .....* 45 Q
Deschambault, Q., spur of gneiss. 15 L
Cambro-Silurian anticline... 29 L
Trenton..... 35 L
Deseronto, O., boring for gas ... 24 Q
Devil's Point, L. Winnipegosis..65, 170 E
Devil's River, Q..... 36, 39 *a*
Devonian, limestone, Athabasca River .....33, 35, 51 D
Red River..... 42 D
Peace River..... 45 D
Vermilion River..... 83 E
dolomite, Lake Winnipegosis 158 E
first recorded in Manitoba.. 163 E
formations, northern Manitoba.....199, 204 209 E
fossils, northern Manitoba .205-209 E
northern N.S.....6, 17-73 P
middle.... . . .. 18-34 P
upper..... ..... . 34-73 P
on Cobequid Bay..... .... 54 *a*
Diabase, grey belt, Windy Lake. 38, 44 F
belts, Sudbury district.....42 A, 44 F
olivine, Spanish River, described..... 78 F
Bruce Mine, described..... 79 F
Nashvak, " (fig.).. 79 F
connection of, with ore bodies 127 S
Diligence River, N.S., Carboniferous. ..... 99 P
igneous rocks ..... 166 P
Diorite, Stobie mine, described.. 70 F
masses, Sudbury district.43 A, 16, 43 F

	PAGE
Diorites, changes in, Sudbury district	46 F
Distillation, theory of origin of hydrocarbons by primary	14 Q
by secondary	17 Q
Ditton, Q., gold mining	64 S
Dolomite, Lake Winnipegosis	154–160, 169–176 E
vesicular	156, 157 E
oolitic	157 E
Lake Wahnapitæ	14 F
Spanish River	31 F
Geneva Lake	40 F
northern N.S., analysis	188 P
Douglas, N.S., manganese ore (analysis)	98 S
Dowling, D. B., work by	26 A, 23 *a*, 5 E
Drain tiles, statistics	197 S, 195 SS
Dresden, O., boring	73 Q
Drift, Pleistocene, Bell River	120 E
northern N.S.	144 P
Drifting River, Valley River	95, 98 E
"Drilling-rig," cost of	89 Q
Drug Brook, N.S., limonite	177 P
"Drumlins," Lake Winnipegosis	67 E
Swan River	76 E
Assiniboine River	137 E
Drury, O., pyrrhotite	42 R
ore, assay	52 R
Dryden, O., fibrolite	68 R
Dublin, O., boring	60 Q
Duck Bay, Lake Winnipegosis	67 E
Duck Lake, B.C., ore, assay	58 R
Duck Mountain, Ma.	104, 126 E
Duck River, South, Ma	103 E
Duck River, North, Ma	105 E
Du Loup River, Q.	43 *a*, 22 M
Dunbar, N.S., limestone	188 P
Dundas, O., boring	31 Q
Dunvegan, Peace River	50 D
Dunvegan sandstone beds, Dunvegan	50, 54 D
Durham, N.S., Permian	113, 126 P
Dyke, Elbow of Spanish River	31 F
Moncrieff	40 F
bifurcated, Hunters Island	62, 70 G
petroleum in, Tar Point	12 Q
Dykeland, northern N.S.	168 P
Eagle Creek, Toad Mtn., gold mining	70 S
Eagle River, Sicamous, freibergite	65 R
Earltown, N.S., Silurian	13, 16 P
Devonian	42, 58 P
igneous rocks	153 P
Earltown, North, Permian	117 P
Earthenware, imports	8 S, 6, 197 SS
East Bay, Cape Breton	70 R
East Brook, Stewiacke River, Carboniferous	93 P
East Wellington, colliery, B.C.	48S, 56, 61SS
Eastern Townships, Q., work in	44 A
Eaton, D.I. V., work by	58 A, 52, 59 *a*, 3 P
Eckstall Inlet, B.C., pyrite	67 R
Economic geology, Athabasca region	62 D
Hunters Island region	74 G
Economic minerals, north-western Ma	24, 219 E
Sudbury district	46 F
north of lower St. Lawrence	67 L
northern N.S	170 P
Economy Falls, N.S., Devonian	68 P
Economy River, N.S., Devonian	66 P
west branch of, section	66 P
igneous rocks	159 P
Eden Mills, O., boring	43 Q
Edison Electric Co., on mica	104 S
Edith Lake, O	16 F
Edmonton, Al., native platinum	65 R
Edward Lake, Q., work on	50 A
Edward's Creek, Ochre River	83 E
Edward's Creek, Thompson River, granite, assay	59 R
Eight Mile Brook, N.S., Permian	126 P
Elevations. *See* Altitudes.	
Elgin, N.S., Devonian	48 P
Elk River, B.C.	15 *a*
Ella Lake, Vermilion River	26 F
Ells, Dr. R. W., work by	44 A, 35 *a*
referred to	5, 13 N
on asbestus mines	19 S
Elm Point, Lake Manitoba	193 E
Elmfield, N.S., Permian	113 P
Elmsdale, N.S., Carboniferous	98 P
Emerald Lake, Hunters Island	62 G
Emery, statistics	8, 10 S, 6, 9 SS
English River, Wanipigow R.	21 A
Entomological collection, additions to	80 A
work on	5 A
Erin, O., boring	43 Q
Erosion, Post-Cretaceous, Ma	215 E
lake basins formed by	67 G
by glaciers	72 G
Erythrite, Prince's mine	48 R
Essex Centre, O., borings	82 Q
Essex county, O., natural gas.	120 S, 106 SS
petroleum	122 SS
Ethnological collection, additions to	77 A, 81–84 *a*
Etoimami River, north, Red Deer River	123 E
Euphemia, O., borings	66 Q
Evans mine, Sudbury, output	51 F
Expenditure	86 A, 92 *a*
Explorations in 1890	8–62 A
in 1891	6–60 A
Exports, table of, for 1890	7 S
for 1891	5 SS
destination of, 1890	8 S
Fairbank, O.	24 F
Fairford mission, Fairford River	41 E
Fairford River, Lake St. Martin	40 E
Fall Brook, N.S., Carboniferous	85 P
Faribault, E. R., work by	61 A, 55 *a*
Faribault, P. A., work by	62 A
Farnham, Q., age of black limestone	45 A
Farnham's Brook, N.S., Triassic	142 P
pyrolusite	184 P
Farquier Lake, Hunters Island, Laurentian	32, 33 G
hornblendic rock	69 G

	PAGE
Fault, Wahnapitæ River	14 F
Faults in coal measures, N.S.	106 P
Faulting, Cambro-Silurian, Eastern Townships.	28 L
Favell River, Swan River	112, 117 E
Felsite, Sudbury, described	61, 79 F
Copper Cliff mine, "	61, 64 F
Lady Evelyn Lake, "	65 F
Rabbit Lake, "	66 F
Felspar, production	6, 111 S, 4, 98 SS
in schists, Hunters Island	48 G
Felspars, analyses of	24 L
Fergusson Brook, N.S., igneous rocks.	154 P
Ferrier, W. F., work by	70 A 73 *a*
on glauconitic rock from Athabasca River	57 D
on rocks from Q.	73-82 L
Fertilizers, statistics	6, 7, 8 S, 6 SS
Fibrolite, Dryden	68 R
Field, B.C., silver and copper	12 A
silver mining	177 S
Fifteen-mile Stream, N.S., gold mining	59 S
Findlay, Ohio, natural gas, composition of.	6 Q
Fir River, Red Deer River	123 E
Fire clay, production	6 S, 4 SS
Fishes, Canadian, catalogue of, in preparation	86 *a*
Fish Creek, B.C., silver mining.	171 S
Fisher River, Lake Winnipeg	24 *a*
Fishpools, N.S., Devonian	46 P
Five Islands, N.S., Devonian	69 P
baryte	192 P
Five Mile woods, Swan River	113 E
Flagstones, statistics.	6, 8, 189 S, 4, 6, 188 SS
Flamborough, O., boring	30 Q
Fletcher, H., work by	58 A, 52 *a*
report by	1-193 P
Fletcher, J., report by	79 A
obligations to	5 *a*
Fleming, J., in the North-west (1858)	15 E
Folds of Coutchiching series	51 G
of Coutchiching and Keewatin	54, 59 G
Cambro-Silurian, eastern Q.	28 L
overturned, Temiscouata Co.	21, 24 M
Foliation of granite	25 G
Folly Lake, N.S., Devonian	61 P
Folly River, N.S., Devonian	31 P
Carboniferous	82 P
Foraminifera, Niobrara	211 E
Forests, Albert and Kent, N.B.	51 *a*
Forest fires, Hunters Island	12 G
Kent, N.B	
Forks, the, Athabasca River	33 D
Fork Creek, Mossy River	74, 96, 99 E
Formations, geological, north-western Ma.	144 E
table of	199 E
northern N.S.	7 P
Forts, old, Red Deer River	125 E
Fort Island, Cedar Lake	152 E
Forty-nine Creek, B.C., ore, assay	58 R
Fossils added to museum	74 A, 82-85 *a*
collections of, supplied	74 A, 79 *a*
Pierre, Athabasca River	28 D
Fossils—*Con.*	
Benton, Burnt Rapids	31 D
Devonian, Athabasca River.	35 D
Pembina River	39 D
Vermilion Falls	45 D
Fox Hill, Lesser Slave Lake	40 D
Wabiscaw River	41 D
Cretaceous, Loon River	41 D
Peace River.	46 D
Peace River sandstone	47 D
Montana, Athabasca River.	54 D
Colorado, Athabasca district	58 D
Pleistocene, Rolling River.	116, 217 E
Post-Tertiary, Shell River	130 E
Pierre, north-western Ma	213 E
Bell River	120 E
Millwood	141 E
Niobrara, north-western Ma.	211 E
Vermilion River	87, 89 E
Wilson River	90 E
Valley River.	94 E
North Pine River	102 E
South Duck River	104 E
Swan River	107, 108 E
Rolling River	112 E
Dakota, north-western Ma.	209 E
Swan River	113 E
Manitoban, north-western Ma.	205 E
Lake Winnipegosis	159-172 E
Dawson Bay	176, 177, 181-183 E
Red Deer River	187, 188 E
Swan River	190 E
Lake Manitoba	192, 194, 198 E
Winnipegosan, north-western Ma.	204 E
Lake Winnipegosis	161-170 E
Dawson Bay	173-186 E
Lake Manitoba	191-193, 196 E
Niagara, north-western Ma.	202 E
Saskatchewan River	147-153 E
Lake Winnipegosis	153-158 E
Trenton, Ste. Anne de la Pérade	34 L
St. Alban.	34, 35 L
Pointe aux Trembles.	36 L
St. Charles River.	37 L
Beauport	38 L
Montmorency Falls	40 L
Loraine, Pointe aux Trembles	43 L
Ste. Anne Montmorency.	46 L
Postpliocene, Quebec	56 L
Cambrian, Mount Wissick.	15 M
Silurian, River Philip	15 P
Devonian, plants, Stewiacke River	22 P
McCulloch's Brook	53 P
Harrington River	69 P
Ishgonish	27 P
foot prints, Debert River	30 P
Carboniferous, Brookfield	94 P
Foster, O	35 F
Foster's Bar, Fraser River, ore, assay	59 R
Fountain Creek, B.C., quartzite, assay	62 R
Four Mile Brook, N.S., Permian	126 P
igneous rocks	155 P
Foxbrook, N.S., Millstone Grit.	103 P

	PAGE
Fraser River, B.C.	17 A
rocks, assays	59-64 R
Freibergite, Eagle River	65 R
French River, N.S., Silurian	11 P
Permian, section	129 P
red hematite	181 P
Fuller's earth, imports	8 S, 6 SS
Fungi, Canadian, catalogue prepared	85 *a*
Gabbro, uralitic, Copper Cliff mine, described	30 F
altered, Vermilion mine, described	73 E
hyperstene, Blezard mine, described	77 F
family subdivision of	73 L
Gairloch, N.S., mineral water	1 9 P
Galena, Mosquito Creek	18 *a*
Granite Creek	8 *a*
northern N.S.	186 P
Game, north-western Ma.	24 E
Garden Island, Lake Manitoba	42 E
Gardner coal mine, N. S	39 S S
Garnets, Lansdowne, B.C.	18 *a*
Sturgeon Lake	20 G
Charlevoix county	49 A
Garthby, Q., ore, assay	50 R
Gas, natural	117 S, 102 S S
Peace River	59 D
Athabasca River	25 A, 64 D
report on, in O	1-94 Q
well borings, O	64 A
St. Hyacinthe	65 A, 7 *a*
Gaspé Basin, Q., petroleum	123 S S
Gay's River, N.S., gold	58 *a*, 145 S S
Geneva Lake, O	39 F
Geological Survey, act relating to	3 A
staff insufficient	7 A
usefulness of	3 *a*
Gersdorffite, Denison, analysis	22 R
Gibson Lake, Vermilion Lake	21 F
Giroux, N. J., work by	44, 48 A, 40 *a*
Glacial deposits, Athabasca River	36, 59 D
Peace River	62 D
Glacial phenomena, Spanish River	35 A
Glacial striæ, north-western Ma.	216 E
Swan Lake	76 E
Lake Manitoba	194, 198 E
Assiniboine River	29 A
Stonewall	25 A
Hunters Island	72 G
north of lower St. Lawrence.	48 L
Kent, N.B.	53 A
northern N. S.	145 P
Glaciation, Hunters Island	71 G
isthmus of Chignecto	49 *a*
Glacier, Great, movement of, Athabasca	36, 59 D
Glaciers, ancient, Q.	42 L
Glacier Lake, Hunters Island	56 G
Gladstone, B.C., silver mine	170 S
Glass and glassware, statistics	6, 7, 8, 111 S, 6 S S
Glauconitic bed, Athabasca River	57 D
Glen Hart, B.C., ore, assay	61 R
Glencoe, O., boring	51 Q
Glencoe Brook, N.S., Silurian	10, 11 P
Glengarry, N.S., Devonian	48 P
igneous rocks	58 P
bog manganese	183 P
Gloucester county, N.B., iron ore	56 A
Gneiss, derived from granite or arkose	56 F
Gneiss, Lake Winnipeg	35 A
Sudbury trough	42 A
Hyman	33, 45 F
Copper Cliff mine, described	67 F
biotite, Stobie mine, described	68 F
"augen," Hyman, described	71 F
north of lower St. Lawrence.	8-26 L
as building stone	70 L
augen, Ste. Marie	16, 19, 20 L
hornblende, J. Cartier River, examined	74 L
mica, examined	76, 79, 80 L
biotite, examined	79 L
iron bearing, Lake Edward	50 A
quarried	51 A
Goat Cave silver mine, B.C.	170 S
Goat River, B.C., silver mines	175 S
Goderich, O., borings	53 Q
salt (analysis)	162 S
Gold, statistics	6, 7, 54 S, 4, 5, 135 SS
mining	58 S
and silver assays	48 R
Peace River	62 D
probable, Hunters Island	75 G
Sudbury, district	58 F
Joliette, Q.	43 *a*
search for, northern N.S.	187 P
Gold field, Shelburne, N. S.	8 A
reported, Brookfield, N.S.	61 A
Gold Hill, B.C., gold mining	14 A, 70 S
silver mines	70 S
silver ore, assay	58 R
Goldmine Brook, N.S., Carboniferous	76 P
Goose Islands, L. Winnipegosis	156 E
Gordon's summit, N.S., Devonian	38 P
Gorry's Mill, Ste. Anne River	15 L
Gosfield, O., borings	82 Q
Gosfield South, O., natural gas	107 SS
Gosford, Q., gneisses	12 L
infusorial earth	71 L
Goufre River, Q.	48 A
peat	51 A
Gowland Mountain, N.B., manganese	95 S, 92 SS
Gowrie coal mines, N.S.	41 SS
Graham, O., danaite, analysis	19 R
arsenopyrite, analysis	45 R
Grand Island, L. Winnipegosis	156 E
Grand Rapids, Athabasca River	23, 29 D
Grand Rapids sandstone	29, 30, 57 D
Grand Rapids, Wabiscaw River	12 D
Grand Rapid, Saskatchewan River	31 A, 80, 148, 200 E
section of Pleistocene (fig.)	146 E
Granite production	6, 186 S, 4, 187 SS
Lake Wahnipitæ, described	59 F
L. Temiscaming, "	62 F
Stobie mine, "	70 F
Murray mine, "	77 F
Levack, "	78 F

PAGE

Granite—*Con.*
Hunters Island ..... 19-30 G
hornblende ..... 30-33 G
bedded structure of..... 37 G
dike (fig.)..... 62 G
structure in gneiss..... 19 L
Granite Creek, B.C., galena assay 80 *a*
Grant's house, Assiniboine River 137 E
Grant's Brook, N. S., Cambro-Silurian..... 9 P
Silurian ..... 13 P
Granulite and asbestus, connection of ..... 15 SS
Graphite, statistics..6, 8, 72 S, 4, 6, 71 SS
Graphite, Denbigh, O..... 67 R
northern N.S. ..... 192 P
Gravel islands of Lake Winnipegosis ..... 61 E
Gravel ridges. *See* Ridges.
Gravel pits, south-eastern N.B.. 52 *a*
"Great Meadows," Swan River. 115 E
Great Village River, N.S., Devonian. ..... 34, 61 P
Carboniferous..... 83 P
Green Hill, N.S., Devonian..... 52 P
Permian ..... 112 P
Greenfield Brook, N.S., Devonian 44 P
Greenstone, meaning attached to the name..... 10 F
Blue Water River..... 30 F
Sudbury district..... 43 F
copper and nickel in..... 46, 50 F
altered, Vermilion mine, described. ..... 62 F
Greenstones, Sananagons Lake.. 64 G
Greenville, N.S., Permian..... 120 P
Greenwater Lake, O ..... 27 *a*
Greywacke, Huronian, Sudbury district..... 41, 45 F
on C. P. R. (fig.) described.. 64 F
Grindstones, statistics..6, 7, 8, 11 S, 4-8 SS
northern N.S. ..... 191 P
Grit, Silurian, northern N.S.... 11 P
Grondines, Q., swamps..... 66 L
Guérin, T., work by (1881) .. 18 E
Gwillim, J. C,, work by..... 19 *a*
Gypsum, statistics..6, 7, 8, 76 S, 4, 5, 6, 75 SS
Athabasca district..... 64 D
north-western Ma..... 229 E
northern N.S. ..... 189 P
Bridgeville. ..... 87 P
Gypsum land, broken, Cunard swamp..... 94 P

Haldimand county, O., natural gas. ..... 106 SS
Halfmoon Millbrook, N.S., Devonian. ..... 45 P
Triassic..... 142 P
Haliburton Creek, N.S., Permian 124 P
Halifax county, N.S., work in.. 56 *a*
Hall silver mine, B.C..... 173 S
"Hälleflinta," rock like..... 24 F
Hallowell Grant, N.S., coal..... 173 P
Hamilton, O., borings..... 30 Q
Hardwood Hill, N.S., Permian.. 128 P
Harmon, D. W., in the North-west (1800). ..... 13 E

PAGE

Harmotome, Beaver mine, anal.. 16 R
Harrington, Prof. B. J., on chemawinite..... 225 E
Harrington, O., boring ..... 48 Q
Harrington River, N.S., Devonian 69 P
igneous rocks..... 161 P
west branch of..... 162 P
Harrowby, Ma. ..... 142 E
Harwich, O., boring ..... 74 Q
Heart Hill, Rolling River..... 116 E
Heart River, Lesser Slave Lake. 18 D
Hector, Dr. J., referred to ..... 8 G
Heldelberg, Lower, formation, northern N.S. ..... 15 P
Hematite, analyses..... 39 R
north of lower St. Lawrence. 67 L
northern N.S ..... 181 P
Heming's Brook, N.S., Devonian 72 P
Hendry's silver mines, B.C..... 174 S
Henry, Alex., in the North-west (1800)..... 13 E
Hensall, O., boring..... 58 Q
Herbarium, additions to. ... .81 A, 88 *a*
Herdt, H. D., work by..... 73 *a*
Heulandite in apatite. ..... 69 R
Higgin's Brook, N.S., Permian.. 119 P
High Rock, Q., phosphate belt.. 155 S
Highland Creek, O., boring for gas ..... 24 Q
Hill Island, Lake Winnipegosis.51, 169 E
Hillsboro, N.B., road ..... 96 S
Hind, Prof. H. Y., work in the North-west (1858)..... 15 E
referred to. ..... 9 G
Hoffmann, G. C., work by.....66 A, 64 A
report by ..... 1-72 R
analyses ..... .222, 228 E
quoted ..... 223 E
Hopewell, N.S., Devonian ..... 47 P
Carboniferous ..... 104 P
search for coal..... 174 P
Horeb, Mount, N. S., Cambro-Silurian..... 9 P
Silurian ..... 11 P
Hornblende, quartziferous, Sudbury district ..... 44 F
in gneiss..... 10 L
Horse-shoe Harbour, Lake Manitoba..... 39 E
Hot Springs silver mine, B.C.... 173 S
Howard, O., boring ..... 75 Q
Hugh's Brook, N.S, Devonian .. 51 P
Hulbert Lake, Hunters Island.. 11 G
hornblende granite..... 31 G
Hulbert Lake route ..... 29 G
Humberstone, O., petroleum.... 122 SS
Hunt, Dr. T. F., on nickeliferous rocks, Sudbury district.. 47 F
quoted ..... .23 L, 14 27 Q
Hunters Island, O., report on .. 1-76 G
boundaries of ..... 6 G
Laurentian area.....18, 25-33 G
Huntsman, B.A.L., work by....58 A, 3 P
Huron, Lake, work north of .... 33 *a*
Huronian, ores in .....126, 142 S
north of Lake Huron . ... 33 A
Sudbury..... .. 43 A, 11, 45 F
Vermilion River ..... 24 F
Wahnapitæ River..... 14 F

	PAGE
Huronian—*Con.*	
rock, volcanic nature of	41 F
Hybla, O., ore, assay	51 R
Hydrocarbons, on formation of	10 Q
Hyman, O	33 F
augen gneiss, described	71 F
Ice on Lake Manitoba	36 E
on Lake Winnipegosis	47 E
Ice action, ancient, north of lower St. Lawrence	47 L
Ice-ground shore, Lake Winnipegosis	63 E
Ice pressure, boulder pavements result of	28 A, 139 E
Ice shoving, Lake Manitoba	42, 44 E
L. Winnipegosis	53, 64, 65, 152, 175 E
Igneous rocks, associated with Cambro Silurian, N.S	8, 147 P
Devonian	149–166 P
Post-Carboniferous	166 P
Illecillewaet, B.C., silver mining	14 A, 169 S
Ilmenite, Château Richer	67 L
Ilvaite, Barclay Sound (analysis)	11 R
Imports, tables of	8 S, 6, SS
Inclusions in granite (fig.)	29 G
in mica	69 R
Indians, farming, Fisher River	24 *a*
Indian village, Angling Lakes	7, 128 E
Wilson River	91 E
Fork River	96 E
Indian geographical names, Sudbury district	91 F
Indian Fields, N.S., goldfield	8 A, 63 S
Infusorial earth, Loon Lake, examined	20 R
Laval and Gosford, Q	71 L
northern N.S	196 P
Ingall, E. D., work by	62 A, 60 *a*
reports by	1 201 S, 1–200 SS
Interbanded structure of gneiss and schists	61 G
International coal mine, N.S	42 SS
Inverhuron, O., boring	58 Q
Iron, native, St. Joseph Island, analysis	12 R
and jasper in greenstone	63 G
pig, statistics	6, 88 S, 86 SS
and steel, statistics	7, 8, 88 S, 5, 6, 87 SS
ore, statistics	6, 81 S, 4, 5, 6, 78, 87 SS
discovery and mining	82 S, 79 SS
analyses	38 R
Hunters Island	68, 75 G
Mattawin River	27 *a*
Big Turtle River	29 *a*
N. of lower St. Lawrence	67 L
titanic, St. Urbain	49 A
hematite, L. Comnissaires	51 A
bog, Joliette	43 *a*
titanic, St. Maurice River	47 *a*
bog, Three Rivers	47 *a*
Gloucester county, N.B	56 A
Buctouche Harbour	53 *a*
mines, northern, N.S	12 P
deposits, northern, N.S	175 P
magnetic, Cobequid Bay district	54 *a*

	PAGE
Iron ore—*Con.*	
Grant's Brook	9 P
specular, John McDonald's	35 P
Salmon River	42 P
Cook's Brook	63 P
limonite, North River	56 P
Clifton	95 P
hematite, Newton Mills	92 P
Londonderry, analyses	179 P
carbonate of, nodules	228 E
pyrites, Athabasca River	27 D
stone, clay, Peace River	63 D
Irwin Lake, N.S., Carboniferous	95 P
Ishgonish, N.S	27 P
Island Mountain Co., B.C., gold mining	69 S
Island Portage, Wahnapitæ River	14 F
Jacko River, Q., gneisses	12 L
swamps	66 L
Jacques Cartier River, Q	16 L
gneiss	17 L
examination of	76 L
anticline	29 L
Trenton	35 L
Loraine	42 L
marine terraces	62 L
river terraces	65 L
swamps	67 L
Jamesonite, Spilimichine River	65 R
Jasper and iron in greenstone	63 G
Jasper Lake, Hunters Island	63 G
Joggins coal mines, N.S	36 P
John River, N.S., west branch, Permian (section)	114 P
igneous rocks	166 P
baryte	191 P
east branch, Permian	128 P
Johnny's Brook, N.S., Devonian	40 P
Johnston, J. F. E., work by	39 *a*
Johnston, R. A. A., work by	16 A, 66 *a*, 3 R
Jointing planes in granite	26 G
Joli Fou, Rapide du, Athabasca River	22 D
Joliette Co., Q., iron deposits	43 *a*, 82 SS
Jones, Prof. T. R., work by	72 A, 76 *a*, 11 E
obligations to	5 *a*
Jordan Mountain, B.C., manganese	94 A, 92 *a*
Jubilee Mountain, B.C., silver mining	180 S
Kahnipiminanikok Lake, Hunters Island	11, 13 G
Laurentian	26, 29, 32 G
Coutchiching	44 G
mica schist	49 G
hornblende rock	70 G
diabase dike	70 G
Kame, Pictou	144 P
Kames, Valley River	92 E
North Pine River (section)	103 E
north of Lower St. Lawrence	53 L
Kamloops, B.C., progress of work in	16 A
coal	18 A

PAGE

Kashapiwigamak Lake, Hunters Island..... 11, 28 G
Kashapiwigamak Lake route.... 16 G
Kawagansikok Laurentian area 18,19-21 G
Kawawakashkigama River, Vermilion River .. ... . 22 F
Kawawiagamak River, Kahuipiminanikok Lake..... 15 G
Coutchiching mica schists... 49 G
Keefer Lake, Hunters Island ... 11 G
Keefer Lake route..... ... 28 G
Keewatin series, Hunters Island 17, 56-70 G
age of Saganaga granite..... 37 G
character of rocks. . . .... 62 G
thickness of..... ... . 67 G
rocks, Seine River.. .. . .. 39 A
Keithley Creek, B.C., gold. .. . 66 S
Kelly's Rapids, Ste. Anne River 14 L
Kematch River, Porcupine Mtn. 118 E
Kemptown, N.S., coal..... .... 170 P
Kemptown, Upper, N. S., Devonian..... . .... 43 P
limonite.... .....43, 177 P
Kennetcook River, N. S., Carboniferous..... 97 P
coal ....97, 172 P
Kent county, O., natural gas, borings..... .... 119 S
Kent, county of, N.B., work in 53 A, 48 *a*
Kenyon, O., spring water, anal.. 25 R
Kettle Fall, Spanish River .... 34 F
Kettle Hill, Swan Lake..... 75 E
terraces (fig.)... ... . 218 E
Kidney Lake, Trout Mountain.. 21 D
Kincardine, O., survey.. ..... 44 A
borings..... ..... 59 Q
Kindberg, Dr. N. C., obligations to .. .. 5 *a*
King's county, N.B., work in.... 62 *a*
Kingstone's Mills, O., boring... 64 Q
Kingsville, O., borings.... .... 76 Q
natural gas..... ..... 120 S
Kirkhill, N.S., coal. .. .. 172 P
Kirkpatrick, A. T., work by.... 16 A
Klein, L. A., on asbestus industry..... .... 12 SS
Koogaming Lake, O..... .... 16 F
Kootanie, B.C., mining district. 15 A
East, silver mines.... .... 176 S
gold... .... 167 SS
gold and silver assays . .. 55 R
West, gold.... ..... 161 SS
gold and silver assays..... 57 R
South, petroleum. . ...143 S, 125 SS
Kootanie Lake, hot spring, water, analysis ... ... 24 R
quartz, assay.. ..... 58 R

La Biche shales ..... 57 D
Athabasca River.. .....27, 53, 57 D
Moose River..... ..... 36 D
Laboratory, progress of work in. 66 A, 64 *a*
La Cloche Mountain, O..... 34 *a*, 13 F
Lachute, Q..... ..... 37 *a*
Lacustral plain, north-western Ma.....22, 34-81 E

PAGE

Lady Evelyn Lake, O., felsite, described.... . ... 65 F
arkose, described.... . .... 68 F
dark rock, described..... 69 F
Laflamme, Abbé J. A. K., work by.. .....48 A, 44 *a*
Lake basin, origin of, Onaping L. 37 F
Lake basins, formed by erosion.. 67 G
Lakes, Athabasca.. ..... 7 D
Manitou route ... . 37 A
Lambe, L. M., work by .29, 36, 73A, 80, 85*a*
Lambton, O., petroleum..... 5 Q
Lanark silver mine, B.C.. .... 169 S
Langenburg, Ma... ..... 142 E
Lansdowne, N. S., Devonian.... 37 P
Laramie, Athabasca..... 7 D
Larchwood, O ..... 23 F
Lardeau River country, B.C., silver ores (assays)..... 171 S
Larix Churchbridgensis..... 143 E
L'Assomption River, Q..... . 40 *a*
Laurentian, Athabasca .. .... 50 D
Hunters Island.... ..... 17-38 G
Lake Huron ..... 32 *a*
Sudbury district..... .... 11 F
Argenteuil..... .... 37 *a*
North of Montreal..... ... 40 *a*
Temiscouata county.. .... 25 M
Laurentides, the, Q., gold in... 65 S
Laval, Q., infusorial earth..... 71 L
Lawson, W., work by.....39 A, 28 *a*, 5 G
Lazulite, Lake Mistassini region. 66 R
Lead, statistics.....6, 8, 90 S, 4, 6, 88 SS
Sudbury district..... 53 F
mine, Pembroke, N.S ..... 92 P
ore, northern N.S .. .. 186 P
Leamington, O., boring..... 84 Q
L'Ecureuil Cliffs, Q., Loraine .. 46 L
Lefroy, in the North-west (1844). 5 D
Lepidoptera from north of Lake Huron .... 87 F
LeRoy silver mine, B.C.... ... 175 F
L'Etête, N.B., pyrrhotite, anal.. 40 R
Levack, O..... ... . 38 F
nickel ore... .... 43 A
pyrrhotite, analysis.....53 F, 43 R
Levy River, O .... 24 F
Librarian, reports of.....85 A, 91 *a*
Lièvre, Rivière du, Q., work on. 60 *a*
Lignite, Athabasca River..... 29, 63 D
Swan River. ....111, 228 E
fragments, L. Winnipegosis. 170 E
Lillooet, B.C., gold..... 174 SS
conglomerate, assay..... 61 R
Lillooet Mountain, B.C., felsite, assay .. .. 60 R
Lime, statistics....7, 8, 192 S, 4, 5, 6, 192 SS
Limerock Brook, N.S., Permian. 127 P
Limestone for flux, production ..6 S, 4 SS
Illecillewaet..... ..... 15 A
Devonian, Red River, Ath.. 42 D
Peace River..... ..... 45 D
Athabasca River..... 51 D
Devonian, L. Manitoba.39, 191-198 E
Lake Winnipegosis...63, 158-172 E
Dawson Bay. .....176-183 E
Red Deer River... .. 187, 188 E
Swan River..... 190 E

PAGE

Limestone—*Con.*
Cretaceous, Vermilion River 87, 89 E
Swan River.....107, 108 E
Niagara, Saskatchewan River.....145-153, 200 E
buttress of broken, Dawson Bay..... 184 E
quarry, Sifton Narrows..... 191 E
Laurentian, western O..... 37 G
magnesian, Lake Panache.. 13 F
Sudbury district..... 54 F
Trenton..... 33-41 L
quarries, St. Alban..... 35 L
Cambrian, pebbles, Temiscouata..... 24 M
Laurentian, Argenteuil Co.. 38 *a*
quarry, Gray's River..... 58 *a*
Charlevoix county..... 48 A
Silurian, northern N.S..... 16 P
Devonian, " ..22, 27, 53, 55 P
crystalline, Phinney Brook.. 71 P
Carboniferous, northern N.S. 85-102 P
Permian, " ..110, 114 P
quarried, " .. 188 P
Limonite, " .. 175 P
North River..... 56 P
Clifton..... 95 P
Linière, Q., silver ore, assay ... 50 L
Listowel, O., boring..... 60 Q
Litchfield, Q., pyrite, analysis.. 114 SS
Litharge, imports.....8, 107 S, 6, 96 SS
Lithological work, progress of... 75 *a*
Lithographic stone, import..... 6 SS
Little Ditton, Q., gold district.. 55 *a*
Little Fellah claim, B.C., silver. 179 S
Little Glacé Bay, N.S., coal mine 42 SS
Little Pine Creek, Lake Winnipegosis..... 96 E
Little River du Lac, Lake Témiscouata..... 16 M
Little Sandy Point, Lake Manitoba..... 43 E
Loganville, N.S., igneous rocks. 151 P
Lomond, Loch, N.S., manganese 98 S
London, O., boring..... 49 Q
Londonderry, N.S., iron mines, Devonian..... 17, 62 P
igneous rocks..... 159 P
limonite..... 177 P
Loon Lake, B.C., tripolite, examined..... 20 R
Loon Lake, Loon River, Ath.... 21 D
Loon River, Peace River.....11, 13, 56 D
shales..... 55, 56 D
Loraine, north of lower St. Lawrence..... 41-47 L
Lorette, Q., Trenton..... 37 L
gneiss, quarried..... 71 L
Lorne, O..... 26, 35 F
pyrrhotite, analyses..... 42 R
Lorne, N.S., Devonian..... 48 P
Carboniferous..... 89 P
Louisa Lake, Hunters Island.... 57 G
Louise, O..... 26 F
Low, A. P., work by.....50 A, 45 *a*
report by..... 1-71 L
Lowe farm, Ma., wells sunk.... 10 A
Lumsden, O., pyrrhotite, analysis 41 R
Lyman, C., obligations to..... 5 *a*

PAGE

Lyman, H. H., report on Lepidoptera from north of Lake Huron..... 87 F
Lyndoch, O., boring..... 48 Q
Lynn, N.S.....161, 162 P
Lyons Brook, N.S., Permian..122, 125 P

Mabel Lake, B.C..... 17 *a*
Mabou, N.S., gypsum..... 77 S
MacDougall, R., work by..... 39 A
McKay, Prof. A. H., on tripolite 20 R
Mackenzie, Sir A., in the North-west (1792)..... 5 D
Macoun, J. M., work by.....81 A, 87 *a*
Macoun, Prof. J., work by....80 A, 83 A
in the North-west (1881).... 18 E
quoted..... 60 E
Macoun Point, L. Winnipegosis.58, 186 E
Madawaska River, N.B., Silurian 8 M
Magdalen Islands, Q., manganese ores..... 99 S
Magnetite, analyses..... 38 R
Spanish River..... 31 F
Greenwater Lake..... 27 *a*
northern N.S..... 191 P
Maidstone, O., borings..... 78 Q
Malaga gold mine, N.S..... 61 S
Malagash, N.S., Permian..... 137 P
section..... 138 P
Malbaie, Q..... 44 *a*
Malbaie River, Q..... 48 A
Malden, O., borings..... 79 Q
Maligne River, Lac la Croix.... 48 G
Manganese ore, statistics 6, 8, 10 S, 4, 90 SS
mining..... 92 S
King's county, N.B..... 62 *a*
bog, near Quebec city..... 68 L
Albert county, N.B..... 51 *a*
northern N.S..... 183 P
oxide, imports..... 6 SS
Manganite..... 93 S
Manigotagan River, Lake Winnipeg..... 21 *a*
Manitoba, origin of name..... 39, 192 E
progress of work in..... 9, 26 A, 19 *a*
north-western, report on.... 1-240 E
Manitoba escarpment..... 22 E
Manitoba House, Lake Manitoba 33, 190 E
Manitoba Island, " .. 39, 191 E
Manitoba, Lake..... 23, 34-45, 190-198 E
tributaries of..... 35 E
Manitoban formation..... 146, 199, 205 E
fossils, list of..... 205 E
Manitou Lake, Wabiscaw River. 20 D
Manitou Lake, Rainy Lake..... 37 A
Manitou, North, Island, Lake Winnipegosis..... 66 E
Manitou, South, Island, Lake Winnipegosis..... 167 E
Maps published..... 83 A, 89 *a*
of north-western Ma..... 6 E
Maple Lake, N.S., Devonian... 18 P
Maple Mountain, Montreal River, arkose, described..... 62 F
quartzite grit, described..... 66 F
Maple Leaf silver mine, B.C .. 170 S

	PAGE
Marble, statistics.. 6, 8, 185 s, 4, 6, 186 ss	
Mistassini River..	52 A
northern N.S..	191 P
Marcasite, nodules of, Lake Winnipegosis .... . . 153, 170 E	
Markhamville, N.B., manganese ore, analysis..... . 94 s, 92 ss	
Marks, C., work by.....	25 *a*
Marl, chalk, Thunder Hill... ..	108 E
Permian.....	114 P
Marlbank, O., cement.....	190 ss
Marlow, Q., scheelite . ..' ...	74 *a*
analysis.....	21 R
Marmora, O., gold mining.....	151 ss
Marshes, salt, agricultural, N.B.	50 *a*
Marshdale, N.S., Devonian.....	48 P
igneous rocks	149 P
Marten Creek, B.C., coal.....	15 *a*
Marten Mountain, Lesser Slave Lake ..... 7, 17, 27, 40, 45 D	
Marten River, Lesser Slave L...	18 D
Martin's Brook, N.S., Devonian.	65 P
Maskinongé Lake and River, Q..	42 *a*
Maskinongéwagaming Lake, O..	16 F
conglomerate, described	66 F
Massive rocks, meaning attached to the term	11 F
Mastodon giganteus	130 E
Matambin Lake and River, Q...	41 *a*
Matawatchan, O., muscovite, analysis.....	21 R
Mattagamashing Lake, O.....	15 F
Mattawin River, O...	27 *a*
Mattawin, Compagnie des mines d'or de, Q.....	43 *a*
Matthew, W. D., work by	52 *a*
McAdam's Lake, N.S., coal mine	43 ss
McBean coal seams, N.S.....	107 P
McCallum settlement, N.S., Devonian	59 P
McCharles Lake, Vermilion Riv.	19 F
McConnell, R. G., work by... 16 A, 18 *a*	
report by..	1-67 D
McCulloch's Brook, N.S., Devonian..	52 P
Millstone Grit	104 P
fault	106 P
Permian.....	112 P
McDonald, J. H., work by	53 A
McDonald's, John, Brook, N.S., Devonian.....	35 P
igneous rocks	154 P
specular iron ore	183 P
McDougall Lake, Hunters Is.... 11, 13 G	
McElman Brook, N.S., Devonian	33 P
Carboniferous	82 P
Triassic.....	143 P
igneous rocks	159 P
McEvoy, J., work by..... 16 A, 16 *a*	
McEwan Lake, Hunters Island.	32 G
Coutchiching ..... 50, 59 G	
McGregor, O., ore, assay..	54 R
McGregor's Mountain, N.S., Silurian	16 P
Devonian.....	47 P
Carboniferous...	82 P
igneous rocks	143 P
McInnes, W., work by..... 37 A, 25 *a*	
report by.....	1-28 M
McIntosh Lake, N.S., igneous rocks.....	151 P
McIntyre Lake, Hunters Island, Laurentian	27 G
Coutchiching.....	43 G
McKay, George, coal seam, N.S.	107 P
McKenzie Brook, N.S., Devonian .... 23, 45 P	
Carboniferous	90 P
McKenzie Inlet, Kahnipiminanikok Lake....	32 G
Coutchiching.....	49 G
diabase dike..	71 G
McKim, O., smaltite..	48 R
McLellan's Brook, N.S., Cambro-Silurian.....	8 P
Silurian..	16 P
Carboniferous.. ..... 85, 107 P	
McLeod, M. H., work by.....58 A, 52 *a*	
McLeod fault, N.S.	106 P
McLeod's Brook, N.S., Millstone Grit.....	104 P
coal measures.	108 P
McMillan, J., work by.....	3 P
McMurdo Creek, B.C., silver...	178 S
McNiece Lake, Hunters Island. 51, 69 G	
McTavish, O., ores, assays.....	54 R
Meadow Portage, Lake Manitoba 16, 49 E	
Medina formation, northern N.S.	11 P
Meguick, Q., gneiss quarry	51 A
Mekinak, Lake, Q.....	46 *a*
Meldona Creek, N.B., bog manganese.....	51 *a*
Mendeljeff, on origin of petroleum.	11 Q
Meldona Creek, N.B., bog manganese.	51 *a*
Mercury, imports:... . 8, 14 s, 6, 100 ss	
native, Barclay Sound.. .	65 R
Merigomish, N.S., Millstone Grit	102 P
Metacinnabarite, Read Island...	66 R
Metamorphism, phenomena of, Hunters Island	55 G
by igneous rocks, N.S ...	14 P
Metcalfe, O., boring	52 Q
Meteorological statistics ..... 26, 33 E	
Metis, Little, Q., Cambrian... .	28 M
Metis Bay, Little, Q., Cambrian	27 M
Mica, statistics.... 6, 7, 103 s, 4, 5, 93 ss	
mining....	101 S
minerals in.	69 R
Michel Creek, B.C., coal.....	13 *a*
Michipicoten Island, Lake Huron, nickel ores.....	47 R
coal mining.....	54 S
Microscopic examinations of rocks from Quebec and Montmorency counties.....	73-82 L
Middle Rapid, Athabasca River	32 D
Millbrook, N.S., Devonian.....	50 P
Permian...	119 P
Mille Lacs, Lac des, Hunters Is.	10 G
Miller, W. G., work by.... ..	31 *a*
Millerite, occurrences.	47 R
Mill-road, N.S., fault..	107 P
Millstone Grit, northern N. S. ,102-105 P	
Millstream, N.B., quartz, assay.	49 R
Millstream River, N.B., iron....	81 S
gold and silver, assays.....	148 S

	PAGE
Milton, O., boring	30 Q
Mimico, O., boring	26 Q
Minas Basin, N.S., Devonian	70 P
south shore, Carboniferous	96 P
north shore, igneous rocks	166 P
manganese ores (assay)	97 S
Mineral production, summary of	6 S, 4 SS
Mineral statistics, division of	62 A, 60A
report on	1-201 S, 1-200 SS
Minitonas Hill, Swan River	111 E
Minnedosa, Man., meteorological observations	26 E
Minudie coal mine, N.S	36 SS
Miramichi River, N.B., ochre	94 SS
Mistassini Lake, pyrrhotite, analysis	40 R
Mistassini region, lazulite	66 R
Mistassini River, marble	52 A
Mitchell, O., boring	60 Q
Molybdenite, production	4 SS
Monarch silver mine, Field	177 S
Monashee Mountain, Shuswap, gold	20 A, 72 S
pyrrhotite, analysis	47 R
Moncrief, O.	40 F
Monkman's Salt Springs, Lake Winnipegosis	69, 165, 220 E
water analysis	31 R
Montague, N.S., gold mining	56 *a*, 59 S
Montana formation, Athabasca	53 D
Montmorency, Q., contact	31 L
Montmorency county, Q., work in	1-82 L
Montmorency River, Q., gneiss	21 L
marine terraces	64 L
river terraces	65 L
Fall, down throw fault	32 L
Trenton (fossils)	40 L
Loraine (fossils)	44 L
Montreal River, O., arkose, described	67 F
Moore, O., boring	67 Q
Moose Creek, N.S.	70, 161 P
Moose Lake, Moose River, Ath.	25 D
Moose River, Athabasca River	23 A, 24, 25, 36 D
Moose River, N.S.	70, 164 P
Moraine, Valley River	92 E
Rolling River	116 E
Shell River	132 E
Moraines, north of lower St. Lawrence	53 L
Morden, Ma., well drilling	29 A
Morgan, O., pyrrhotite, analysis	43 R
Mosa, O., boring	50 Q
Mosquito Flat, North Thompson River, ores	18 *a*
Mossy Portage, eastern, Lake Winnipegosis	73, 164 E
Moulding sand, production	6, 111 S, 4 SS
Mount Albion, O., boring	32 Q
Muddy River, Loon River	13 D
Mudpout Lake, Trout River	20 D
Müller, Dr. C., obligations to	5 *a*
Munroe Point, Lake Manitoba	197 E
Murdock Lake, Hunters Island	11 G
Murphy Brook, N.S.	69, 260 P
Murray mine, Sudbury	52 F
discovery of	124 S
Murray mine—*Con.*	
ore (fig.)	49 F
roasting of	133 S
amphibolite, described	73 F
granite, described	77 F
Muscovite, Hunters Island	20 G
chromiferous, Matawatchan, analysis	21 R
Museum, additions to. *See* Collection.	
progress of work in	65 A, 66 *a*
visitors	86 A, 91 *a*
Muskeg River, Athabasca River	26, 38 D
Nachvak, Labrador, diabase, described (fig.)	79 F
pyroxenite, described (fig.)	81 F
Nairn, O.	35 F
pyrrhotite, analysis	41 R
Namakan Lake, Rainy River, Laurentian	11, 26 G
Coutchiching	39 G
Namakan River, Rainy Lake	10, 11, 15
"Nanabozhoo's snowshoe tracks"	23 F
Nanaimo, B.C., coal mining	45 S, 48, 60 SS
Napier Lake, B.C., ore, assay	61 R
Nappan River, N.S.	49 *a*
Nautilus Brookfieldi	94 P
Nauwigewauk, N.B., gold	147 SS
Neelon, O., pyrrhotite, analysis	41 S
Nelson River, Hudson Bay	33 A
New Annam, N.S., Devonian	26, 51 P
igneous rocks	156 P
New Brunswick, progress of work in	65 A, 48 *a*
ores, assays	49 R
graphite	71 SS
iron	81 SS
nickel	112 SS
silver	146 SS
New Glasgow, N.S., bore hole	109 P
New Glasgow conglomerate, N.S.	109-120 S
New Larig, N.S., Devonian	50 P
New Vancouver Coal Mining Co	49 S
Newberry, J. S., on origin of petroleum	17 Q
Newton gold mine, N.S.	62 S
Newton Mills, N.S., Carboniferous	92 P
hematite (analysis)	182 P
Niagara Falls, south, O., borings	36 Q
Niagara formation, north-western Ma	200-204 E
fossils, list of	202 E
limestone, Saskatchewan R.	145-153 E
Lake Winnipegosis	153-158 E
northern N.S.	15 P
Niccolite, Denison, analysis	45 R
Nicholson, Dr. H. A., work by	76 *a*, 11 E
obligations to	5 *a*
Nickel, statistics	6, 7, 8, 141 S, 4, 5, 6, 110 SS
mining	121 S
uses and properties	137, 142 S
imports to the United States	141 S
ores, analyses	39 R
Levack	43 A
and copper, Sudbury district	46 F
Nickel City, O., nickel mining	140 S

	PAGE
Nickeliferous rocks, Blue Water River	30 F
Spanish River	34 P
Nicola, Lower, B.C., ore, assay	59 R
Nicola Lake, B.C., rock, assay	60 R
Nicola Milling Company, silver mining	181 S
Nicola Mining Company, Kamloops	19 A
Nicola valley, B.C., coal	81 SS
Niobrara formation, north-western Ma	199, 210 E
fossils, list of	210 E
shale, Edward's Creek	84 E
Vermilion River	87 E
Wilson River	90 E
North Pine River (section)	102 E
South Duck River (section)	104 E
Armitt River	122 E
shale and limestone, Swan River	107, 112 E
Nodules, sand, in sandstones, Peace River	49 D
of marcasite, Lake Winnipegosis	57, 124 E
of chert, Lake Winnipegosis	155 E
of carbonate of iron	228 E
holding petroleum	14 Q
Noel, N.S., Triassic	143 P
Devonian	99 P
Noire, Rivière, St. John River	12 M
North fault, N.S	108 P
North River, N.S., middle branch	
Devonian	26, 56 P
upper Carboniferous	78 P
Triassic	142 P
igneous rocks	152, 156 P
coal	171 P
North Burgess, O., ore, assay	51 R
North Field coal mine, Nanaimo	46 S, 52 SS
North Gower, O., boring for oil	23 Q
North Star phosphate mine, Q	156 S
North-east Harbour, N.S., voigtite	65 R
North-west Territory, progress of work in	20 A, 18 *a*
coal mining	36 S, 44 SS
petroleum	123 SS
silver	124 SS
Northumberland county, N.B., work in	48 *a*
Norwich, O., boring	47 Q
Nova Scotia, progress of work in	8, 57 A, 52 *a*
report of work in	1-193 P
ores, assays	48 R
coal mining	36 S, 28 SS
gold mining	57 S, 137 SS
copper	66 SS
iron	79 SS
silver	140 SS
Nuttbeg, N.S., Devonian	26 P
Oak Leaf silver mine, B.C	170 S
Ochre, statistics	6, 8, 106 S, 4, 6, 93 SS
north of lower St. Lawrence	68 L
near Three Rivers	48 *a*
Ochre River, Lake Dauphin	71, 81 E
Odanah series, north-western Ma	199, 214 E
fossils, list of	214 E
shale, Edward's Creek	83 E
Vermilion River	85 E
Assiniboine River	141, 143 E
Oil. *See* Petroleum.	
Oil Springs, O., petroleum	6 Q
boring	62 Q
Okanagan, B.C., gold	178 SS
Okanagan Lake, B.C., ore, assay	59 R
Old Bridgeport coal mine, N.S	41 SS
Oldham, N.S., gold mining	60 S, 144 SS
Onaping Lake, Onaping River	36 F
Onaping River, O	36 F
vitrophyre tuff, described (fig.)	74 F
Onion Point, Lake Manitoba	43, 198 E
Onslow, East, N.S., manganese mines	184 P
Onslow, North River of, N.S., Devonian	23 P
Ontario, progress of work in	37 A, 25 *a*
ores, assays	51 R
iron	86 S, 83 SS
copper	68 SS
natural gas	102 SS
nickel	114 SS
petroleum	122 SS
silver	150 SS
Onwatin Lake, Vermilion River	18, 23 F
Opal, Savona, examined	16 R
Ord, Mr., referred to	25 M
Ore bodies, characteristic of, Sudbury	127 S
Orford, O., boring	75 Q
Orillia, O., boring	28 Q
Orleans, Island of, Q., fault	31 L
Orthoceratidæ, Trenton, of Winnipeg basin, published	75 *a*
Orton, Dr. D., on formation of hydrocarbons	13 Q
Ottawa, O., boring for gas	22 Q
Ottawa County, Q., phosphate deposits	155 S
Ottawa Islet, Hudson Bay, variolite described	80 F
Otter Rock Lake, Vermilion R	19 F
Onaquagamasis, Lake, Q., gneiss quarry	51 A
Ours, Rivière aux, Q	53 A
Overflowing River, Lake Winnipegosis	57, 124 E
Owen, Dr. D., referred to	8 G
Owen Sound, O., cement	190 SS
Owl River, Red River, Ath	16 D
Oxford, O., boring	119 S
Palæontological collection, additions to	74, 82-87 *a*
Palæontology, contributions to Canadian, published	70 A, 75 *a*
Palæozoic rocks of O	5 Q
Panache, Lake, O	34 *a*, 13 F
Paonan Peninsula, L. Manitoba	43, 198 E
Paraffine wax, imports	8, 153 S, 6, 128 SS
Paris, O., borings	44 Q
Park's Falls, N.S., Cambro-Silurian	8 P

PAGE

Parker Douglas gold mine, N.S. 61 S
Parkhill, O., boring 52 Q
Parrsboro', N.S., Carboniferous. 101 P
coal 173 P
Parrsboro' River, N.S., Devonian 73 P
Devonian and Carboniferous 100 P
Peace River, Slave River..13-15, 45-50 D
Peace River sandstones, characters of 56 D
Wabiscaw River. 41 D
Peace River 47-49, 56 D
Peat, N.B. 51, 56 A, 51 *a*, 50 S
Pebbles, angular, Lake Winnipegosis 156 E
Peckham, S. F., on origin of petroleum 12, 19 Q
Pegmatite vein, Sturgeon L. (fig.) 19 G
veins in gneiss 10 L
Pelican Bay, Lake Winnipegosis. 62, 171 E
saline spring water, analysis. 30 R
Pelican Creek, Pelican Bay, Ma. 63 E
Pelican Lake, Pelican River, Ath. 10 D
Pelican Rapids, Red Deer River. 188 E
Pelican River, Ath. 9, 39 D
Pelican sandstone, Athabasca R. 28, 57 D
Pelican Shale, Athabasca River. 29, 57 D
Pelly, Fort, Assiniboine River.. 135 E
Pembina River, Clearwater River 39 D
Pembroke, O., boring 23 Q
Pembroke, N.S., Carboniferous. 92 P
lead mine 92, 186 P
conglomerate, assay 49 R
Pemmican Island, Lake Winnipegosis 66, 169 E
Penhallow, Prof. D. P., work by 11 E
Penny's Mountain, N.S., Devonian 25 P
Carboniferous 90 P
Pentamerus Point, Lake Manitoba 197 E
Permian, northern N.S. 7, 108-141 P
New Glasgow conglomerate. 109-120 P
Middle group 120-131 P
Upper group 131-141 P
Petrolea, O., borings 61 Q
petroleum 120 SS
Petroleum, statistics. 6, 8, 148 S, 4, 6, 120 SS
occurrences 143 S
refineries, production 147 S
tanking 148 S
report on, in O. 1-94 Q
definition of 5 Q
on origin of 10 Q
search for, Pincher Creek. 9 *a*
Cameron Falls brook. 11 *a*
Akamina brook 11 *a*
Sage Creek 12 *a*
region, Ath. 24 A, 66 D
well borings in O. 64 A
in Q. 65 A
Philip River, N.S., fossils. 15 P
Phinney Brook, N.S., Devonian. 71, 98 P
Phlogopite, inclusions in 69 R
Phosphate, statistics. 6, 7, 153 S, 4, 5, 133 SS
deposits 155 S
mining methods 158 S
Phosphate rock, Cape Breton., 70 R

PAGE

Phosphate shale, Wilson River, Ath. 161 S
analysis. 26 A
Photographs taken, list of, north-western Ma. 231 E
Pickerel Creek, L. Winnipegosis 157 E
Pictou, N.S., coal field, Devonian 46 P
Carboniferous 74 P
Permian. 121 P
borings, sections 122 P
kame 144 P
Pictou county, N.S., work in. 1-193 P
coal 31 S S
Pictou Harbour, N.S., Permian. 122 P
search for coal 174 P
Pictou Island, Permian. 141 P
soil 169 P
Pictou, East River of, Cambro-Silurian 9 P
Silurian. 16 P
Carboniferous. 86 P
igneous rocks 149 P
limonite. 175 P
coal mine 37 S S
west branch of, Devonian. 18, 53 P
igneous rocks 149 P
Pictou, Middle River of, Devonian 19, 36, 48 P
Carboniferous 103 P
Permian. 111 P
Pictou, West River of, Devonian 20, 35, 38 P
Carboniferous. 90, 103 P
fault 113 P
igneous rocks 1 0 P
search for coal. 174 P
specular iron. 183 P
Pierre fossils, Athabasca River. 28 D
formation, north-western Ma. 199, 212 E
fossils, list of. 213 E
shales, Vermilion River 87 E
North Pine River. 1 3 E
Bell River 12 1 E
Assiniboine River. 135, 141 E
Pigeon River route, Hunters Island. 15 G
Pigments, mineral, production. 105 S, 4, 93 S S
Pincher Creek, Al., petroleum. 9 *a*, 123 S S
Pine timber, Hunters Island. 11, 14 G
Pine Brook, N.S., Devonian. 31 P
Carboniferous 81 P
Triassic 143 P
igneous rocks. 158 P
Pine River, Lake Winnipegosis. 68 E
North branch. 96, 101, 103 E
South branch 87, 100 E
Pine River trail 95, 97 E
"Pitching Ridges," north-western Ma. 6, 95, 98-101 E
Plainfield, N.S., Permian. 113 P
Plainfield Brook, N.S., Permian 128 P
Plants, Canadian, catalogue published 80 A, 89 *a*
Plaster of Paris, in ports 8, 79 S, 6, 77 SS
Plaster mills, northern N.S. 189 P
Plateaus, Athabasca. 43 D
Platinum, statistics. 6, 8, 112, 4, 6, 98 S S

	PAGE
Platinum—*Con.*	
native, Edmonton	65 R
Pleistocene, north-western Ma.	120, 215 E
section (fig.), Grand Rapid.	146 E
Plumbago, statistics	7, 76 S, 5 SS
St. John, N.B.	62 *a*
Pogamasing, O.	27 F
Pogamasing Lake, O.	28 F
Pohenegamook Lake, Q., Cambrian	16, 17 M
Point Lévis, Q., Cambro-Silurian	13 M
Pointe aux Trembles, Portneuf Co., Q., spur of gneiss	18 L
anticline	29 L
Trenton	36 L
Loraine (fossils)	43 L
quarries	69 L
Pointe Claire, Q., Portland cement	190 SS
Pollet River Lake, N.B., tripoli (analysis)	9 S
Pond, Peter, in the North-west (1778)	5 D
Pooh-Bah Lake, Hunters Island	11, 23, 53 G
Laurentian area	18, 21-25, 33 G
Poorman gold mine, B.C.	70 S
Pope Manganese Company, N.B.	93 S
Porcupine Mountain, Ma.	118 E
Port Colborne, O., borings	34, 40 Q
Port Elgin, O., borings	58 Q
Port Franks, O., boring	64 Q
Port Greville, N.S., Devonian	72 P
Port Haney, B.C., natural water (analysis)	23 R
Port Stanley, O., boring	49 Q
Portage Bay, Lake Manitoba	41 E
Portapique River, N.S., Devonian terraces	64 P, 145 P
Portneuf, Q., glacial stride	50 L
Post-Tertiary formation, north-western Ma.	199 E
Pot-hole Falls Vermilion River.	21 F
Potash salts, imports	8 S, 6 SS
Pottery, imports	6, 199 S, 196 SS
Potton, Q., pyrrhotite, analysis	40 R
Prairie, Snake River	105 E
Prince's mine, Lake Superior, erythrite	48 R
Proudfoot's Lake, O	20 F
Proudfoot's lines	8 F
Publications of Geological Survey	7 A
Pumice, statistics	8, 10 S, 6, 7, 9 SS
Pyrite, production	6, 181 S, 4, 180 SS
Eckstall Inlet	67 R
iron and copper, Stadacona.	51 A
Pyrolusite, northern N.S.	184 P
Pyroxene belts, holding phosphate	155 S
Pyroxenite, Nachvak, described (fig.)	81 F
Pyrrhotite, analyses	39-44 R
Schreiber	8 *a*
Sudbury district	47 F, 128 S
Quaco Head, N.B., manganese	94 S
Quarry Brook, N.S., Permian	126 P
Quartz, production	6, 11 S, 4 SS
graphic, Hunters Island	28 G
veins, "	75 G
Quartz—*Con.*	
sand, Coal River, O.	70 R
Quartzite, chipped, Valley River.	95 E
origin of, Sudbury district	42 F
grit, Maple Mountain, described	63 F
stretched, Spanish River, described (fig.)	72 F
Silurian, northern N.S	11, 13 P
Devonian "	18-73 P
Quebec city, rocks	31 L, 6, 13 M
Quebec county, work in	1-82 L
Quebec group, new conclusions on	5 M
Quebec, province of, progress of work in	44, 56 A, 35 *a*
and N.S., gold bearing rocks, correspondence of	55 *a*
geology and economic minerals of part of	1-82 L
ores, assays	50 R
gold mining	58, 64 S
copper	67 SS
graphite	72 SS
iron	82 SS
natural gas	109 SS
nickel	114 SS
petroleum	123 SS
silver	149 SS
Queen's county, N.S., work in	59 *a*
gold	143 SS
Quesnelle River, B. C., gold placers	67 S, 159 SS
Rabbit Lake, O., felsite, described	66 F
Radnor, Q., iron furnace	43, 48 *a*
Rainfall statistics, Minnedosa, Ma	28 E
Russell, Ma	32 E
Rainy Lake	10 G
Rainy Lake district, exploration.	37 A
Rat River, Q.	53 A
Rawdon, N.S., gold mining	60 S
Read Island, B.C., metacinnabarite	66 R
Rear Brook, N.S., Permion	121 P
Red River, Peace River	15 D
Red River, Athabasca River.	15, 38, 42 D
Red Deer Lake, Red Deer River.	77, 188 E
Red Deer Point, L. Winnipegosis	69 E
Red Deer River	59, 77, 121-126 E
mouth of	185 E
valley, water supply	10 A
saline springs, water, analysis	33 R
s mi-anthracite	70 R
Reed Island, Lake Manitoba	193 E
Renfrew, N.S, gold mining	60 S
Reserve coal mine, N.S.	41 SS
Resin, fossil, Saskatchewan River	30 A, 79 E, 14 S
examination of	225 E
Revelstoke, B.C., smelting plant	13 A
Rice Creek, Red Deer River	77 E
"Rice-rock," Sudbury district	45 F
Richard Point, Lake Manitoba.	40, 193 E
Richardson, Sir J., in the North-west	13 E
Richibucto River, N.B.	53 A
Ridges of boulders, Lake Winnipegosis	65, 67 E

PAGE

Ridges—*Con.*
gravel, Eastern Mossy Portage ... 55 E
Lake Dauphin ... 71 E
Valley River ... 72, 73 E
Ochre River ... 82 E
Pine River trail ... 97, 101 E
South Duck River ... 104 E
Red Deer River ... 122 E
See also "Pitching Ridges."
parallel, Hunters Island ... 9 G
parallel to shore, Q ... 22 M
Rimouski, Q., Cambrian ... 26 M
Rimouski county, work in ... 1-18 M
River, course of, reversed, Red River, Ath ... 16 D
channel, ancient, Saskatchewan River ... 128 E
Rivers, relation of, to geological basin ... 18 F
Riversdale, N.S., Devonian ... 20, 39, 43 P
Roasting of nickel ore ... 132 S
Robert, J. A., work by ... 3 P
Robertson, A. C., work by ... 31 *a*
Robin, Lake, Hunters Island ... 11 G
Roches moutonnées, Saganagons Lake ... 66 G
Kahnipiminanikok Lake ... 73 G
Roche rouge, Saskatchewan River 149 E
Rocklin, N.S., Devonian ... 49 P
Roland Island, Lac la Croix, contact ... 41, 48, 53, 55 G
Rolling River, Swan River. 111, 115, 129 E
Rondeau, O., boring ... 74 Q
Rose Island, Swan Lake ... 189 E
Ross Mine, Sudbury district, ore, assay ... 53 F
Ross location, Morgan, O., pyrrhotite, analysis ... 43 R
Routes, district of Athabasca ... 8 27 D
canoe, Hunters Island ... 15 G
Rover Creek, B.C., gold ... 71 S
Royal Canadian, B.C., gold mine 71 S
Royal gold mine company, N.S. 62 S
Russell, H. Y., work by ... 45 *a*
Russell, W. W., on Algoma iron deposits ... 83 S
Russell, Ma ... 143 E
meteorological observations at ... 30 E
Russell Lake, Sturgeon Lake, glacial striæ ... 72 G
Rüst, Dr. D., work by ... 11 E
quoted ... 120 E

Saddle Island, N.S., Permian ... 139 P
Saganaga Lake, Rainy River. 10, 61, 68 G
Saganaga Laurentian area ... 19, 33, 37 G
Saganagons Lake, Rainy River ... 65 G
Coutchiching ... 50 G
Keewatin ... 56, 64 G
hornblende rock ... 70 G
glacial striæ ... 73 G
Sage Creek, B.C., petroleum ... 12 *a*
Sagemace Bay, L. Winnipegosis 68 E
Saline springs, Athabasca ... 36, 63 D
analysis of water ... 64 D
Pembina River ... 39 D

PAGE

Saline springs—*Con.*
Tar Island ... 49 D
Saline, La, Athabasca River ... 35 D
Salmon River, N.S ... 13 P
Devonian ... 22, 41 P
igneous rocks ... 152 P
gold mining ... 59 S
Salt, statistics ... 6, 7, 8, 175 S, 4, 5, 6, 181 SS
occurrences, analyses ... 162 S
preparation of, from saline waters ... 36 R
northern N.S ... 189 P
manufacture of, Ma ... 220, 223 E
Salts, various, compared ... 164 S
Salt springs, Ma. and Sk ... 26-35 R
north-western Ma ... 24, 219 E
Pelican Bay ... 63 E
Pelican Creek ... 64 E
Monkman's ... 69, 165, 220 E
Red Deer River ... 78, 188 E
Swan Lake ... 199 E
Salt water, brook of, Dawson Bay 179 E
Salt Point, Lake Winnipegosis ... 60 E
Saltsprings, N.S., Devonian ... 54 P
Permian ... 125, 127 P
Saltspring Brook, N.S., Carboniferous ... 83 P
Sand, moulding ... 6, 112 S, 4 SS
northern N.S ... 193 P
Sands and gravel, statistics ... 7, 8, 199 S, 4, 5, 6, 197 SS
Sands, Kent county, N.B ... 56 A
tar-bearing. *See* Tar.
Sand flats, shifting, Shubenacadie River ... 168 P
Sand rock, basal or Archæan, Q ... 28 L
Sand Point Lake, Rainy River ... 11 G
Laurentian ... 26, 27 G
Coutchiching ... 40, 52 G
Sandstone, Ath. *See* Athabasca, Dunvegan, Peace River, Pelican.
north-western Ma. *See* Dakota.
Echo Lake, described ... 65, 66 F
conglomeratic, Bay Lake, described ... 67 F
felspathic, Lake Wahnapitæ, described ... 69 F
for building, Charlevoix Co. 49 A
Silurian, Rivière Noire ... 12 M
Cambrian, Temiscouata ... 20, 26 M
Cambro-Silurian, northern N.S ... 8 P
Silurian, northern N.S ... 14 P
Devonian, " ... 20-73 P
Carboniferous, " ... 80-85, 103 P
Permian, " ... 114-141 P
Sandy Lake, Sandy Lake Creek. 10 D
Sandy Lake Creek, Wabiscaw R. 10 D
Sans Bout, Lac, Q ... 42 *a*
Santé, Cap, Q., Loraine shales ... 42 L
lime ... 70 L
Sarnia, O., borings ... 68 Q
Saskatchewan River, Lake Winnipegosis ... 30 A, 144-153 E
gold mining ... 66 S
Sault à la Puce River, Q., anorthosite ... 22 L
examined ... 76 L

PAGE

Sault à la Puce River, Q.—*Con.*
fault ..... 33 L
gneiss, examined..... 76 L
Savannes, Rivière des, Q., Cambrian ..... 17 M
Savona, B.C., opal, examined... 16 B
Scenery, Lake Winnipegosis.... 60 E
northern, N.S..... 6, 168 P
Scheelite, Marlow..... 74 *a*
analysis..... 21 R
Schist, chlorite, Copper Cliff mine, described..... 69 F
hornblende, Vermilion mine, described..... 77 F
Schists, Coutchiching, Hunters Island..... 39-56 G
mica, Hunters Island .... 48 G
hornblende, Saganagons L.. 66 G
chloritic, Saganagons Lake. 58, 64, 67 G
Schreiber, O., pyrrhotite..... 8 *a*
analysis..... 46 R
ores, assays..... 53 R
nickel..... 119 SS
Scotsburn, N.S., Permian..... 125 P
drift..... 145 P
Scudder, S. H., obligations to... 5 *a*
work by ..... 76 *a*, 11 E
Seaforth, G., boring..... 57 Q
Section, Cretaceous, Athabasca River..... 24 A, 53 D
Athabasca River..... 29 D
Burnt Rapids (fig.)..... 31 D
The Forks (fig.)..... 34 D
Moose River..... 37, 38 D
Peace River (fig.)..... 48 D
glacial, Athabasca River.... 60 D
Turtle Mountain..... 43 S
Post-Tertiary, Valley River. 94 E
Benton, North Pine River.. 101 E
Niobrara, " " .. 102 E
South Duck River..... 104 E
kame, North Pine River.... 103 E
Swan River..... 110 E
Pleistocene, Rolling River.. 116 E
Red Deer River ..... 125 E
Churchbridge..... 142 E
Pleistocene, Grand Rapid (fig.)..... 146 E
Lake Winnipegosis..... 159 E
Dawson Bay (fig.)..... 178 E
Silurian, Grand Rapid..... 200 E
Archæan rocks, north of lower St. Lawrence..... 8 L
Utica, Ste. Anne de Montmorency..... 45 L
drift, Ste. Anne de la Pérade River..... 60 L
Clifton, Baie des Chaleurs... 12 S
Amherst, N.B..... 55 A
west branch of Economy R.. 66 P
East River of Pictou..... 87 P
Permian, River John..... 114 P
Waugh River..... 117 P
Pictou..... 123 P
French River ..... 129 P
Cape John..... 131 P
Malagash Point ..... 138 P
Caribou Island..... 139 P
See also Boring.

PAGE

Seine River, O., survey. ..... 39 A, 29 *a*
Selkirk, East, Ma., Trenton limestone ..... 23 *a*
Selkirk Island, Lake Winnipeg.. 23 *a*
Selkirk Range, B.C.. ..... 20 A
Selma, N.S., coal..... 172 P
Selwyn, Dr. A. R. C., work by.. 8 A, 6 *a*
reports by ..... 1-86 A, 1-92 *a*
in the North-west (1875).... 6 D
referred to..... 9 G
on coal deposits, N.W.T.... 42 S
on gold region, N.S... .... 62 S
Serpentine and asbestus, connection of ... . 13 SS
Seven Islands, St. John River, Silurian..... 10 M
Sewer pipes, production..7, 199 S, 4, 196 SS
Shade Lake, Hunters Island.... 69 G
Shale, phosphatic ..... 14 S
Wilson River ..... 91, 229 E
Shales, Assiniboine River... ... 28 A
origin of, O..... 20 Q
oil, Collingwood..... 27 Q
Loraine, north of lower St. Lawrence..... 41-47 L
Cambro-Silurian, northern N.S..... 8 P
Devonian ..... 19, 25-73 P
Permian..... 120-139 P
See also Benton, Cretaceous, La Biche, Niobrara, Odanah, Loon R., Pelican, Pierre.
Sharp, Cape, N.S., Carboniferous 99 P
Shebandowan Lake, O..... 26 *a*
Shelburne, N.S., gold. .....8 A, 62 S
Shelburne county, work in .... 59 *a*
Sherks Station, O., natural gas.. 117 S
Shoal River, Lake Winnipegosis .73, 189 E
Shoal River House, Swan Lake.. 76 E
Shore cliff, ancient, Lake Winnipegosis..... 50 E
Shore lines, ancient, Lake Dauphin .... 71 E
Kettle Hill. .. .. 218 E
Armitt River ..... 122 E
Nappan River. ... ... 49 *a*
Short Creek, Valley River ..... 132 E
Short Lake, N.S., Carboniferous 94 P
Shubenacadie River, N.S., clay.. 59 *a*
Carboniferous .. .. 95 P
Triassic..... 143 P
sand flats .... 168 P
Shuswap, B.C., progress of work in..... 17 A
Shutt, F. J., analysis of gypsum by..... 77 S
Sicamous, B.C., silver ore, assay. 59 R
Siderite, northern N.S ..... 175 P
Sifton Narrows, Lake Manitoba. 35, 39, 191, 196 E
Silence, Lake, Hunters Island .. 69 G
Silex, imports ..... 9, 10 S, 6, 9 SS
Silurian, north-western Ma....200-204 E
fossils, list of..... ... 202 E
Lake Manitoba..... 195 E
Temiscouata county ..... 7-13 M
northern N.S..... 6, 10-17 P
Silver, statistics.....6, 7, 167 S, 4 139 SS

	PAGE
Silver—*Con.*	
mining	168 S
and gold assays	48 R
-lead ore, Field	12 A
ores, Mosquito Flat, assays	18 *a*
search for, northern N.S.	187 P
Silver Creek, Ma., pavement of striated boulders	139 E
Silver Peak, near Hope, B.C., silver	181 S
Silver Point, Cayoosh Creek, dolomite, assay	63 R
Similkameen, B.C., gold	179 SS
Simon Lake, Q., terrace	65 L
Simpson, T., in the North-west (1836)	13 E
Siwash Creek, B.C., gold	71 S, 177 SS
Six-Mile Brook, N.S., Permian	127 P
Skidegate Inlet, B.C., volcanic tufa (examined)	71 R
Skill, H. G., work by	31 *a*
Skynner, W., work by	5 F
Slate, statistics	7, 8, 187 S, 4, 5, 6, 188 SS
Richmond Co., Q., analysis and test	187 S
Slates, black, age of, Illecillewaet	4 A
Silurian, Temiscouata Co	8 M
Cambrian, "	15 M
Silurian, northern N.S.	12–16 P
Devonian, "	17, 19–73 P
quarried	193 P
Slate Lake, Saganagons Lake, Coutchiching	50 G
contact, Keewatin and Laurentian	57 G
Slave Lake, Lesser, Athabasca River	17, 40 D
Smaill, Mr., work by	52 A
Small's Brook, N.S., Permian	110 P
Smaltite, McKim, O	48 R
Smelt Brook, N.S., Permian	121 P
Smelters, new, B.C.	13 A
Smelting, Copper Cliff	135 S
Smith, H. B., work in the N.W. (1873)	16 E
quoted	45, 54 E
Smith, W. H. C	37 A, 28 *a*
report by	1-57 G
Smithfield, N.S., lead mine	92, 186 P
Carboniferous	92 P
"Smoking Tent," Armitt River	122 E
Smoky River shales, Peace River	50, 54 D
Snake Island, Lake Winnipegosis	162 E
Snake River, Swan River	105 E
Snow fall statistics, Minnedosa	28 E
Russell, Ma	32 E
Soapstone, production	6, 113 S, 4 SS
Soda salts, imports	8 S, 6 SS
Soldiers' Portage, Hunters Island, granitic area	34 G
Coutchiching rocks	39 G
Sombra, O., boring	67 Q
Sorcier, Lac au, Q	42 *a*
South Field, B.C., coal mine	46 S
South Fork Hydraulic Mining Co., B.C.	68 S
Southampton, O., boring	59 Q
Southesk, Lord, in the North-west (1859)	16 E
Southfield, Nanaimo, coal mining	50 SS
Spanish River, Lake Huron	27-36 F
Spelter, imports	8, 116 S, 6, 102 SS
Spence's Bridge, B.C., ore, assay	63 R
Spencer, Dr. J. W., work in the North-west (1874)	17 E
Spencer's Island, N.S., Carboniferous	98 P
Sperrylite, Vermilion mines, analysis	132 S
Sphalerite, Burrard Inlet	66 R
Spiedel Hill, N.S.	154 P
Spilimichine River, B.C., jamesonite	65 R
Spillemcheen Mountain, B.C., silver mining	180 S
Spreadborough, W., work by	86 *a*
Springs, hot, water, analyses	24 R
mineral, La Saline, Ath	35 D
Lake St. John, Q	52 A
See also Saline, Salt.	
Spring Hill, N.S., coal mine	35 SS
Springville, N.S., manganese ore (analysis)	98 S
Square Plain, Swan River	114 E
St. Alban, Q., Trenton	34 L
limestone quarries	69 L
St. Ambroise, Q., Loraine	43 L
limestone quarries	70 L
St. Andrews, Q	37 *a*
St. Ann's, N.S., quartz, assay	48 R
Ste. Anne River, Q., gneisses	11-16 L
Ste. Anne de Beaupré, Q., anticline	33 L
anorthosite and gneiss, examined	81 L
Ste. Anne de Montmorency Riv., Q., section	45 L
ochre	68 L
Ste. Anne de la Pérade River, Q., Trenton	33 L
glacial striæ	49 L
terraces	53, 58, 65 L
section of deposits	60 L
swamps	66 L
St. Basile, Q., gneiss quarry	70 L
St. Catharine, O., boring	32 Q
Ste. Catherine, Q., gneisses	17 L
terraces	62 L
St. Charles River, Q., Trenton	37 L
St. Francis River, St. John Riv., Silurian	8 M
St. Gabriel, Q., gneiss	17 L
quarried	71 L
terraces	62 L
swamps	66 L
St. Honoré, Q., Cambrian	18 M
St. Hyacinthe, Q., natural gas	6 *a*, 109 SS
St. Joachim Falls, Ste. Anne de Montmorency R., gneiss quarried	71 L
St. John, N.B., graphite	62 *a*, 71 SS
St. John, Fort, shales, Peace Riv.	47-49 D
Smoky River	50 D
St. John, Lake, Q., region, work in	50 A
spring water, analysis	26 R
St. John River, Q., Silurian	8 M
St. Joseph Island, Lake Huron, native iron, analysis	12 R

PAGE

St. Joseph, Lake, Q., gneiss.... 17 L
St. Léon, Q., mineral springs.... 97 ss
St. Louis de Ha! Ha! Q., Cambrian..... 17 M
St. Magloire, Q., Cambrian. ... 18 M
St. Malo, Q., ochre. ... .48 *a*, 94 ss
Ste. Marie, Q., augen-gneiss..... 16 L
St. Martin's Lake, Ma..... 203 E
St. Martin's River, L. Winnipeg 23 E
St. Mary's, O., boring..... ... 60 Q
St. Mary's River, B.C., ore, assay 55 R
St. Maurice River, Q..... ... 46 A
St. Pamphile, Q., Silurian..... 10 M
St. Raymond, Q., terrace. ..... 58 L
St. Simon, Lake, Q., Cambrian. 25 M
St. Stephen, N.B., pyrrhotite, analysis..... 39 R
nickel ore..... .. .. 112 ss
analysis..... .. .. 98 S
St. Tite, Q., ochre..... . . 48 A
St. Urbain, Q., iron ore..... 49, 51 A
Stadacona, Q., pyrites..... ... 51 A
Staff, changes in the. .. .... 86 A, 92 A
insufficient for the work .... 7 A
Staple's Brook, N.S., Triassic... 143 P
Statistics, mineral, collection of, B.C... .... 13 A
division of, progress of work in.. ... ...62 A, 60 A
reports on.....1-201 S, 1-200 ss
Steel and iron, statistics7, 8, 88s, 5, 6, 87ss
Steel's Run, N.S., Devonian.... 42 P
Steele's River, N.S., Carboniferous ... . 75 P
Steep Bank River, Athabaska River .... 39, 44 D
Steep Rock Cliff, Lake Manitoba40, 194 E
Steep Rock River, Lake Winnipegosis .... 59, 182 E
Stellarton, N.S., Carboniferous.. 89 P
coal . . . . 33 ss
Stephenson, Mr., on gold placers, Quesnelle River ..... 68 S
Stewiacke River, N.S..... 60 A
Devonian ... . 22, 40 P
Carboniferous .... 92 P
drift..... .. .. 145 P
Stobie mine, Sudbury, ore (fig.) . 50 F
output. ..... 51 F
biotite gneiss, described..... 88 F
granite, described ... . 70 F
Stone, lithographic, import..... 6 S
Stones, building, statistics 6, 7, 8, 182 S, 5, 6, 183 ss
north of lower St. Lawrence 69 L
northern N. S..... 190 P
Stones, precious, statistics 6, 8 S, 4, 99 ss
northern N. S.... ..... 190 P
Stoneham, Q., gneiss. ..... . 20 L
Stonewall, Ma., glacial striæ.... 25 *a*
Stormon Lake, Winnipeg ..... 33 A
Straight Lake, O..... ..... 41 F
Huronian outlier. . ..... 38 F
Stratford, O., boring..... . 60 Q
Strathroy, O., boring..... .... 50 Q
Street, L., work by..... ..... 59 *a*
Stretched quartzite, described (fig.)..... 72 F
diabase, described .... 78 F

PAGE

Stringocephalus zone of Winnipegosan formation.. .. 180 E
Structural materials, production 6, 182 S, 4, 183 ss
Stump Lake, B.C., ores ..... 19 A
quartzite, assay ..... 60 R
silver mines .. .. 181 S
Sturgeon Lake, Maligne River, Laurentian . . .. 19 G
Coutchiching.. ..... 46, 53 G
mica schist ... . .49, 64 G
glacial striæ..... 72 G
Sturgeon River, O.. . ..... 17 F
arkose, described..... 61 F
Subsidence, Pleistocene, Kent county, N.B. .... .. 55 A
Sudbury, O., surveys. ..... 41 A
mining district, report on... 1–95 F
felsite, described..... .... 61, 79 F
sandstone, described.. .... 71 F
nickel and copper.....122 S, 115 ss
Sugar Lake, B.C. .. .. 17 *a*
Sulphate of copper, import..... 6 ss
Sulphur, import.. ....8, 161 S, 6, 181 ss
Sulphuric acid, statistics.....7, 8 S, 6 ss
Sunday Lake, Hunters Island... 69 G
Sunnybrae, N.S., Devonian. ... 18 P
hematite, analysis..... 39 R
Sussex, N.B., manganese .... . 93 S
Swamps, north of lower St. Lawrence ..... 66 L
Swamp Creek, L. Winnipegosis.. 57 E
Swampberry Creek, Swamp-berry Lake ... .. . 19 D
Swampberry Lake, Wabiscaw R. 19 D
Swan Brook, N.S., Devonian ... 73 P
Swan Lake, Ma.. ....75, 189 E
saline spring, water, analysis 32 R
Swan River, Swan Lake, Ma..105, 118 E
bore..... ....18, 106 E
delta . . .. 189 E
Swansea, O., boring..... . 25 Q
Swift Current Creek, Birch River 45 D
Sydney, N.S., coal mining....42 S, 38 ss
Syenite, northern N.S.... .... 191 P
Sylvan, O., boring..... .. .. 53 Q
Sylvester, N.S., Permian..... 113 P

Tableland, North-western Man.. 23 E
Talc, Clarendon, O.... ..... 67 R
Tanner's Lake, Coutchiching.. . 53 G
Tar in boulder clay... . ... 60 D
Tar-sands, Athabasca. ..... 23 A, 32, 34, 38 D, 144 S
Dakota age of.. .... 58, 65 D
analysis..... ..... 65 D
Tar Island, Peace River..... 49 D
Tar Point, Gaspé, petroleum in dyke . . .. 12 Q
Tatamagouche, N.S., Permian.. 136 P
hematite ... . 182 P
copper ore . ..... 186 P
Taylor, Prof. R. S., origin of petroleum.. .... 12 Q
Temiscaming, Lake, Q., granite, described ... . 62 F
arkose, described. ... . 63 F
lead mine .... 90 S

	PAGE
Temiscouata county, work in....	1–18 M
Temiscouata, Lake, Q., Silurian.	7 M
Cambrian.....	15 M
Temperature, observations, Minnedosa	26 E
Russell, Ma.....	30 E
of water in lakes and rivers, Ma.	47 E
Templeman's quarry, Lake Beauport, Trenton.....	39 L
Templeton, Q., ore, assay.....	50 R
asbestus	29 S
Tenycape, N.S., manganese mine184 P, 97s	
manganese ore, analysis.....	98 S
Terra cotta, statistics ..7, 195 S, 4, 193 SS	
test of..	196 S
Terraces, Assiniboine R...28 A, 136, 140 E	
Lake Winnipegosis.	53 E
Kettle Hill . . ..76, 218 E	
Thunder Hill.....	108 E
Bell River..	120 E
Shell River.....131, 133 E	
north of lower St. Lawrence.	56 L
marine.	58 L
river.....	65 L
cut out of till.....	61 L
Portapique River.....	145 R
Tertiary, coal bearing, Kamloops	18 A
Texada Island, B.C., quartzites, assays....	64 R
Thamesville, O., boring.....	72 Q
Thecla strigosa.....	87 F
Thetford, Q., asbestus mine...20, 24, 27 S	
Thom, Mount, N.S., Devonian..	39, 42 P
igneous rocks	151 P
Thompson, D., in the Northwest (1797). .... .5 D, 12 E	
Thompson River, B.C., rocks, assays.	59-63 R
North, ores....	18 *a*
Thorburn, Dr. J., reports by...81 A, 91 *a*	
Thorburn, N.S., coal mines....	33 SS
Thorn Brook, N.B., graphite....	71 SS
Thornbury, O., boring...	30 Q
Thorold, O., boring.....	33 Q
Three Rivers, Q., bog iron ore...	47 *a*
Thunder Bay district, O., silver mining	168 S
gold mining	152 SS
Thunder Hill, B.C., gold.....	270 SS
Thunder Hill, Swan River.. ...	107 E
Tilbury, O., borings.....	77 Q
Tiles, drain, statistics... ..... 7, 8, 197 S, 4, 6, 195 SS	
Till, north-western Ma.....	217 E
Mossy River..... ..	74 E
Wilson River..	90 E
Swan River	107 E
Shell River.....	131 E
upper and lower Assiniboine River.....	138 E
including gravel, Assiniboine River.	141 E
north of lower St. Lawrence	52 L
Tilsonburg, O., borings...	45 Q
Timber, north-western Ma..	24 E
northern N.S	168 P
Tin, imports.... .... 7, 115 S, 6, 101 SS	
Toad Mountain, B.C., gold.....	70 S
silver..	172 S
Toney River, N.S., Permian...127, 131 P	
section	131 P
Torbrook, N.S., iron mining....	80 SS
Toronto, O., boring	25 Q
Tortue, Lac., Q	47 *a*
Totten's Brook, N.S., Devonian, Carboniferous.....	30 P
igneous rocks	158 P
iron ore.....	178 P
Trail to Whitefish Lake, Ath ... 18-22 D	
to Moose Lake.....	24 D
bridle, Swan Lake to Pine Creek	75 E
to Duck Mountain	104 E
Birch River..... 118–120 E	
Red Deer Lake to Porcupine Mtn ... .121–125 E	
cart, Pine Creek..... 96–104 E	
to Fort Pelly	113 E
Trail Creek, B.C., silver mines..	175 S
Tramway, Grand Rapid, Sk....	80 E
Trap, metals and minerals in...	54 *a*
Trees, photographs taken of Canadian	86 *a*
forest, Ath.	6 D
Lake Winnipegosis ..55, 58, 61 E	
Ochre River.....	82 E
Trembling Mountain, Q	36 *a*
Trenton, north of lower St. Lawrence..... .. 33–41 L	
limestones	27, 69 L
Farnham.....	45 A
Trias fauna, Alpine, Kamloops	19 A
Triassic, northern N.S ..... 7, 141-144 P	
sandstone, Cobequid Bay...	53 *a*
igneous rocks	54 *a*
Tripoli, production. .. .. 9 S, 7 SS	
King's Co., N.B., analysis..	9 S
Tripolite, Loon Lake, B.C., examined.....	20 R
Trout Lake, Trout River, Ath..	20 D
Trout Lake, O...	26 *a*
Trout Mountain, Ath....	7, 27 D
Trout River, Wabiscaw River...	11, 20 D
Truro, N.S., Devonian.....	45 P
Tufa, volcanic, Skidegate Inlet..	71 R
Tuff vitrophyre, Onaping River, described (fig.).....	74 R
Tumbo Island, B.C., coal mining	60 SS
Tungsten ore, Marlow	74 *a*
Turtle Mountain, N.W.T., coalfield. ....11 A, 43 S	
Turtle River, Lake Dauphin....	71 E
Twin Islands, Lake Manitoba...	42 E
"Two Creeks," Assiniboine R.	138 E
Two Islands, Minas Basin, Devonian.....	71 P
Tyrrell, J. B., work by .....26 A, 19 *a*	
report by.... .... 1-240 E	
Uniacke, N.S., gold mining.....	61 P
Union Centre, N.S., Millstone Grit.....	105 P

	PAGE
Valcartier, Q., gneiss	98 L
terrace	63 L
swamp	66 L
Valley, pre-glacial, Swan River.	113 E
ancient, Red Deer River	125 E
Valleys of Champlain epoch, Ma.	128 E
north of lower St. Lawrence.	6 L
ancient	52 L
Valley, N.S., Devonian	44 P
Triassic	142 P
igneous rocks	152 P
Valley River, Lake Dauphin..72, 91,	98 E
head of	127 E
Variolite, Ottawa Islet, described	80 F
Verendrye, Sieur de la, in the North-west (1739)	12 E
Vermilion Falls, Peace River. .. 15,	45 D
Vermilion Lake, Minnesota, gold	75 G
Vermilion Lake, Vermilion River, O.	23 F
Vermilion mine, Denison, nickel ores, analysis	44 R
Vermilion mine, Sudbury	51, 52 F
altered greenstone, described	62 F
gabbro, described	73 F
schist, "	77 F
Vermilion River, Lake Dauphin 71,	85 E
Vermilion River, O	17 F
Verte, Rivière, Q., Cambrian	21 M
Victoria Hydraulic Gold Mining Co., Quesnelle River	68 S
Victoria coal mines, N.S.	39 SS
Vienna, O., boring	48 Q
Visitors to Museum	86 A, 91 *a*
Vivian, H. H., and Co., nickel mine, Sudbury	139 S
Voigtite, North-east Harbour	65 E
Wabagizhik, Lake, Vermilion R.	25 F
Wabiscaw Lakes, Wabiscaw R.	10 D
Wabiscaw River, Ath. 11,	40 D
Wad	93 S
Waddell's Lake, O., pyrrhotite, analysis	41 R
Wahnapitæ, Lake, O	14 F
conglomerate, described	58 F
granite, "	59 F
sandstone, "	69 F
Wahnapitæ River, O.	14 F
arkose, described	65 F
Wainfleet, O., boring for gas	40 Q
Wait, F. G., work by	66 A, 66 *a*, 3 R
Wait-a-bit Creek, B.C., cookeite.	67 R
Wakefield, Q., ore, assay	50 R
Walker, H. H., work by	31 *a*
Wall. on formation of asphalt	16 Q
Wallace Mine, Sudbury in 1848.	47 F
nickel ore (analysis)	122, 130 S
Wallace Harbour, N.S., Carboniferous	102 P
Wallace River, N.S., Permian	111 P
Wanipigow Lake, Wanipigow R.	21 *a*
Wanipigow R., Lake Winnipeg.	21 *a*
Warnstorf, C., obligations to	5 *a*
Wassiemeska River, Lake St. John	52 A
Wasson's Bluff, N.S., Carboniferous	71, 100 P
Water supply, Red River valley.	10 A
Water falls, northern N. S.	168 P
Water, mineral, analyses	22 R
statistics	6, 8, 108 S, 6, 96 SS
northern N. S.	189 P
Water's Brook, N.S., Carboniferous	90 P
Water's Hill, N.S., Devonian	53 P
Waterhen Lake, Waterhen River	45 E
Waterhen River, Lake Manitoba	23, 35, 45 E
Waterloo, O., borings	41 Q
Waterhen River, B.C., magnetic analysis	38 R
Watervale, N.S., Devonian	53 P
Carboniferous	74 P
Watervale Brook Devonian	54 P
Waugh River, N.S., Devonian	55 P
fault	114 P
Permian (section)	117, 128 P
drift	144 P
igneous rocks	154 P
agricultural lands	169 P
Waverley, N.S., gold yield	56 *a*
coal mining	59 S
Wayagamak Lake, Q.	46 *a*
Webster, N.S., iron mine, rocks.	13 P
Webster's Mountain, N.S., hematite	181 P
Welland county, O., natural gas	118 S, 102 SS
petroleum	122 SS
Wellington colliery, Nanaimo..47 S,	60 SS
Wells, A. W., work in the North-west (1857)	14 E
Wells, petroleum, Oil Springs, O.	7 Q
Wentworth, N.S., Silurian	14 P
Permian	131 P
igneous rocks	159 P
Wentworth Grant, N.S., hematite	181 P
Wessick, Mount, Lake Temiscouata	7, 20 M
Cambrian	15 M
West gold mine, N.S.	62 S
Westmoreland county, N. B., work in	48 *a*
Weston, T. C., work by	72 A, 77 *a*
Weston Point, L. Winnipegosis.	166 E
Westville, N.S., coal mine	37 S, 31 SS
Wet Lake, Hunters Island	32 G
Whetstones, northern N. S.	191 P
Whitby, O., boring for gas	24 Q
White, J., work by	65 A, 60 *a*, 4 SS
White Mud River, Lake Manitoba	35 E
White Sand River, Assiniboine River	136 E
Whiteaves, J. F., work by..70 A,	75 A, 11 E
Whiteaves Point, Lake Winnipegosis	60 E
Whiteburn, N.S., gold	63 S
Whitefish Lake, Whitefish River, Ath.	18 D
Whitefish River, Bear Lake	19 D
Whitefish River, Lake Huron	13 F
Whitehill, N.S., Devonian	50 P
Whiting, statistics..7, 8, 113 S, 4, 6,	99 SS
Whitson Creek, Vermilion River, Ath.	24 F

PAGE

Wicksteed Lake, Hunters Island, Laurentian ..... 27 G
Widder Station, O., boring..... 65 Q
Wiggins, T., work by ..... 37 A
Wild Fox silver mine, B.C.. ... 171 S
Wilkins, Point, Dawson Bay.... 183 E
Williams, Prof. G. H., obligations to. ..... 5 A
on rocks of Sudbury district. 55-82 F
Williams Lake, Hunters Island. 11, 24, 43 G
Willimott, C. W., work by....69 A, 71 *a*
Wilson, W. J., work by. ... 53 A, 49 *a*
Wilson River, Ma., phosphatic shale (analysis)..... 26 A, 161 S
Winchell, N. H., and H. V., referred to .. ..9, 33, 37 G
Windermere Mountain, B. C., silver mining..... 180 S
Windy Lake, O ..... 38 F
Wingham, O., boring.... ... 56 Q
Wink Lake, Hunters Island .... 22 G
Winnipeg, Lake, work on .....31 A, 20 *a*
lacustral plain of... .... 22, 34-81 E
tributaries of..... .... 23 E
Winnipeg River, Lake Winnipeg 22 *a*
Winnipegosan formation, northwestern, Ma ....200, 204 E
fossils, list of .... 204 E
dolomite, Lake Winnipegosis.....161, 166, 169 E
Dawson Bay ... ..173-181, 185 E
limestone, L. Winnipegosis . 163 E
Dawson Bay.....178, 183 E
Lake Manitoba.....191-193, 196 E

PAGE

Winnipegosis, Lake, Ma..46-69, 153-186 E
saline spring waters, analysis 26-32 R
Wolframite, Lake Coutchiching. 21 R
Wolseley Lake, Namakan River. 35 G
Wolverine River, Peace River.. 14 D
Woods, Red Deer River.... ..124, 125 E
Woods, Lake of the, pyrrhotite, analysis .... 46 R
Woodstock, O., boring .... . 48 Q
Woodstock, N.B., search for gold 62 A
silver... .... 146 SS
ore, assays. .... 148 SS
Worthington mine, Sudbury ... 52 F
Wyoming, O., boring..... 63 Q

Yale, B.C., rocks, assays..... 64 R
gold . . .. 177 SS
Yale Creek, B.C., gold and silver 181 S
Yellow metal, imports... ... . 8 S, 6 SS
York county, O., natural gas ... 107 SS
Yum-yum Lake, Hunters Island 51, 69 G

Z, Island, Lake Winnipegosis... 158 E
Zinc, imports.....6, 115 S, 6, 101 SS
Sudbury district .. . . 57 F
Zoological collection, additions to .....72, 75 A, 77, 81-85 *a*
work, progress of.....72 A, 77 A