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GEOLOGICAL AND NATURAL HISTORY SURVEY

OF CANADA.

REPORTS AND MAPS

OF

INVESTIGATIONS AND SURVEYS.

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THE HONOURABLE EDGAR DEWDNEY, M.P.,
Minister of the Interior.

SIR,—Herewith I have the honour to submit Vol. IV, new series, of the Reports of the Geological and Natural History Survey of Canada. It consists of 10 parts or separate reports, with maps and illustrations, relating to the geology, mineralogy and natural history of various sections or of the whole of the Dominion from the Atlantic to the Pacific.

The several parts were issued separately at intervals during the past twelve months, and can be purchased at from twenty to thirty cents with maps. Copies of the maps can be purchased separately at ten cents.

I have the honour to be,
Sir,
Your obedient servant,
ALFRED R. C. SELWYN,
Director.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

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

ANNUAL REPORT

(NEW SERIES)

VOLUME IV.

1888-89.

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For $1,908,966, first line in above table, *read* $9,650,653, and in totals, for $17,910,980 *read* $25,652,667, page 7, PART S.

PART N.

Page 11 N, line 23 from bottom, *for* eastern *read* central.
Page 15 N, line 5 from top, *for* they *read* the latter.
Page 20 N, line 2 from bottom, *for* coats *read* coast.
Page 25 N, line 14 from bottom, *omit* there.
Page 50 N, line 12 from bottom, *for* evels *read* levels.
Page 65 N, llne 5 from top, *for* sta *read* station.
Page 74 N, line 4 from top, *for* dryer *read* drier.
Page 81 N, line 16 from top, *omit* general.
Page 81 N, line 17 from bottom, *for* generally *read* locally.

Maps Nos. 2, 3 to 11, and 15 to 17 are unavoidably delayed and will be issued later.

SUMMARY REPORTS

OF THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1889.

DEPARTMENT OF THE INTERIOR,
GEOLOGICAL AND NATURAL HISTORY SURVEY AND MUSEUM BRANCH,
OTTAWA, 31st December, 1889.

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

SIR,—I have the honor to submit herewith the customary summary report of the work of the Geological and Natural History Survey corps during the past calendar year.

From January to May was occupied in the preparation of the reports and maps that have since been published, forming a volume, in two parts, of about 1,400 pages, with numerous maps and illustrations. It contains thirteen separate reports, relating to the geology, the mineral resources and the natural history of various portions of the Dominion, from British Columbia and the North-West to Hudson's Bay and Nova Scotia.

The following publications have also been prepared and published during the year:—

1. Vol. I., Part 2, Contributions to Canadian Palæontology.
2. Description of eight new species of fossils from the Cambro-silurian rocks of Manitoba, with six plates.
3. Contributions to the Micro-Palæontology of the Cambro-silurian rocks of Canada: by Ulrich.
4. List of publications of the Geological and Natural History Survey of Canada from 1843 to 1889, with prices, and a brief description of the contents and the arrangement of the Museum and Library. 36 pp., R. 8vo.

There are also in preparation and in part ready for press:

1. Enumeration of Canadian Liverworts, with Notes.
2. Part V. of the Catalogue of Canadian Plants.
3. Catalogue of Canadian Birds, with their Habits and Range; also list of species now represented in the Museum.
4. The Vertebrate fossil fauna of the Tertiary rocks of the North-West, with plates: by Prof. E. Cope.

Early in April, 16 parties were organized for field exploration, and were distributed as follows:—British Columbia, 3; North-West Territory, 2; Manitoba, 1; Ontario, 2; Quebec, 4; New Brunswick, 2; Nova Scota, 2. A brief summary of these explorations is given in the following pages; as well as of the work that has been performed in connection with the Museum, the Chemical Laboratory and the Library.

Up to the end of June my own time was fully and constantly occupied in attending to executive details, in answering enquiries verbally and by letter, and in work connected with editing the Annual Report and maps above referred to. On the 5th June I left Ottawa, for the purpose of making some observations at various points along the north shore of the lower St. Lawrence and in the Strait of Belle Ile. This was effected by securing a passage on board the Lighthouse Service steamer "Napoleon," but afforded opportunities for examination only at widely separated points, mostly at or in the vicinity of the lighthouses, along the great stretch over 500 miles of coast line, extending from Point de Monts to Belle Ile. Some interesting facts were, however, ascertained, and I have acquired such a general knowledge of the character of the country as will enable me better to direct any future explorations that may be undertaken in this region with a view of ascertaining what its mineral resources are. In this connection it may be stated that Belle Ile itself, hitherto supposed to be composed of Laurentian gneiss, was found to consist largely, if not wholly, of various crystalline and sub-crystalline strata, like those of the Huronian mineral-bearing belts of the country north and west of Lakes Huron and Superior, and it is not improbable that considerable areas of these rocks may yet be found on the main land of Labrador; and, if so, they may expect to be accompanied by deposits of valuable economic minerals, like those which characterize them in all the areas where they have yet been recognized and explored.

Hasty examinations were made, and specimens collected, at the following places:—Point de Monts, Egg Island, Pentecoste, Sheldrake, Seven Islands, Perroquette Island, Esquimax Island, West, South-west and South points of Anticosti, Greenly Island, Point Amour, Chateau Bay and Belle Ile; and in Newfoundland at Cape Bauld and Quirbon

Harbor, and at Capes Norman and Rich. The geological formations of the northern peninsula of Newfoundland have been described in the Geology of Canada, 1863, and are there all referred to one or other of the divisions—Levis, Lauzon and Sillery—of the Quebec group. From what I have seen this summer I am led to believe that the true order of succession of the strata has been misinterpreted, as it was in the Eastern Townships, and that much of the so-called Sillery and Lauzon is probably Huronian, but certainly not more recent than Lower Cambrian. Diorites and serpentines appear to be somewhat largely developed, and it seems quite likely that valuable deposits of asbestos may accompany them, as they do in the Eastern Townships of Quebec.

In this connection it may be interesting to quote some passages from a Memoir by A. S. Packard, Jr., read before the Boston Society of Natural History, October, 1865, and published in Vol. I of its Memoirs.

On page 216, under the heading "Huronian Group," he says: "A system of quartzite and trap rocks which lie in a depression of the Laurentian rocks, about 125 miles long and probably 25 miles broad, stretching along the coast between Domino Harbor and Cape Webuc, I refer with some hesitancy to the Huronian series of Sir Wm. Logan, and consider as probably equivalent to the Quartzose division of the primitive slate formation of Newman and Keilhau. It agrees in part with the Domino gneiss of Mr. Lieber." The author then gives further interesting details of these strata, and in conclusion, page 218, says: "Should further search prove the existence, in connection with this quartzite, of beds of a true conglomerate, which we should look for in the interior, and of the presence of copper ore in connection with quartz veins near the trap rock, the identity of this formation with the Huronian rocks of Canada and of similar rocks in Sweden would seem satisfactory; and, if proven, will be interesting, not only to the geologist, but be of practical value in the search for ores on this coast."

Mr. Packard also describes the remarkable columnar basaltic, trap rocks of Castle and Henley Islands, in Chateau Bay, but I think erroneously assigns them to the Laurentian. From their attitude and appearance, they are, I think, more probably of Cambrian age and equivalent to the Animikie of Thunder Bay, Lake Superior, Lake Nipigon, and the islands on the eastern shores of Hudson's Bay. No such rocks are, so far as I am aware, associated anywhere with the Laurentian system. If this proves to be correct, we may expect to find areas in East Main and Labrador of both the Archæan (Huronian)

Boston Society Natural History, Vol. I., 1866-69.

and the Cambrian (Animikie) metaliferous-bearing zones of Lake Superior. The white quartzites of Marble Island, described by Dr. Bell * as Huronian, seem to correspond closely with those described by Mr. Packard at Domino Harbor and Cape Webuc, while the columnar basalts of Castle and Henley Islands, Chateau Bay, are almost identical with those of Castle Peninsula, Richmond Gulf, † the Outer and Inner Barns of Lake Nipigon and the better known trap formation of Thunder Cape, Pie Island and McKay's Mountain, on Lake Superior.

At Sheldrake near the eastern end of the Seignoiry of Mingan, and both east and west of the settlement, the coast is occupied by massive Labradorite rocks. On shore, where tidal action has polished these rocks, some fine examples of the beautiful opalescent anorthosite or labrador spar were observed, but specimens could not be easily obtained without appliances for blasting the rock. Inland for a considerable distance, where the vegetation has been burnt, the weathered surfaces of these rocks are perfectly white, making the country look as if there had been a heavy fall of snow. The extent of the area of these rocks in this region is entirely unknown. It is not impossible that it is continuous with that described by Prof. Hind, on the Moisie River and its branches, ‡ and that this again extends continuously south-eastward to Pentecoste River, where similar rocks occur as described by Richardson.§ We should then have in this region the largest known area in Canada of these Norian rocks, and here doubtless it would not be difficult to determine their true relations to the red and grey granitoid orthoclase gneisses, which they have been supposed to unconformably overlie. There can, however, be little doubt that they are intrusive igneous rocks. On the 29th July I returned to Quebec, where Prof. C. Walcott, of the United States Geological Survey, met me by appointment, for the purpose of examining some of the typical sections around Quebec, on the correct interpretation of which so much has of late years been said and written by the geologists of the United States and Canada.

From the 14th to the 23rd August I was occupied, in company with Prof. Walcott, in studying the relations of the Cambrian and Cambro-silurian formations on either side of the boundry between Vermont and Canada, with a view to uniformity of mapping by the respective surveys, and which, it is hoped, will now be secured.

After attending the meeting of the American Association for the Advancement of Science, in Toronto, from the 28th of August to the

* Report Geological Survey of Canada, 1882-83-84 P. 35 D.D.,

† Bell—Geological Survey of Canada, Report 1877-78, p. 14c.

‡ Explorations in the interior of the Labrador Peninsula, 1863.

§ Geological Survey of Canada, Report 66-69, p. 307.

2nd of September, a few days were spent—with a similar object in view to that above referred to, but in connection with the work now in progress along the Minnesota boundary, in company with Professor N. H. Winchell, of the United States Survey, and Dr. Lawson—studying the Huronian rocks around Sudbury and Algoma, and in an endeavour to show that the metaliferous Huronian strata of the Sudbury-Algoma region do not differ in any important particular from the similarly metaliferous schists, etc., which occur in the country between Lake Superior and Lake Winnipeg, including the Lake of the Woods, and Rainy Lake and River. In connection with this matter, and the importance of the work of tracing out and mapping these bands or belts of Huronian rocks, I may here quote what I wrote respecting it in 1873: * *

"Apart from the geological interest which attaches to the determination of the distribution of these rocks and their precise relations to the underlying Laurentian gneiss, the foregoing facts show that it is economically important that the extent of these bands be defined; and that their mineral characters should be closely investigated is equally so, inasmuch as the gold, the copper and the iron of the region, as far as known, are associated with similar strata, and thus not only the best land, but likewise valuable mineral deposits are to be looked for within the limits which they occupy." * *

Since the above was written, nearly all the discoveries and developments of mines and minerals in the Huronian areas that have been indicated by the Survey have been made. That these facts are somewhat of the nature of cause and effect may, I think, reasonably be surmised; and whether they prove the truth or otherwise of the reiterated and apparently somewhat popular statements that of recent years the Survey has paid no attention to and takes no interest in the devlopement of the mineral resources of the country, may perhaps be left to the decision of the public and to the testimony of the sixteen volumes of reports, maps and other documents that have been published by the Survey since 1870.

In the enormous area which stretches from the Georgian Bay north-west to the Mackenzie River, and from the same point north-east to the Straits of Belle Ile and Cape Chudleigh, there are probably many such areas to be investigated and located; and a map on which they are even roughly indicated will always be a valuable guide to the mineral prospector.

The rest of the season, from the 9th of September to the 10th of October, the date of my return to Ottawa, was devoted to investiga-

Geological Survey Report of Progress, 1872-73, pp. 15-16.

tions and enquiries bearing on water supply in the North-West. The artesian wells of the James River valley and Devil's Lake, in Dakota, were visited, and also the boring now in progress at Deloraine. The quality of the water in the Dakota wells varies considerably. Most of the wells give a copious supply of excellent water. At Devil's Lake, however, though a copious supply was obtained at about 1,750 feet, the water, though good for stock, contains too much saline matter for ordinary domestic uses. There seems every probability, when a sufficient depth has been reached at Deloraine, of a good supply of artesian water being obtained. What the quality will be there is no evidence to show, but this is not now important, because even if as saline as is much of the surface and the artesian water of the Red River valley, it can, by a simple and inexpensive process of filtration, be made sufficiently pure for all domestic uses. This has recently been proved by experiments made at my suggestion on some of the most saline water of the Red River valley south of Winnipeg. It consists in simple filtration through from 50 to 60 feet of sandy gravel. Further experiments will perhaps suggest additions to the material used that would render the process still more perfect. Even as it is, the importance and value of this discovery to the whole of Manitoba and the North-West in such seasons as that of 1889 can scarcely be estimated.

The history of the discovery and development of natural gas in Ontario, to which I briefly referred in my last summary report, is interesting; but as it is somewhat of a personal character, I shall not now refer to it. The results attained during the past year are stated under the head of mineral statistics. They are highly satisfactory; but it would be well to bear in mind that the supply is not inexhaustible, and that wells that are now sending out their millions of cubic feet a day will gradually decline and become extinct. The greater the number of wells bored in a district the sooner will this inevitable event occur. Unlike water, neither gas, nor oil, nor coal, are constantly replenished, and must therefore sooner or later be exhausted. I called attention to this in my summary report for 1887, pages 24-25; and on page 30 of my summary report for 1888, in commenting on Mr. Coste's report on investigations I had directed him to make the spring of that year. I said: "There seems no reason why further trials, especially in that part of Ontario betweeen Lake St. Clair on the south-west and Lake Simcoe on the north-east, should not prove more successful and yield as abundant a supply of gas or petroleum as do some of the Ohio wells." Since that expression of opinion, all the large gas wells now referred to have been bored.

Dr. G. M. Dawson was, during the past season, again occupied in continuing the geological exploration of the southern part of the province of British Columbia. In consequence of the recent important mineral discoveries in the West Kootanie district, it was considered desirable that he should visit that district in the first instance, and should afterwards give as much time as possible to the completion of the more systematic work on which he had previously been engaged in the Kamloops region. Dr. Dawson, who was assisted by Mr. McEvoy, B., Ap. Sc., and by Mr. P. Edgar, furnishes the following summary account of the explorations carried out:—

"About a month, in the earlier part of the summer, was devoted to the examination of the more important localities in the West Kootanie district, which have lately been proved to afford valuable ores. While I was occupied in this work, accompanied by Mr. Edgar, Mr. McEvoy was independently engaged in examining a stretch of country between the North Thompson and Bonaparte Rivers, along the northern edge of the geological map-sheet now in course of completion. Work during the remainder of the season was practically confined to the area of the sheet just referred to.

"It should be explained that, in conformity with the suggestion made in last year's Summary Report, the area covered by the original reconnaissance map of the Southern Interior portion of British Columbia was divided into four equal parts, each forming a square of eighty miles side, and including a superficies of 6,400 square miles. The scale was at the same time increased from that of eight miles to that of four miles to the inch, and a preliminary compilation on that scale was made by Mr. McEvoy before field work commenced. The sheet to which the field work of last summer related extends in longitude from the vicinity of the North Thompson to that of Lillooet (long. 120° 10′ to 122), in latitude from 50° 10° to 51° 20′. The exploratory work required for this sheet may now be considered as completed, with the exception of a belt of mountainous country to the west of the Fraser between Lillooet and Lytton. The enlargement of the scale of the map will enable greater justice to be done to the somewhat complicated geological and topographical features of the country.

"The Kootanie district, to the south of the line of the Canadian Pacific Railway, is naturally separated by the high, rugged, axial portions of the Selkirk and Purcell ranges, into eastern and western sub-districts. The first of these may be reached by ascending the Columbia from Golden, the second from Revelstoke, by way of the Columbia River and Arrow Lakes. Much prospecting has been going on in both East and West Kootanie for the past two or three years, and a large number of promising discoveries—chiefly of silver-bearing ore—have been made. The West Kootanie sub-district was that visited by me last summer, and in it no previous observations by officers of the Survey had been made, with the exception of a traverse of the Columbia and Arrow Lakes by Mr. Bowman in 1884.

"Attention was first permanently drawn to the mineral wealth of the West Kootanie region when the discovery of rich ore by the Hall Brothers on a mountain which has since been known as Toad Mountain became known in 1887. Many prospectors soon flocked to the vicinity and a large number of claims have since been taken up, not only on and near Toad Mountain, but also at Hot Springs or Ainsworth, on the west side of Kootanie Lake, at Hendryx on the opposite side, and at many outlying localities. At Nelson and Ainsworth town sites have been laid out, and the first steps toward the establishment of permanent mining centres have been taken.

"Speaking generally of the district, I may say that the result of my examination has been to convince me that the importance of the mineral discoveries made has not been exaggerated, while their number and the area over which they are distributed is such as to guarantee a large and continuous output of good ore so soon as adequate means are provided for the transport of the product to market. As a number of details respecting the various deposits (chiefly obtained through the kindness of Messrs. G. B. Wright and G. M. Sproat) have already been given in my report on 'The Mineral Wealth of British Columbia,' recently printed, it will not be necessary in the present summary to speak of the individual claims and deposits visited by me. These particulars I hope to embody in a more comprehensive report shortly to be published. It may be noted, however, that in nearly every instance the result of my personal examination has been to verify the accuracy of the statements made in the publication just alluded to.

"The majority of the ores met with are to be classed as silver ores, and in the vicinity of Hot Springs and Hendryx these are for the most part argentiferous galenas, which, in a number of instances near Hot Springs, are decomposed to a considerable depth, forming so-called 'carbonate ores.' These possess a special value owing to the ease with which they are worked and their importance in the process of smelting the unaltered galenas. The aggregate quantity of such 'carbonate ores' to be found in the deposits already proved must be great, but all will no doubt pass in depth into sulphide ores.

"At Hot Springs or Ainsworth a truly remarkable number of metalliferous veins has already been brought to light within a very limited area, and additional discoveries are still being made from time to time even within this area. Near the lake-shore, the country-rock is a coarse mica-schist which is overlain further back by green and grey schists, and these in turn are followed by limestones and black argillaceous schists, a mass of granite bounding the whole at a distance of two to three miles inland. In evident relation to this change in the country-rock is the circumstance that the ores improve almost uniformly in respect to content of silver in crossing the series of veins in a westward direction from the lake and rising higher above the lake-level. Some of the deposits associated with the limestones hold more or less native silver in a filiform condition, and very high assays are frequently obtained from these. It is not yet possible to quote assays of the ores of this vicinity made from specimens collected by myself, but it is safe to say that from several of the claims considerable quantities of ore can already be obtained by ordinary hand picking, which yield from 50 to over 100 ounces of silver to the ton, in addition to a high percentage of lead.

"At Hendryx, the only considerable developments made are those of the New Haven Mining and Smelting Company. The principal feature at this place is a lode of very great size, consisting largely of galena, but classing in respect to silver as a low-grade ore. So soon as efficient means are provided for handling and smelting this ore and shipping the product, a very large output may be counted on.

The Toad Mountain ores differ from the foregoing in containing a large amount of copper and less galena. The Hall Brothers' property, known as the 'Silver King Mine,' from the name of the claim on which most work has been done, is so far the leading one here, and has turned out a considerable quantity of ore, which has approached or surpassed $300 to the ton in total value as sold at the smelter. Other claims are, however, being opened out, some of which present a very favourable appearance.

"At the east end of Toad Mountain, a whole belt of rusty schistose rocks, containing more or less quartz and much iron pyrites, has been discovered. The superficial portions of this belt have been completely oxidised and afford free-milling gold. This property has been acquired by an English company, known as the Cottonwood Company, and a Huntingdon mill has been erected for the purpose of treating, in the first place, the decomposed surface material, of which there is, in the aggregate, a great quantity in sight. The results of trials so far carried out have not been made public. Should it prove, however, that the deeper pyritous portion of the deposit contains sufficient gold to pay for concentration, roasting and chlorination, the quantity of the ore appears to be almost unlimited. Another gold-bearing deposit, in the form of a well-defined vein traversing a granite rock, is situated on Eagle Creek, toward the west end of Toad Mountain. Work is being carried on here and a stamp mill is in process of erection.

"Beyond the neighborhood of the better known centres, a great number of discoveries, chiefly of silver ores, are reported throughout the district. Most of these isolated localities time did not permit me to visit. Mention may be made, however, of an extensive deposit of copper-pyrites, on the north side of Kootanie River, nearly opposite Forty-nine Creek, and of a peculiar and apparently important occurrence of magnetic iron-ore on the same side of the river below the lower fall.

"No large quantity of ore has yet been shipped from the deposits of the vicinity of Kootanie Lake and Toad Mountain, but small shipments of hand-picked rich ores have been made from time to time during the two past summers, representing a total value of over $75,000. The ore has been carried down to the lake-shore on horses or mules, taken by steamer to Bonner's Ferry in Northern Idaho, thence over thirty miles by waggon to the nearest point on the Northern Pacific Railway, and then, as a rule, to Montana, where it has been sold and smelted. The cost per ton of transporting the ores to smelter by this route has not been less than $30, and when to this is added the cost of mining and cobbing the ore, it is evident that very high-grade ore alone can thus be utilized, while even in the case of deposits capable of yielding a considerable proportion of such high-grade material, the greater part of the ore extracted, embracing the lower grades and requiring concentration, must at present be put to one side.

"It may thus be said that the West Kootanie district is at present waiting merely for some satisfactory outlet for its ores, and the developments already made, though for the most part merely of a preliminary character, are such as in my opinion to justify the expenditure necessary to provide such an outlet at once. It might be added that capital for the proper development of the various discoveries is also required; but this will naturally follow as soon as the district is rendered more accessible, and can only be prevented from doing so, for a longer or shorter time, by the exaggerated ideas of the value of undeveloped properties too apt to prevail among the holders of claims in such new districts.

"The construction of a railway twenty-four miles in length along the unnavigable portion of the Kootanie River, between Nelson on the West Arm of Kootanie Lake and Sproat's Landing on the Columbia, would connect the navigable waters of this lake with those of the Columbia and Arrow Lakes, and would enable ores to reach the Canadian Pacific Railway at Revelstoke. A still more efficient and permanently satisfactory route would, however, be afforded by a direct line of railway from the north end of Kootanie Lake to Revelstoke, a distance of about eighty-six miles by the route which would have to be followed. Of this length of line, however, only that part between Kootanie Lake and the North-east Arm of Upper Arrow Lake need be constructed in the first instance, with a length of about forty-eight miles; the remaining portion of the distance being for a time served by steamer on the Columbia. Still another alternative outlet may also eventually be supplied by a branch line from the Northern Pacific Railway; but it is of importance to the prosperity of the district that it should have a means of communication independent of the rulings of the United States Customs as to the introduction of silver-lead ores, &c., into that country. The metals likely to be produced in quantity in the district are silver, lead and copper, all of which may be sold to advantage at first hand in the markets to which the same metals are exported by the United States.

"For the purpose of treating the ores from the East and West Kootanie districts, a large and well appointed smelter has just been completed at Revelstoke, while arrangements for the erection of a second are in progress at Golden.

"In the above summary, particular prominence has been given to the main features which appear to be of immediate economic importance in the West Kootanie district. It is of course impossible to give here any general review relating to the province as a whole. It may, however, be stated that during the past summer a considerable amount of substantial progress has been made in the exploration of mineral deposits already known, while a number of new discoveries of promise have occurred. The output of ore, which has already in a small way been fairly initiated, will now doubtless increase from year to year, till British Columbia attains the prominence from a mining point of view which her great mineral resources guarantee. The rate at which this development may preceed must depend for the most part on the degree of energy which those primarily interested exhibit.

"I have reason to believe that the publication giving a synoptical account of the minerals of the province, printed last spring under the title of "Mineral Wealth of British Columbia," has already served a useful purpose, in directing the attention of capital to the province. I may also take this opportunity of stating that gypsum, one of the minerals enumerated in the above mentioned publication among those unknown in British Columbia, has since been discovered, and, according to the accounts received, in large quantity. The locality is stated to be on the Salmon River, about twenty miles distant from the railway. From the excellent quality of the specimens which I have seen this discovery may prove to be of importance."

Mr. Amos Bowman was occupied during a portion of the summer in continuing the examination of the country on the Lower Fraser River, with special reference to the question of the occurrence of beds of coal or lignite-coal of economic importance. This work was briefly referred to in my last summary report, and the facts then ascertained were given. No report of the past season's work has yet been received from Mr. Bowman.

Mr. R. G. McConnell left Ottawa on the 30th of April, with instructions to explore the almost unknown country north of Lesser Slave Lake:, bounded by the Peace and Athabasca Rivers. On this work he reports as follows: "I reached the Athabasca landing on the 19th of May, and descended the Athabasca to near the mouth of the Pelican River. From this point a portage of three miles brought us to the Pelican, some miles above its mouth, and above most of the bad rapids. We then followed the Pelican—a small, winding stream—to its source in Pelican Lake, and crossing the latter, followed up Beaver Creek for a short distance, and then made a portage of a couple of miles across the height of land to Sandy Lake, which drains northward to the Peace. Following the outlet of Sandy Lake, we soon reached the Wabiscaw Lakes, and crossing these, entered the Wabiscaw River, which we descended to its junction with the Loon, and then continued our way down the latter until it emptied into the Peace.

"Loon River, with its continuation, the Wabiscaw, has a length of about 350 miles, and drains an area of over 25,000 square miles. It might be navigated with strong, light-draught steamers, and by using the line in some places, up to the Grand Rapids, a distance of about 150 miles. Its principal tributaries are Bear River, Pine Creek, Panny Creek, Trout River and Wooden-house River—all fair-sized streams, but reported to be very swift and filled with rapids.

"From the mouth of the Loon we ascended the Peace to Fort Vermilion for supplies, and, then returning, explored little Red River for a distance of 200 miles. I ascended this river with the expectation of finding exposures of the bitumen-bearing sands which outcrop along the Athabasca, but failed in this, as the river in its upper part does not cut down below the boulder clay, and for long distances is destitute of any valley whatever. The geological data it affords are in consequence very slight.

"Returning from Red River to Fort Vermilion, a trip with pack-horses was made into the Buffalo-head Hills, after which we continued our way up the Peace to the Peace River landing, making on the way exploratory excursions eastwards into the wooded country which borders the river.

"From the Peace River landing we crossed over to Lesser Slave Lake, and engaging there a small pack-train, started north along an execrable trail for Trout Lake, where we left the horses and pushed on, partly on foot and partly with canoes, until we reached the Wabiscaw and made connection with the previous traverse down that stream. On this trip I sketched in the outlines of White-fish Lake, Loon Lake, Bear Lake, Trout Lake and a host of smaller ones, and crossed and followed for some distance a score of streams, but obtained little geological information, as the country is everywere so deeply mantled with drift that none of the streams which I examined have succeeded in cutting through it and so exposing the rocks beneath.

"After returning to Lesser Slave Lake I coasted around it, examining on the way the tertiary plateau south of the lake, and Martin Mountain at the north-east corner, and then continued our way down Lesser Slave River to the Athabasca, and down the latter to the Athabasca landing, making side trips on the way to Moose Lake and Baptiste Lake. We arrived at the landing on the 1st October and started at once for Ottawa, arriving there on the 13th October.

"The whole country between the Peace and the Athabasca north of the Loon—an area of about 25,000 square miles—is generally forested, mainly with spruce and poplar, and is everywhere characterized by an abundance of lakes and of muskegs and marshes. Narrow strips of excellent land are usually found along the main rivers and surrounding many of the lakes, and in the interior many areas often equal in size to an eastern county, might be selected which are well adapted for cultivation, but the wide morasses which separate these detract greatly from their value. Numerous streams, mostly draining northwards, everywhere intersect the surface. Few of these have large valleys, and they usually flow in a sluggish manner, often dilating 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 Loon River and Red River, none of the streams are navigable.

"Two ranges of hills cross the district in question. One of these, the Buffalo-head Hills, commences abruptly about fifty miles above the mouth of the Loon, with an elevation of 1,000 feet, and running in a south-south-westerly direction, with a gradually diminishing height, dies away opposite the mouth of Battle River, while the other commences north of the east end of Lesser Slave Lake and extends in an easterly direction towards the Athabasca.

"Excellent sections of the rocks of the country are found along the Peace and Athabasca and the lower parts of the Loon, but the geological information obtained in regard to the interior of the district is small, owing to the almost complete absence of deep valleys or scarped banks showing exposures. The exploration has, however, added largely to our geographical knowledge of this little known region.

"Lignite was found in several places along the Peace River, but in some too small to be workable. It was also found in the Laramie plateau, south of Lesser Slave Lake. Here four seams were found ranging in thickness from one to four feet, besides a number of smaller ones, scattered through about 1,000 feet of shales and sandstone. This lignite is apparently of fair quality, but has not yet been analyzed. Drift lignite was also found in Martin River near the base of Martin Mountain, but was not traced to its source.

"Clay iron stone is of universal occurrence in the Cretaceous shales exposed along the Peace Valley, and, in many places between Battle River and the mouth of the Smoky forms thick accumulations at the foot of the cliffs lining the valley, some of which may prove to be of economic value.

"Gold was found in many of the bars along Peace River and in several places in sufficient quantities to deserve attention. Four miles above the mouth of Battle River is a large bar, nearly a mile long, from which we obtained fifteen or twenty *colours* of fine gold by washing a few handfulls 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 1,000 feet wide, the bar might be easily and inexpensively worked on a large scale. A few miles further up the river another bar was examined, which yielded from twenty to forty *colours* when washed in the way just mentioned.

"A couple of *colours* of gold were washed out in one place on Loon River. This is of some interest, as the Loon heads in a south-easterly direction, and has no connection whatever with the mountains.

"Inspissated petroleum, lining cracks in calcareous nodules, was found along Peace River for some sixty miles below the Peace River landing. At Tar Islands, about thirty miles below the mouth of Smoky River, there is a saline spring which is kept in a constant state of ebullition by the escape of natural gas. Small quantities of tar line the sides of the spring and float on the surface of the water. This spring and a couple of others which are reported near by, are situated near the axis of a broad, flat anticlinal, one of the essential conditions of a successful oil field. Gas and oil in paying quantities are most frequently found in these great natural domes, and the only element of uncertainty in this district is the presence or absence of some porous formation to act as a reservoir. It is possible that the loose sands found along the Athabasca extend this far, or that some equivalent formation occupies their place, but as natural sections are wanting this can only be proved by artificial sections obtained by boring.

"Bituminous nodules were also observed along the north side of Lesser Slave Lake, and a tar spring is reported on this lake near the mouth of Martin River, but its situation is kept a secret by the Indian who professes to have discovered it.

"The Athabasca River was not examined during the past season, but it is proposed to devote next summer to it and its tributaries.

Cost of season's exploration, $2,183.63."

Mr. J. B. Tyrrell, assisted by Mr. D. B. Dowling, was engaged during the past season in making a thorough geological examination and completing the surveys of the shores and islands of Lake Winnipegosis. Red Deer, Swan, Dauphin and Waterhen Lakes were also surveyed and examined. The Red Deer River was explored up to the mouth of the Etoimami, and several excursions were made into the Porcupine Mountains. The expedition was eminently successful in obtaining a continuous section from the Cambro-silurian to the Devonian rocks, and in determining the exact contact of the latter with the over-lying Cretaceous beds.

Mr. Tyrrell reports as follows:—

"On 11th May I left Ottawa and proceeded to Winnipeg, where supplies were obtained sufficient to last for the summer, after which I descended the Red River to West Selkirk.

"A small fishing smack had been purchased from Wm. Watts & Son, of Collingwood, and shipped by Canadian Pacific Railway to West Selkirk, whither Mr. Dowling had preceded me by a few days, in order to have the boat launched and properly rigged. Into this the cargo of supplies and general camp equipage, &c., was stowed, and on the afternoon of 23rd May we left West Selkirk and sailed down the river and thence northward across Lake Winnipeg to the mouth of the Little Saskatchewan River.

"In descending the Red River from Winnipeg the banks first seen consist entirely of grey stratified alluvial clay. This deposit gradually decreases in thickness, and at the first rapid the river is found to have cut through these bedded clays into unstratified till containing boulders. From this point downwards the banks constantly show little cliffs of boulder clay containing many boulders of white or cream coloured limestone, mixed with some of gneiss, &c., and from those cliffs are falling the boulders that are afterwards carried into the channel, and there cause the rapids which form such serious impediments to the navigation of the river.

"At Lower Fort Garry the Cambro-silurian limestone makes its appearance for a short distance, and thence to the mouth of the river the banks are generally low and wooded, and the channel is wide and deep, so that boats have no difficulty in ascending the stream after the bar at the south end of the lake is crossed.

"Leaving Red River, a straight course was taken across the lake to the north end of Big Island and thence to Black Island.

"The object we had in view in visiting this latter locality was to examine the deposit of iron ore known to occur on its south shore, owned by the International Smelting and Mining Company, of Winnipeg.

"The island itself lies at the north end of the southern expansion of Lake Winnipeg, fifty-four miles from the mouth of Red River, in a large bay or depression in the east shore of the lake, with deep channels both to the east and west of it; that to the west separates it from Big Island, on which there is now a flourishing Icelandic settlement. It has a total length of twelve miles and three-quarters in a direction N. 56° E, and a general width of four miles and three-eighths, and an area of 40·4 square miles.

"The southern portion of the island is overlain by horizontally stratified sandstone and limestone of Cambro-silurian age, the latter being somewhat similar to that quarried at East Selkirk and used so extensively in Winnipeg as a building stone. The surface of the island is thickly wooded with poplar, birch and spruce.

"Five miles and a-half along the south-east shore from its south-west point, altered and highly inclined rocks are for the first time met with. They consist of light green cericitic schists and quartzites, probably of Huronian age, which are often externally reddened by oxide of iron. When first met with they strike N. 15° E. and S. 15° W., and dip at angles varying from 60° to 75°. These schists outcrop along the shore for a distance of 450 paces, forming generally a rough, irregular beach which slopes gradually into the water.

"Towards the north-east end of the exposure, however, a low rugged cliff rises above and behind the sloping beach, and on examination this cliff is found to consist in the centre of a mass of hematite, which extends along the shore for a distance of a hundred paces and rises to the height of seven feet above the water. As shown in sections running back from the shore, it dips away from the lake at an angle of 30°, and in the vicinity of the mass of ore the bedding of the schist is almost entirely obliterated.

"The ore is a more or less pure hematite, not very compact on any of the exposed surfaces, and with numerous little seams and particles of crystaline calcite scattered throughout the mass, along with which are also a number of small lenticules and crystals of quartz. In some places, especially near the outside of the mass, the hematite assumes quite a pisolitic or botryoidal structure, the spherules being often arranged in very well defined rows, the interspaces of which are filled with calcite.

"Towards the outside of the mass in places the ore has been converted for from a few inches to a foot into a hydrated oxide of iron or limonite.

"No analyses have yet been made of the typical specimens collected during the past summer, but a number of analyses have been made of specimens previously sent in from Black Island, both in the laboratory of the Geological Survey of Canada and by Messrs. Gilchrist, Riley and Miller, in London, England.

"These show an amount of metallic iron ranging from 53.99 per cent. downwards. None were found to contain more than a trace of phosphorus. One specimen gave on analysis 2.026 per cent. of sulphur, the sulphur being present in the ore as finely disseminated iron pyrites, while three other specimens show respectively 0.07,0·12 and 0·032 per cent. of this impurity. In the other five analyses the sulphur was not determined. No iron pyrites was seen in the general run of the ore, but indications of decayed nodules could be traced in a very few places as yellow incrustations on the surface of the rock, and two or three small nodules were seen lying loose at the bottom of the cliff.

"As stated above, the deposit extends for about 300 feet along the shore, which has here a direction of N. 70° E., rises to a height of seven feet in the centre of the exposure, and dips back from the shore at an angle of 30°. The direction of its strike differs very materially from that obtained for the schists at the south-west end of the exposure, but in the immediate vicinity of the ore itself the bedding was entirely or almost entirely obliterated, so that it was impossible to determine in the short time at my disposal whether it was a true bedded deposit, or a lenticular inclusion in the schists.

"The hematite is underlain at the water's edge by a green quartzitic schist, and is overlain by a greenish white argillaceous breccia from one to two feet in thickness. Overlying this is a mixture of quartzite (or infiltrated quartz) and rather hard green schist, containing a considerable quantity of hematite. This quartzose band is again overlain by light green agillaceous or cericitic schists, very much crumpled, but generally dipping at an angle of 60° and striking on the west side of the ore N. 50° E. and S. 50° W. Beyond this is twelve feet of light green soft cericitic schist, and this then runs into the harder and more quartzitic schists, which comprise the rest of the whole exposure of Huronian rocks along this part of the shore.

"On our way north from Black Island we stopped for a short time at the north end of Big Island, at Big Grindstone Point and at Deer Island. The cliffs at these places present some very interesting geological features, being capped by compact impure Trenton limestone, below which are white, more or less soft, sandstones, interstratified with bands of light blue clay shale. These sandstone beds have been referred by Mr. Billings to the horizon of the Chazy of Eastern Canada, on the evidence of a few obscure fossils. These rocks require a much more extended examination, but some fossils were this year obtained from them, which, it is hoped, may determine more accurately their taxonomic position.

"At Deer Island we were delayed several days by heavy northwest winds, so that it became advisable to secure the services of a little steamer that was passing, and obtain a tow to Swampy Island. While waiting at this island for the wind to moderate I secured a fine collection of fossils from a cliff of Trenton limestone, a mile west of the Fishing station. These were immediately packed and, along with the fossils and rock specimens from Black, Big and Deer Islands, and Grindstone Point, were shipped directly to Ottawa, where some of them have since been examined, and are described by Mr. Whiteaves in the Transactions of the Royal Society of Canada, Volume VII.

"From Swampy Island we sailed to the mouth of the Little Saskatchewan River, where the services of several Indians were secured, and the next four days were spent in tracking and poling the boat and canoes with their loads of provisions up to St. Martin's Lake, after which the greater part of a day was occupied in ascending the Partridge Crop River to Lake Manitoba. It was late in the evening of Saturday, the 10th of June, when we arrived at Manitoba House, where we were hospitably received by Mr. and Mrs. Armit.

"The Little Saskatchewan River, from Lake St. Martin to Lake Winnipeg, is for much of the way a swift stream 250 feet wide, and with a depth varying according to the seasons from one to five or six feet. It has a total length of 31·2 miles and a fall in this distance of eighty-five feet, the larger part of which is accumulated into the lowest seven miles of its course.

"Following the river upwards from its mouth for 1·1 mile, the banks are generally low and consist of stratified alluvial clay without pebbles or boulders. The water is moderately deep and flows with an easy current. At this point, however, a light brown calcareous sandstone makes its appearance at the bottom of the bank. This sandstone is in general horizontally bedded, though sometimes slightly undulating, and a few obscure fossils found in it show it to be of the age of the Hudson River formation. It is exposed in low outcrops along the bank for 1·75 mile, when it finally disappears. Throughout the distance it is overlain by stratified blue clay, five or six feet in thickness.

"Above the last outcrop of bedded rock the banks rise rapidly to a height of twenty feet above the bed of the stream, and are here seen to be composed of light grey unstratified boulder clay or till, containing pebbles and boulders, chiefly of white limestone, though some are of gneiss; above which the banks again fall, relatively to the stream, till at the distance of 7·5 miles from the mouth they are only four feet above the water. At this latter point there is another low exposure of rock, consisting of a soft, light, buff-colored, semi-crystalline, horizontally stratified dolomitic limestone, in which are very few traces of organic remains.

"The river between the highest and lowest rock exposures here mentioned is one succession of heavy rapids, the bed of the stream being covered with gravel and boulders. Very few of these latter are of any great size, and it is rather their number then their magnitude that gives rise to the rapids. The channel is very clearly defined; there is no valley, other than the channel itself, and there is no bottom-land, though an occasional slide from some of the higher banks has sometimes the appearance of a kind of grassy terrace. The banks were once very generally timbered with poplar and spruce, but much of this has lately been burnt, and there is now little else to be seen but a succession of dead tree-trunks.

"This long rapid is, as will be seen, a very serious obstruction to the general navigation of the river, but on the other hand it will furnish a water-power that will be of the greatest value to Northern Manitoba in years to come. Above this rapid, which, on account of our heavy load, cost us two days of incessant labor to surmount, the river up to the Elbow, a distance of 8·36 miles, is, on the whole, remarkably beautiful. It consists of stretches a mile or more in length of quiet water, severed by six short, though often swift rapids or shoals, where considerable care must be exercised in navigating the boat, though it was rarely necessary to lighten it. The grassy banks, not more than two or three feet in height, descend in a graceful curve to the edge of the water, or break down in little scarps covered with sliding clay and pebbles. Open park-like woods of aspen poplar fill in the centre of the picture, and it is only now and then that occasional glimpses can be had of the coniferous forest in the distance,

"Above the Elbow to Lake St. Martin the river has a length of 15·28 miles, in which distance there are three short rapids and three other short stretches of river where the current is very swift. For the rest it is generally wide and sluggish, with low, flat meadow banks, evidently often flooded, stretching back to a forest of poplar and spruce. Lake St. Martin is a shallow, evaporating basin or expansion at the head of the Little Saskatchewan. It has an elevation of eighty-five feet above Lake Winnipeg, or 795 feet above the sea, a shore line of eighty-five miles, an area of 118¼ square miles, and a greatest depth, as far as at present ascertained, of fifteen feet. In it are situated a number of islands, with a total area of 3¼ square miles, some of which, however, are chiefly interesting from the fact that they, along with several hills in the vicinity, are composed of trap and gneiss which rise as bosses above the surface of the surrounding bedded Silurian limestone, though these limestones abut sharply against the gneiss, &c., and are quite undisturbed by it. The islands and hills are thus shown to be original inequalities in the paleozoic ocean floor on which the limestones were laid down, and as these are probably unusually high points on this floor, so there may be unusually deep depressions holding rocks much lower than any now known in Manitoba, the existence of which, however, will in all probability be determined only by close and long continued investigation.

"The total distance through St. Martin Lake from the head of the Little Saskatchewan to the mouth of the Fairford River is twenty-two miles and a half.

"The Fairford River flows from Lake Manitoba into Lake St. Martin, expanding in the middle of its course into a shallow, marshy lake, known as Partridge Crop Lake. The river has a total length of ten miles and a total fall in this distance of about fifteen feet. Most of this fall occurs in two rapids, one a short distance below Partridge Crop Lake and the other a mile and a-third in length, between the Fairford

Mission and Lake Manitoba. This latter is caused by a bed of compact white limestone, which crosses the river at the head of this rapid, while most of the other rapids, both in this and the Little Saskatchewan River owe their origin to banks of hard boulder clay and the great numbers of boulders that fall from them and dam back the water.

"The total distance by water from Lake Winnipeg to Lake Manitoba is sixty-three miles and three-quarters, and the time occupied in the journey was a little more than five days.

"After the week of severe and incessant labor, the Sunday at Manitoba House was thoroughly enjoyed as a day of rest.

"Monday was spent in obtaining two experienced canoe men, and on Tuesday morning we set sail for the north end of Lake Manitoba and the mouth of Waterhen River. The wind proved to be contrary, and we were obliged to beat up to Garden Island, where a day was spent running tie lines in the north-west portion of the lake, to correct some errors that had crept into its topography.

"From Garden Island we crossed to the mouth of the Waterhen River, and with a fair wind sailed up the river to the Hudson's Bay Company's post, near the south end of Waterhen Lake. From Waterhen Lake we ascended the upper portion of Waterhen River, in which there are no rapids, and skirted along the low lying, gravelly shore on the west side of the long point of land that separates Lake Manitoba from Lake Winnipegosis, till the Meadow or Plain Portage was reached, and of which a careful examination was made. This portage has been already pretty thoroughly reported on by engineers sent out at the time the old location of the Canadian Pacific Railway was being surveyed. It is about two miles in length, and runs over a low, flat ridge, the top of which is either marshy or wooded with small oak and poplar, the water in the marshes being dammed back by a ridge of sand and gravel running along the summit of the eastern slope. The top of this gravel ridge is the highest point on the portage, rising from ten to twelve feet above Lake Winnipegosis. This whole point may possibly be underlain by limestone, though none was seen, or it may be a compact ridge of till, with the exception of some of the higher, narrow ridges of sand and gravel above mentioned. A little further to the south I was informed that in seasons of high water the Indians can pass from one lake to the other in their birch canoes without making any portage at all. From the Meadow Portage we coasted along the south shore of Lake Winnipegosis to the mouth of Mossy River, calling at Snake, Spruce and other islands on the way. Numerous exposures of fossiliferous Devonian limestone were examined. The islands, both here and throughout the rest of the lake, were surveyed with a

Massey's patent floating log. A micrometer and compass survey was made by Mr. Dowling, of the Mossy River, and the shores of Lake Dauphin were run in with the floating log. Descending the Mossy River, we coasted northward along the west shore of the lake, past the old Salt Springs—where salt used to be boiled down for the supply of the Red River settlement, and from which water was collected for analysis in the laboratory of the Survey—to the mouth of Pine Creek, where there is another large saline area, from which brine was collected. From the Hudson's Bay Company's store at Pine Creek the specimens of brine and the fossils collected up to that date were shipped to Ottawa in order to avoid possible delay on my return in the autumn.

"North from Pine Creek the shore and adjacent islands were carefully examined, both in connection with any outcrops of the underlying rocks, and to gain all the other information possible about the structure of the islands, the mode of formation of beaches, &c. Many of the islands were found to be rounded or lenticular hills of boulder clay (Drumlins), lying with their longer axis parallel to the glacial striæ and rising a few feet above the surface of the water.

"A number of soundings were taken, sufficient to show the general depth of the lake in different places, and a record was also kept of any timbered areas seen, although most of the forest has been destroyed by fires that have ravaged this country in late years. We reached the mouth of Shoal River on the 30th of July, but before ascending the river I considered it advisable to examine the islands in Dawson Bay, on many of which cliffs of bedded rock were known to occur. These islands were accordingly visited, and the scientific results obtained from them quite exceeded our most sanguine expectations. They were found to consist chiefly of thick-bedded dolomites very rich in fossils of lower and middle Devonian age, rising in vertical cliffs out of from twenty to thirty feet of water. The high point on the west shore of the bay, known as Point Wilkins, was also found to be particularly interesting, as it showed the lowest sandstones of the Cretaceous rocks in this area resting unconformably on horizontally stratified Devonian limestones. Leaving these interesting cliffs for a time, we took two canoes and ascended Shoal River to Swan Lake. This was a task of considerable difficulty, as the water during the past season was very low, and in periods of high north winds the bar at the head of the river was almost dry. Swan Lake was thoroughly examined, and a survey made of the islands dotted through it. These were found to present exposures of fossiliferous Devonian limestone similar to that seen in Dawson Bay.

"At the south end of Swan Lake a small brine spring is flowing out on the shallow, muddy beach, while a short distance back in the woods a hill rises to a height of between 200 and 300 feet. Its sides are beautifully terraced, showing successive stages in the recession of the water of the general lake under which this country was submerged down to the conditions at present existing. On some of these terraces many traces are to be seen of a thick deposit of the white sandstone of the Dakota group. These Dakota sandstones have not previously been definitely recognized in Manitoba, though for a number of years they have been known to occur in the states, immediately to the south, and it has been thought that the bitumen-bearing sands on the Athabasca River are also of the same age. This discovery will form an important link in the chain connecting the typical sections in the United States with those in the far North-West of Canada. The sandstones are here found not to be bituminiferous, however, and no bitumen is seen in the underlying limestones, as there is said to be in the limestones on the Athabasca. Their position, immediately overlying the horizontal Devonian limestones, also for this district practically settles in the negative the question of the existence or non-existence of intermediate Carboniferous rocks.

"From the west side of Swan Lake an excursion was undertaken along the foot of the Porcupine Mountain to Wild Turnip River, a branch of the South Woody River, where a good section of Cretaceous beds was seen, and meanwhile Mr. Dowling crossed to Bell River, and ascended it to the summit of the mountain, also obtaining an excellent section of the Cretaceous shale and the overlying drift. North of Porcupine Mountain the 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 this lake, and with two men I struck back to the foot of the mountain and obtained a good section of the Niobrara-Benton rocks on the North Woody River. From this stream two gravel track ridges were followed alternately to near the mouth of the North 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. The valley in all its upper portion was found to be thickly filled with till or alluvial deposits. On approaching the lake, however, the river cuts a deep gorge, in which the Dakota sandstones are well shown. The whole of the wide plain or valley lying between the Porcupine and Pasquia Mountains would appear to be underlain by rich alluvial soil, and will doubtless in the near future be the home of a thriving population. Portions of it are now thickly wooded with large spruce, which if protected from destruction by forest fires will furnish Manitoba with an abundant supply of timber.

"From the mouth of Red Deer River we coasted round the north shore of Lake Winnipegosis to the two Mossy Portages, which are respectively the winter and summer highways to Cedar Lake. The western Mossy Portage was examined and surveyed by Mr. Dowling, who found it to be between four and five miles in length, running for the greater part of the distance through a deep mossy swamp, thinly wooded with small spruce and tamarac. The eastern portage runs along the summit of a gravel ridge for all but the northern half mile of its course, the land descending on either side into a mossy spruce and tamarac swamp. About the middle of the portage some small cedars were first noticed, and from here north to Cedar Lake they may be seen at intervals. An old corduroy road is still in existence at the northern end of the portage, made by the Hudson's Bay Company to facilitate the transport of their goods in carts from one lake to the other.

"From Mossy Portage we descended the east side of the lake, where, on account of the extreme low stage of the water, the underlying limestone, here found to be of Silurian or of Cambro-silurian age, was in many places visible. When the water is at its mean elevation this rock would be entirely covered.

"From the Hudson's Bay Company's post at Pine Creek I despatched Mr. Dowling with the boats to Manitoba House, where he arrived safely on the 20th of October. On the way he again examined some rock exposures in the south-eastern portion of Lake Winnipegosis, and made a survey, with the floating log, of Waterhen Lake. Meanwhile, I took horses and carts and made an odometer survey of a new cart trail back to one of the upper gravel ridges near the foot of the Duck Mountain, here connecting with my survey of 1887. I also ascended one of the forks of Pine Creek to the summit of Duck Mountain, determining the existence of the Pierre shales in this vicinity. I then drove southward and then eastward through the flourishing settlement on the Lake Dauphin plain to Manitoba House, where I arrived on the 21st of October. We then sailed southward to Westbourne, where the men were paid off, and the boats laid up for the winter.

"Returning to Winnipeg, I made a hasty trip to Deloraine, in south-western Manitoba, where a deep well is being sunk through Cretaceous shales in the hope of finding water. An excellent set of specimens from this well was obtained. The gentlemen engaged in sinking this well have shown the most commendable enterprise in their endeavor to supply a very pressing want in this beautiful section of country; and also, as soon as asked to do so, in collecting specimens from every five or ten feet bored through, in order to make the well of thorough scientific and practical value to the surrounding country. It is sincerely to be hoped that a large supply of water will be obtained as soon as the permeable Dakota sandstone is struck.

"I returned to Ottawa on the 10th of November, having been absent exactly six months.

"During the year a very large and interesting collection of Cambro-silurian, Silurian and Devonian fossils was gathered, and typical rock specimens were obtained from all the exposures of older rocks, and also from many places where the sands, clays and gravels were examined. Having a small schooner, we were able to transport them to the railway, whereas, if we had been entirely dependent on canoes, it would have been very difficult or perhaps impossible to have got them out of the country. Specimens of brine from all the principal springs in Swan and Winnipegosis Lakes and Red Deer River were also secured, and are now in the Museum of the Survey.

"One hundred and ten photographs were taken, illustrating points of geological and historical interest, and showing the general character of the country and the peculiarity of its native inhabitants. Most of these photographs were developed by Mr. Dowling in the field.

"It affords me much pleasure to acknowledge the efficient assistance that I have received from Mr. Dowling throughout the season, not only in carrying on the surveys connected with the exploration, but in carefully collecting fossils and rock specimens from any exposures visited.

"Cost of season's exploration, $2,176.73."

Dr. A. C. Lawson, assisted by Messrs. W. H. Smith and William Lawson, was engaged during the season in prosecuting geological and topographical surveys in the country north-west of Lake Superior, in continuation of the work of which he has had charge for some years past. He reports as follows:—

"The usual preliminary work of purchasing supplies and hiring men for the season was begun at Port Arthnr on 31st May, and a few days later the party proceeded to Savanne, where the survey work proper began. It was deemed expedient to divide into two parties, Dr. Lawson, as usual, devoting his time to the study of the geology of the region; while Mr. Smith, accompanied by Mr. W. Lawson, with a somewhat larger outfit of canoes and men, was engaged throughout the season in making surveys between Savanne and Pine Portage, and thence throughout the country south of the Seine River as far as Sturgeon Falls.

The nature and extent of these surveys may be briefly summarized as follows:—

1. A transit and micrometer line down the old Dawson Route from Savanne to Pine Portage, and thence to the north end of Hunter's Island, connecting there with previous surveys.

2. A transit and micrometer line from a point on the above line, running down the Atic-okan River, and thence from the Seine River to Sturgeon Falls, where connection was made with previous surveys in the Rainy Lake region. These two lines aggregate about 160 miles in length, and afford an excellent base line, to which can be tied the various more rapid compass and micrometer, or compass and log surveys, of the numerous lakes which are distributed over the region.

3. The survey of all the known lakes south of the Seine River, with prismatic compass and log or micrometer.

4. The survey of a chain of lakes in Hunter's Island which it had been found impossible to finish the previous season.

The measurements of these various lake surveys aggregate about 450 miles, and the distances so measured served as the bases for compass triangulation whereby other distances were determined. The area under survey comprised about 1,400 square miles.

Throughout this survey work Mr. Smith took careful notes of the geological features of the country through which he passed, and these, together with an excellent suite of rock specimens which he collected, will be of much service in the mapping of the region, and in giving direction to future geological examination by Dr. Lawson. Mr. Smith also visited the new iron locations on the Seine River route, which are attracting attention, and procured specimens of the ores. His topographical survey completes all the field-work necessary for the construction of the south half of the Seine River sheet. It is estimated that another season's work will be required for the completion of the northern half.

While Messrs. Smith and W. Lawson were carrying out these surveys Dr. Lawson proceeded with the geological examination of a portion of the country where topographical surveys had already been made, supplementing these by his own sketches when necessary. From Savanne he proceeded across Lac des Milles Lacs to the portage leading to Kashabowie Lake, and thence across Kashabowie Portage to Shebandowan Lake. From the west end of this lake a route leading by several long portages and small lakes was followed to Round Lake, and thence the Kahwawiagamak River was followed to Hunter's Island. Hunter's Island was the principal field of study, and this route to it was followed chiefly because it passed through a new country, which had not been before examined. The greater part of two months was spent by Dr. Lawson in circumnavigating Hunter's Island and in traversing it in various directions by the numerous chains of lakes which lie within it. The work done, together with that of a former year, supplemented by the notes and specimens secured by Mr. Smith in 1888, while making a topographical survey of the island, supplies us with all the data necessary for the compilation of a geological map of the region, the drafting of which is now under way. This sheet, which is known as the Hunter's Island sheet, will, it is expected, be ready for the engraver in the course of a month.

Hunter's Island is interesting economically, chiefly for the iron ores associated with jaspery beds which occur on its south-east side, and which are entirely analagous, geologically, to the famous iron ores of Vermilion Lake at Tower, Minnesota. Some patches of good pine at the west end of the island also are of considerable value. Having thus completed all the work that was deemed necessary for the Hunter's Island sheet, Dr. Lawson proceeded to Port Arthur for the purpose of inaugurating some preliminary enquiries into the ancient beaches and terraces of Lake Superior. In various parts of the continent the ancient shore lines of lakes which were once necessarily perfectly horizontal are found at the present day to be tilted at a considerable slope, the measurement of which affords us important data for determining the extent of the local elevation or depression of the crust of the earth in quite recent geological times.

It becomes, therefore, desirable to ascertain whether the old beaches of the north shore of Lake Superior will throw any light on this important problem. With this object in view, Dr. Lawson walked along the Canadian Pacific Railway track from Port Arthur to Terrace Bay, north of the Slate Islands. Numerous old beaches were observed and many interesting notes on the geology of the sections along the railway and the coast were obtained. It was seen that there is a regular succession of beaches and terraces which range between the present level of the lake and an altitude of probably 350 feet. It would seem from the observations made that the beaches run to higher altitudes towards the east, and it was concluded that very interesting results would be obtained by a systematic levelling of the beaches from Sault Ste. Marie to Pigeon Point. This trip along the railway occupied the latter half of August, and at its conclusion Dr. Lawson proceeded to Toronto to attend the meeting of the American Association for the Advancement of Science, in the geological section of which he read two papers on subjects pertaining to Canadian geology. On the way back some days were spent on the Huronian rocks between Sudbury and

Sault Ste. Marie for the purpose of comparing them with the analogous formations north-west of Lake Superior. On the return to Port Arthur the remainder of the season was occupied in levelling up instrumentally the old lake beaches between that town and Pigeon Point; in visiting and examining the Badger silver mine, one of the newest and most successful of the mining enterprises of the region, and in investigating certain reported finds of native copper in the townships of Blake and Crooks.

The season's work was brought to a close at Port Arthur on 17th October, when Dr. Lawson and party left for Ottawa.

Cost of season's operations for both parties $2,300.

Mr. E. D. Ingall, Mining Geologist to the Survey, has been engaged during the summer in continuing the investigation into the nature and lithological surroundings of the deposits of apatite of the River du Lièvres district in Ottawa county, P.Q.

He says: "In prosecuting this work during the past summer, the main lines upon which it had been started the previous season were adhered to, and efforts were made to further elucidate and understand the nature and origin of the pyroxenite belts, with which the apatite deposits are mostly associated, and the relationships of the same to the rocks forming the general mass of the district, as well as to add to our knowledge of the nature and habits of the apatite deposits themselves.

"In connection with the latter, as many deposits were visited and studied as the time necessarily expended upon the other branch of the work would allow of, whilst the principal mining developments of the district were visited from time to time, so as to watch for and note any new features that might be brought to light during their progress, plans being made of some of the chief of these.

"In pursuance of the first object mentioned, the main source of information on these points would naturally be found in a close study of the contacts of the pyroxenites with the surrounding gneissic and granitoid rocks, so that the investigation thus naturally confined itself to a detailed examination of these points along some of the more thoroughly worked belts, where, in the course of considerable mining developments, the ground had been sufficiently cleared of bush, &c., to give a reasonable chance of seeing sufficient rock exposures to acquire the evidences sought.

"Thus the geological work was found to concentrate itself chiefly on the broad and extended belt upon which are the considerable excavations of the Crown Hill, High Rock and Star Hill mines, time being also found to similarly investigate for some distance the belt on which are the openings of the North Star mine and adjacent properties, at which latter point, the belt being narrow and the bush and surface cover having been more thoroughly removed by clearance and bush fires, better facilities were afforded than elsewhere for acquiring the necessary data.

"With a view to illustrating some of the results thus attained, and as a necessary prelude to the purely geological part of the work, the limited areas thus dealt with were mapped accurately and in detail, where small the plane table alone was used, whilst where of greater extent that instrument was used to fill in the detail in connection with skeleton transit and chain surveys.

"In this way it is hoped to obtain a few thoroughly worked-out examples which may serve as illustrations of the numerous similar belts in the surrounding country and of their nature, associations and habits, thus possibly adding something to our stock of knowledge of the pyroxene belts and the associated apatite deposits. Such systematized knowledge, systematically applied, must necessarily be the basis of all intelligent mining ventures.

Mr. Jas. White continued attached to the party as topographical assistant, and besides laying out the transit and chain skeletons for the more detailed mining plans and some underground surveys, was mostly engaged completing the necessary surveys throughout the surrounding district for the compilation of an accurate topographical map of the area comprehending the chief mines, with a view to showing their position, means of communication and other such information pertaining to the phosphate district in general.

The topographical work was commenced under Mr. Jas. White's direction on 10th June and finished 16th September, whilst Mr. Ingall followed, and was occupied in the geological investigation from the 10th of July to the 28th of September.

The total expenditure on this work was $1,399.56.

Mr. Ingall having been recently appointed to the vacant position of Mining Engineer to the Geological Survey, in charge of the collection of the statistical and other information for the compilation of the annual report on the mining and mineral production of the Dominion, his time will be necessarily considerably encroached upon by these new duties, but it is hoped, notwithstanding, during the winter, to prepare for publication the results of the above-mentioned work in the Lièvre phosphate belt.

During the season of 1889 Dr. Bell has continued the geological survey of the district around Sudbury, on which he was engaged the previous year, and he has now completed this work over an area measuring 72 miles from east to west by 48 miles from north to south, which will be represented on sheet No. 130 of the regular series of maps on the scale of four miles to one inch. A part of this area has been surveyed into townships by the Crown Lands Department of Ontario. Some of the lakes and rivers within it had been traversed by the late Alexander Murray, of the Geological Survey, in 1856. These surveys, and also those of the Canadian Pacific Railway lines, were utilized by Dr. Bell in laying down his work, but it was found necessary to do a good deal of topographical surveying before the natural features within the limits of this sheet could be correctly mapped. In this work Dr. Bell was again assisted by Mr. A. E. Barlow, who left Ottawa for the field on the 10th of June and returned on the 18th of September, while Dr. Bell started on the 5th of July and returned on the 26th of October.

In addition to the geological investigation work of the season, Dr. Bell made a micrometer survey of Pogamasing Lake and the Spanish River, from near Spanish Forks to the township of Hyman, a distance of about seventy miles, below which the river is laid down on the maps of the Ontario Crown Lands Department and those of the late Mr. Murray. He also made a careful track-survey of Onaping Lake, which was found to be about thirty miles in length, and of a smaller lake lying parallel to it on the west side, and a similar survey of the Onaping River throughout its entire course. Mr. Barlow's time was mostly occupied in surveying the following lakes and rivers by means of the micrometer, at the same time making notes on the rocks which came under his observation: Panache Lake (which had been outlined by Mr. Murray in 1856), two small lakes which he named Wavy and Gabodin Lakes, lying to the north-east of the east end of Panache Lake, a canoe-route from Round Lake to Rat Lake, the southern branch of Veuve River, Aiginawassing, Elbow and Red Deer Lakes, the western bay of Lake Nipissing, parts of two western branches of Wahnapitæ River, and the Vermilion River from the intersection of the main line of the Canadian Pacific Railway to a point east of the township of Lumsden.

In the district covered by the above-mentioned sheet there are a few settlements, chiefly along the line of the Canadian Pacific Railway, but the district may be described in a general way as still in a state of nature. Scarcely any common roads exist, and it was therefore necessary to carry on operations principally from the railway and from the lakes and rivers as bases from which the minor explorations were made. The surveyor's lines were often useful, not only for locating geographical positions, but in facilitating journeys in the woods. Still, there were some tracts in which there were neither the advantage of such lines nor of canoe routes, and in those it became necessary to make the best traverse possible through the primeval forest.

The following are some of the most notable geological features within the limits of the above sheet: The western and north-western part of the ground is occupied principally by a great area of reddish quartz:-syenite, which extends beyond the limits of the sheet in these directions. It appears to belong to the Huronian rather than the Laurentian system. The position of the boundary between these two systems was traced north-eastward across the sheet,—the Laurentian consisting almost entirely of gneiss, occupying its south-eastern corner. There is also a considerable area of these rocks in the middle of the northern part of the sheet.

The great Huronian belt of Lake Huron runs diagonally across the whole sheet, from south-west to north-east, and embraces a considerable variety of rocks, including crystalline schists, quartzites, breccias, conglomerates, argillites, greywackés, diorites, diabases and syenites. These rocks seldom appear to run far as distinct bands with parallel boundaries, but have rather the form of elongated masses, which pinch out in both directions or give place to other rocks. The Huronian region, including the syenite areas, is traversed by diabase dykes, newer than any other rocks of the district, which are remarkable for their persistence in length. Their commonest direction is about west north-west.

Ores of copper and nickel are the most important of the economic minerals which have yet been discovered in the above district. Five mines are in operation at present. Three of them are worked by the Canadian Copper Company, namely: the Stobie, three miles and a-half north north-east of Sudbury Junction, the Copper Cliff, three miles and a-half south-west of the same point, and the Evans, one mile further south. The Dominion Mineral Company is working a mine, situated about a mile north-east of the Stobie, and the Messrs. Vivian, of Swansea, are opening the Murray Mine, on the main line of the Canadian Pacific Railway, three miles and a-half north-west of Sudbury Junction. Similar deposits of these ores have been found in various localities within the district examined, and these will be described in the fuller report to follow.

The general character of the mixed ore and its mode of occurrence are nearly the same in all three localities. It consists of pyrrhotite in which some of the iron is replaced by nickel mixed with more or less chalcopyrite. These sulphides are mingled with fragments of all sizes of quartz-diorite in some cases, and of a kind of greywacké in others, so that the ore has often the appearance of a conglomerate. The ore-bearing masses are of all sizes, and they take the form of lenses or pod-shaped bulges, conforming with the large scale lamination of the strata. Around the richer ore bodies the country rock is filled with coarse and fine impregnations of the sulphides. These deposits may be described as "stockwerks" in which the vein structure is very obscure. The strata of the whole district generally stand at high angles, approaching the perpendicular, so that the underlie of the ore-masses is usually very steep. The rocks immediately associated with them are not always the same, but it most frequently happens that the ore itself occurs in some form of diorite, more particularly in diorite breccia, with quartz syenite or gneiss on one side. The diabase dykes above referred to were seen near the ore deposits in several instances and further search may show their presence in all cases. It would not be surprising if they should prove to have had some connection with the concentration of the ore in these masses, which may be locally enriched portions of certain ore-bearing belts.

Two smelting furnaces, capable of reducing 300 tons of ore a day, are in operation at the Copper Cliff mine. One of them has been running without interruption for nearly a year. The other went into blast on the 4th September. Both the Dominion Mining Company and the Vivians are erecting similar blast furnaces.

The rock specimens collected in the above district during the season number 285, but 665 had been obtained in the same district the previous year, making a total of 950 specimens.

The cost of the season's field work was about $1,800.

Mr. Low was employed during the past summer in completing the geological investigation of the N. E. sheet of the Eastern Townships map on the north side of the St. Lawrence River, comprising the southern portion of the counties of Quebec and Portneuf—the work extending from Ste. Anne de la Parade on the west to the Montmorency River on the east.

He left Ottawa 23rd May and was engaged until 17th June making a micrometer survey of the Ste. Anne River and its north branch from the northern limit of the sheet to the St. Lawrence.

Odometer surveys of the roads to the west of the Jacques Cartier River occupied the time to 31st July, when a geological examination of that river was made, which lasted until 5th August.

The road survey to the eastward was then continued up to 1st October, with four days spent in making a section along the north shore of the St. Lawrence, from Deschambault to Cap Rouge.

In all eight hundred miles of surveys were completed, comprising six hundred and four miles of odometer, seventy-five miles of micrometer, seventy-one miles of pace, and fifty miles of track surveys. By these surveys the contact of the Laurentian gneisses with the Cambro-silurian limestones and shales was traced out and the boundaries of the latter formation established.

The rocks of the Laurentian area were carefully examined for economic minerals. Magnetic iron ore in small disseminated masses was found to be common in many localities, but never in sufficient quantities to be practically worked, but showing that such masses may exist.

The prevalent rock being a mica gneiss without pyroxene or limestone, no phosphate areas were found, and are not likely to be discovered in this vicinity. The areas covered with drift and superficial deposits were noted, and will be mapped on the sheet, as they are of considerable economic importance, from the deposits of bog iron ore which occur associated with all, or nearly all, of the stratified sands of the region.

The work of Dr. Ells during the past season was, for the most part, confined to the south-west quarter sheet map of the Eastern Townships, and to that portion lying south of the Grand Trunk Railway, between Acton and Richmond, to the Vermont boundary.

In addition, however, accurate chain and micrometer surveys were made of the Black Lake and Thetford asbestos areas, in order to complete the proposed map of that district. The area examined during the season contains nearly all the outcrops of serpentine in the south-western section. A careful study of these was made to determine the presence of asbestos-bearing belts. The character of the serpentine in this section appears to present several points of difference as compared with that from Thetford and Coleraine, and in so far as examined asbestos in workable quantity has not yet been found in it.

The results obtained during the past season are not yet in shape for publication, more particularly as regards the determination of the exact age and the relative position of several of the slate formations. The Sutton mountain range of Pre-Cambrian schists and associated rocks was carefully traced to the River St. Francis, and the position of the black slates series, as intermediate between these, and the overlying red and green slates and sandstones of the Sillery, verified; but further careful examinations of these belts will be necessary during the coming season in order to determine from the evidence of fossils, if possible, or in some other way, the exact horizon of the rocks which extend across into Vermont, and in which surveys are now being carried on by the United States geologists, more especially by Prof. Walcott.

But little work is being done in this section at present in the way of mining. The new mine of the Memphremagog Mining Company, lot 28, range ix, Potton, was examined. It shows a body of ore, mostly iron and copper pyrite, about sixteen feet thick, and extending for several hundred yards. This is capped by a considerable body of bog iron ore, which should be valuable if facilities for shipping and smelting were afforded. But little work other than exploratory has yet been done at this place.

Some efforts have been made to develop asbestos areas on the east side of Brompton Lake, on lot 26, range x, Brompton Gore, but at present this locality is accessible with difficulty, and the indications are not equal to those presented at Thetford and Coleraine. On lot 7, range xv, Cleveland, the slate quarry, formerly Stubs', has been re-opened by Mr. Bedard and others and some very good slate extracted. At the time of my visit, however, this work was not sufficiently advanced to warrant an opinion as to its ultimate success. On lot 18, range x, Brompton Gore, a new quarry, in red rock slate, has been started.

Quarries of excellent granite are in operation on the east side of Lake Memphremagog, in the area which extends across the Vermont boundary.

During the past season Dr. Ells was assisted by Mr. Giroux. The surveys of lakes, roads and streams aggregate 750 miles, of which 17 were by chain, 87 by micrometer, 105 by pacing and 547 by odometer. A large collection of graptolites in a very fine state of preservation was obtained from the black slates on the west side of Memphremagog Lake.

The cost of the season's operations was $1,100, and occupied from the 27th May to the 18th October inclusive.

Mr. F. Adams left Ottawa on 10th July, 1889, and spent about three weeks in continuing the examination of that portion of the St. Maurice district which is included in the N.W. sheet of the Eastern Townships map. On this work he reports as follows:

"I proceeded first to St. Michel des Saints, a village situated in the township of Brassard, in the county of Berthier, and having secured a canoe and two men, made an examination of the Rivière du Poste (or Rivière au Lac Clair, as it is called on our map), as well as of the lakes out of which it flows. I then examined the country about the Red Canoe River and descended the Matawin to Birch Rapids, about fifteen miles from its junction with the River St. Maurice. I then returned to Montreal by way of Shawenegan, reaching that city on 2nd August. The country examined is all underlain by Laurentian gneiss, that along the Matawin, east of Ile de France, dipping at very low angles, and in many places lying flat. Thin bands of crystalline limestone were found at several places on the eastern arms of Lac Croche (Lac Long), as well as on the discharge of Lac Clair, and at three points along the course of the River Matawin, viz.: (1) in woods about four miles north of Rapids Lacroix, (2) just above Rivière à l' Aigle, and (3) two miles and a half below this river. In the last mentioned locality the limestone band is about ten feet thick. These limestones hold little grains of serpentine, mica, apatite, &c., and in character are identical with the Laurentian limestones elsewhere. Bands of quartzite, and occasionally thin bands of pyroxenite, are also found associated with these gneisses; their presence, taken in connection with that of the crystaline limestones, shows that the series cannot be considered as belonging to the lower or fundamental gneiss, as had previously been stated. The only anorthosite which was observed, with the exception of that in the township of Shawenegan, which was mentioned several years ago by Mr. McConnell, was a small band which crosses Ile de France, situated in the River Matawin, a short distance below the mouth of the Rivière du Poste, and which was again met with about five miles north of the Matawin, between Red Canoe Lake and the Riviére du Poste."

Cost of season's exploration, $158.10.

The Rev. Abbé Laflamme has made some further interesting observations in working out the geology in the Saguenay region and in determining the position and approximate extent of certain areas of Cambro-silurian limestones which lie there in depressions in the Laurentian gneiss, but are often largely covered by superficial deposits. Such areas are of considerable economic importance as future sources of lime. Further details of the work in this district will be given in the Annual Report.

Cost of season's work, $400.00.

On the work in northern New Brunswick and Quebec, Professor Bailey reports as follows:

"The work of the summer of 1888 having been devoted chiefly to

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the study of the Silurian system in its extension northward to Lake Temiscouata, as well as east and west of the latter, and to the preparation of the map sheet (No. 17 N.E.) illustrating the same, that of 1889 has had for its main object the study of the Cambrian and Cambro-silurian rocks, making up a portion of the so-called Quebec group which lies between the lake referred to and the shores of the St. Lawrence, being the area to be included in the next succeeding sheet (No. 18 S.E.) of the series of maps of New Brunswick and Quebec.

As connected with this work, and with a view to a better understanding of the Cambrian strata of the succession, a few days were devoted, in company with Mr. G. F. Matthew, at the commencement of the season, to a revision of those which occur in the valley of the St. John River, in King's county, N.B., and which were referred to in the report of 1873. This revision led to the recognition, in the district mentioned, of most of the sub-divisions of the Cambrian system, as distinguished in the St. John basin, including the red rocks of the series (Series A), bands *a*, *b* and *c* of Division 1 (Series B), and an imperfect representation of Division 2; while Division 3, containing the Dolgelly and Arenig faunas, appeared to be wholly wanting.

In Division 1, Band *b*, of Caton's Island, examples were collected of *Obolus pulcher*; Matthew, a fine species resembling *Lingula* (?) *favosa*, Linnarson, of the Eophyton sandstone of Sweden, but larger, and (at Belyea's Landing) specimens of *Volbrothella tenuis*, a species of the blue clay of Russia, thus, according to Mr. Matthew, extending the vertical range of this species in New Brunswick from near the base of the Cambrian deposits upwards nearly to the *Paradoxides* beds. The fossils referred to have been forwarded to the office of the Survey.

After the examinations last described I proceeded northward to the Temiscouata region, devoting a few days, on the way, to search for fossils in the supposed Cambro-silurian rocks of Carleton county, but without adding anything to the information previously had upon the subject.

Upon reaching my proper field of work my first efforts were given, in accordance with your instructions, to the examination of the region about the head waters of St. John River and adjacent to the Quebec boundary, with a view to determine, if possible, the limits of the Silurian basin in that direction, and the distinction between the latter and the resembling rocks of the Eastern Townships, which, formerly regarded as Upper Silurian, have recently been referred by Dr. Ells, upon palæontological and stratigraphical grounds, to an earlier horizon. For this purpose a traverse was made across the country from L'Islet, on the St. Lawrence, to Big Black River, and down the latter to the

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St. John, this being followed by the ascent of the last-named stream to one of its principal sources in Baker Lake, and a return traverse, by way of the north-west branch of the St. John and its tributary, the Daaquam, to St. Magloire and St. Valier. These traverses afforded good opportunities for observing some of the varying aspects of the so-called Quebec group, the members of which are generally well exposed, but as regards the rocks in the country lying to the south of the latter, the age of which was one of the chief questions sought to be determined, the results were much less satisfactory, owing chiefly to the almost entire absence of any exposures from which conclusions could be drawn. As far as could be seen no appreciable change in the character of the slate occupying the valley of the St. John was discovered, nor any reason for regarding the strata about its head as other than an extension of those of Silurian age found around the lower half of Lake Temiscouata, and over large areas in northern New Brunswick, Quebec and Maine. At one point only (the falls of the North-West Branch) were they found to be fossiliferous; but the remains, in the form of branching and corrugated stems of plants, were too imperfectly preserved to be of any value in the determination of the age of the strata. With the view, if possible, of obtaining further information upon the subject, a few days were subsequently spent, in company with Dr. Ells, in the vicinity of Sherbrooke, where a similar doubt had arisen as to the age of certain slates which hitherto had been regarded as Silurian, but which Dr. Ells now considers as belonging to the Cambro-silurian. The close resemblance of portions of them to the slates of the Upper St. John valley is certainly quite marked, but without more extended information than we have as yet been able to obtain upon the subject we do not feel justified in concluding that the two are of the same age.

Examinations were also made of portions of the country adjacent to the Temiscouata portage road and in the vicinity of Rivière du Loup, St. Paschal, Kamouraska, Cacouna and L'Islet, partly alone and partly in company with Mr. McInnes. Having taken the field on the 1st of July, my work was continued, with the interruption of a few days only, until the 1st of October."

Mr. McInnes left Ottawa on the 10th of August and arrived at Rivière du Loup on the 12th. The first part of the season was spent in pacing a section along the coast from the long wharf at Rivière du Loup eastward as far as St. Luce. But few fossils were found in the pre-Silurian rocks during the season. Fucoidal marking, or trails, occur in the greenish-grey slates which underlie the limestone conglomerates, and were noticed at varions points along the coast.

Numerous fragments of trilobites were found in a pebble in the limestone conglomerate near Trois Pistoles, and obscure brachiopods and a fragment of a trilobite in bands of fine limestone conglomerate, enclosed in soft shale, at the portage road above Rivière du Loup.

A few days were spent on the Rimouski River, in an examination of the high ridge south of Lac Ferri. This was found to be made up of undoubted Silurian strata, highly contorted slates, with bands of limestone. A collection of fossils was made from the Silurian shales at Tuladi Falls, on the Rimouski River. These have not yet been examined.

The remainder of the season, after the 20th of September, was devoted to a survey, by prismatic compass and odometer, of the roads of the district. Two hundred and sixty-two miles were surveyed in this way, and about one hundred miles by pacing. The field work was closed on the 23rd of October:

" In the study of the region referred to we have necessarily had constantly in view the work of previous laborers in this field, and more particularly the recent investigations made by Dr. Ells and his associates in the Gaspé peninsula, and by the same gentleman, as well as by Dr. Selwyn and others in the Eastern Townships and around Quebec. As the results of these investigations, in common with our own, differ in important particulars from those of earlier investigators, and tend to place the age and succession of the so-called Quebec group in a very different position from that which it first occupied, we had hoped that the report of Dr. Ells, embodying these results, would have been in hand during the progress of our own field work and have been available for purposes of comparison. As this, however, has not been the case, we are at present unable to judge how far our conclusions are concordant with or likely to be modified by those obtained by more extended examinations. In view of this fact and the desirability of the avoidance of any conflict of opinion, it is suggested that a more lengthened report upon the work here reviewed be postponed until such time as will allow of a further study of the important questions involved."

Mr. Chalmers left Ottawa on the 2nd of May, with instructions to continue the exploration and mapping of the superficial deposits of southern New Brunswick, on which he had been engaged during the two previous seasons (1887 and 1888). Mr. E. W. Swinyard accompanied him as volunteer assistant. The area on which Mr. Chalmers has now spent three seasons is that delineated on the three $\frac{1}{4}$ sheets—1 S.W., 1 S.E. and 1 N.E.—in which lie the counties of Charlotte, St. John, King's, the chief part of Queen's, and portions of Albert, Westmoreland and Sunbury. The survey of the surface geology of this area is now completed, at least as far as the nature of the country will admit of such being done in detail. Considerable portions are still unsettled and in a wilderness state, and in these, of course, the study and mapping of the surface deposits could only be done in a very general way. The data on hand seem sufficient now, however, to enable the surface geology to be exhibited on the three sheets referred to with a considerable degree of detail, and to prepare a report thereon. This will be done during the coming winter.

The main portion of the past season's work was on the surface geology of sheet No. 1 N.E., that is in the counties of King's, Queen's, Albert and Westmoreland; but unfinished portions of the districts examined during the two previous seasons were also studied. Much difficulty was experienced in determining the mode of glaciation and the distribution of the superficial deposits in the hilly country lying to the south of the great Carboniferous overlap. In the cleared and settled parts, however, careful investigations have been made in regard to striæ, boulder-clay, stratified deposits, alluviums, agricultural character of the soil, forest covering, &c., and the results obtained will, it is hoped, serve to elucidate, in some degree, the problems which perplex students of surface geology.

On the 2nd of July Mr. Chalmers engaged Mr. W. J. Wilson, of St. John, to examine and map, under his direction, the southern part of Queen's County, included in sheet No. 1 N.E. Mr. Wilson continued this work till the 9th of August, and showed himself competent to perform the duty assigned him in a satisfactory manner. Mr. Chalmers further reports as follows: "The glaciation of the eastern part of the area embraced in ¼-sheet 1 N.E., in which lies the north-eastern extension of the ridge or plateau bordering the Bay of Fundy, was investigated with some care, and facts of much interest discovered. This ridge forms a prominent feature in the landscape, being higher than any part of the country, except the north-western highlands or the Gaspé peninsula. Here, therefore, we might naturally expect to find traces of a continental glacier, if any such ever swept over the eastern part of New Brunswick. None were observed, however; on the contrary, great masses of decayed rock *in situ* encumber its northern and north-western flanks, while along the valleys of rivers descending from it northwardly into the Petitcodiac striæ were found clearly indicating northerly ice movements. Along the Petitcodiac valley, however, which lies below the 200 feet contour line, striæ were seen to follow its course, showing ice movements in an easterly direction. It is evident that local glaciers and icebergs were amply sufficient to produce all these phenomena.

On the summit of the Bay of Fundy ridge or plateau referred to, local areas which served as gathering grounds for glaciers sent some of these off towards the Bay of Fundy. A large number of facts relating to the glaciation of the district will be given in the detailed report.

Excellent opportunities for studying boulder distribution are afforded in eastern and southern New Brunswick. One fact worth noting here is that while boulders from the Bay of Fundy pre-Cambrian ridge are found to have been transported northwardly over the low Carboniferous area, none from the latter rocks were found upon the ridge itself. The older ridges of crystalline rocks have, it would seem, been the centres of boulder distribution, and have sent off waste material in all directions around them. Along coasts and areas submerged during the Post-Tertiary period various distributing agencies seem to have been in active operation, rendering boulder distribution on these lower levels a somewhat complex problem.

Till or boulder-clay is found wherever there are traces of glacier or iceberg action, and in some places where there are none. My study of the boulder-clays in New Brunswick has led me to the conclusion that they have formed in two or three different ways, viz.:—(1) by land ice or icebergs, these two producing similar deposits; and (2) by the kneading and compacting of ordinary decayed rock material *in situ* by ice passing over it, or simply by the weight of ice and snow acting upon it, while saturated with water; and, in some cases, in their beds, by a mechanical assorting of the clays, gravels, &c., somewhat in the manner that hardpan is produced. The first two usually contain transported and glaciated materials; the last do not, except on the surface. Another kind of deposit which resembles boulder-clay, but which occurs in limited quantities, is that of landslips. These landslips may sometimes have produced striæ. It is found along the base of cliffs and of mountains, &c., and is without glacial boulders.

The above classification may render some slight change in the definition of the terms till or boulder-clay necessary. Full details respecting them will be given in my forthcoming report.

The examination and study of the other superficial deposits in the area under consideration have revealed no new facts. I shall now, therefore, briefly refer to the materials of economic importance observed in connection with the work during the past season.

Peat bogs are numerous and well developed near the Bay of Fundy coast and in many places inland. Those near Musquash, Popelogan and Digdeguash Rivers are quite extensive. Lying just east of Musquash Harbor is a bog covering an area of 450 acres and 20 feet in depth, which is now about to be utilized in the preparation of "moss litter." This is an article used in stables as bedding for horses. Owners of studs in the United States have for some time been looking for a material for this purpose sufficiently light and porous to be an absorbant of the liquids, moisture and ammonia which collect in stables, and which could afterwards be used as a fertilizer in gardens, &c. A few capitalists from St. John, St. Stephen and other places have formed what is known as the Musquash Moss Litter Company, and having purchased this bog, are now erecting buildings and machinery there for the preparation of this article, which, it is claimed, is well adapted for the object intended, and as good as the imported European moss litter. The kind of peat used is not the upper or living peat, nor the deep-lying, decayed material, but that between the two, in which the mosses and rootlets are only partially decomposed, and which has the fibres nearly whole. The chief process in its preparation is depriving it of the water, of which it contains 90 to 95 per cent. This is done by a plunger, by pressing it between rollers and by evaporation. When thoroughly dried it is packed in bales for shipment, and is worth $15 to $17 per ton in the principal United States cities. This new enterprise promises to be successful.

Brine springs are found at Sussex, at Salina, on Salt Springs Creek, and at Bennett's Brook, near Peticodiac. Five or six hundred bushels of salt per annum are manufactured at Sussex. This is all consumed locally, and used chiefly for table and dairy purposes. Several springs occur near the site of these salt works. A boring 125 feet deep was recently sunk at one of these springs—13 feet of it through surface deposits and 112 feet in rock. The object was to find the salt rock, but nothing of the kind was met with. The strength of the brine, I was informed, increased slightly till the solid rock was reached; beyond that it did not perceptibly change. At Salina an attempt was made some years ago to manufacture salt from the brine of the surface springs there, but was discontinued. Possibly a series of borings might result in improving the quality of the brine, but none have yet been made. At Bennett's Brook nothing has been done to utilize the springs there, to my knowledge. In all these places the brine contains a considerable percentage of sulphate of lime or gypsum. There appears to be less, however, in that of the Sussex Springs than at Salina or Bennett's Brook. The salt manufactured at the Sussex works is said to be of a superior quality.

Medicinal springs are met with at Apohaqui and at Havelock

Corner, King's county. The one at the former place, which is situated about a mile from Apohaqui station, Intercolonial Railway, has attained quite a reputation for its therapeutic properties. It is an alkaline water, and is said by chemists to resemble the famous Vichy water, and also to be a natural emulsifier. Favorable mention has been made of it in the *Canada Medical and Surgical Journal*, and it has been used in the General Public Hospitals of Montreal and St. John, N. B.

The Havelock mineral water has, for some years, had a local reputation as a remedy for certain diseases; and as an extensive deposit of mud surrounds the spring, it might be utilized for the establishment of "mud baths," which are said to be beneficial in the treatment of some diseases.

Infusorial earth has been reported as occurring at Fitzgerald Lake, St. John county, and at Pollett River and Pleasant Lakes, King's county. The deposits at the two first mentioned places are quite large. Mr. Wm. Murdock, C. E., of St. John, who owns the one at Fitzgerald Lake, is endeavoring to introduce this material into use in some ways. Clays and sands suitable for brick-making, &c., occur in many parts of the district. Near Sussex, and at St. John and Fairville, there are large brick-making establishments.

On the 21st of October Mr. Swinyard left for Ottawa. Afterwards I visited the ship railway now under construction across the Isthmus of Chignecto. In an excavation which is being made for docks in the salt marsh at its western end, the following series of deposits is disclosed:– (1) Marsh mud, 5 to 10 feet; (2) fine-grained, stratified blue clay, holding numerous shells of *Mya arenaria* and *Macoma fusca*—thickness, from a few inches at one end to five to eight feet at the other; (3) peat or humus, six to fifteen inches thick, containing roots and stumps of small trees, chiefly hacmatac, and in some places portions of the stems. This peat or forest bed evidently grew on a sloping bank at the border of a lagoon or quiet inlet. The lowest part of it is now twenty feet or upwards below the level of high tides in the Bay of Fundy.

At Aulac station, Intercolonial Railway, which is on the great Tantramar salt marsh, a boring 305 feet deep was put down under the direction of P. S. Archibald, chief engineer, Intercolonial Railway. This boring shows likewise (1) marsh mud, eighty feet; (2) "turf and bog;" (3) red clay, &c. These facts clearly establish the conclusion that a subsidence has taken place here since the growth of the peat beds, and confirms the observations made previously by Sir J. W. Dawson, (Acadian Geology, 3rd ed., p. 13).

Later on a cursory examination of the surface geology of the northern and western parts of Nova Scotia was made. In Pictou county striæ and transported boulders, showing northerly ice-movements, were observed. In Annapolis valley boulders derived from the South Mountain were also found strewn about in profusion. Numerous facts having a close relation to the surface geology of southern New Brunswick were noted.

Field work was continued until the 14th of December.

Cost of season's explorations, $997.75.

The district examined by Mr. Fletcher in Nova Scotia in 1889 comprises a portion of Pictou and Colchester counties, lying between the Gulf of St. Lawrence west of Pictou harbor, and Cobequid Basin, including the valleys of Toney, John, Waugh and French Rivers, on the north side of the Cobequid Hills, and of the Salmon, North, Chiganoise and Debert Rivers on the south side of these hills. The northern part of the district is being opened up by the short line of railway from Oxford to Pictou, now nearly completed, which will pass near the celebrated red freestone quarries of River John, Tatamagouche and Toney Rivers.

Along the north side of the hills, as far west as Waugh River, runs a belt of red conglomerate, described as Permian in previous reports, of the same geological age as that of New Glasgow, interstratified with red grit, sandstone and marl, and overlaid by grey sandstones, like those of Pictou and the West River. These are succeeded in turn by brownish and red sandstones and marls, with one or two thin layers of limestone. They form the rich agricultural country which borders the Gulf shore. All are affected by important east and west faults. Associated with the conglomerates, and also occasionally with the grey sandstones are veins of albertite and of baryte. The veins of albertite are not, however, confined to these rocks. Hitherto no veins of greater thickness than four inches have been found, and these are lenticular and irregular. Barytes was quarried to some extent in the grey sandstone of Hodson, near River John, some years ago, but at present none of the known deposits are being worked, none of them perhaps warranting a large expenditure for exploitation. Small seams of bituminous coal have been discovered in the grey sandstone, but none seem to be persistent.

Reference has often been made to the grey sulphide and carbonate of copper found associated with carbonized plants in calcareous, concretionary beds among the grey sandstones of this formation, or as nodules in red and green marls. In many places, but particularly on Waugh River and French River, these ores have been largely but not profitably worked.

The rocks of the eastern slope of the hills, from Salmon River to Great Village River, near the Londonderry iron mines, consist for the most part of the brick-red crumbly sandstone and conglomerate, called Triassic by Sir J. W. Dawson, underlaid here and there by Carboniferous and probably also by Permian rocks, in some of which unimportant seams of coal have been discovered.

The structure of the Cobequid Hill is much more varied and interesting. No evidence of the age of the trap, felsite, syenite, diorite and schistose rocks was found on the north side of the hills, where they are immediately overlaid by Permian strata evidently newer; but on the south side and towards Earltown, similar rocks cut Silurian and Devonian in such a manner as to make it appear probable that they are igneous and younger than these sedimentary strata. The Silurian is confined to small areas at and near Earltown, in Waugh River, and at Wentworth railway station, the principal sedimentary rocks being an extension of the Devonian slates of Mount Tom and of Waters' Hill, and McCulloch Brook, at the north-western corner of the Pictou coal field, similar to a group containing iron ores in Guysboro', Antigonish and Pictou counties, including the iron ore belt of the Londonderry mines, in the slate of which, on the I. C. R., and many of the brooks of the neighborhood, many well preserved remains of plants have been discovered.

The small coal seams of West River, Riversdale and Kemptown, with their associated slaty shales and quartzites, have been traced in the North, Chiganoise and Debert Rivers, where much money has been spent in attempts to find them in workable shape. In every case in which the including strata have been followed to contact with the syenite and diorite of the hills, they have been found greatly altered.

Towards the close of the season, several weeks were spent in a further examination of the Pictou coal field, in which 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 the field. A visit was also made to Kennetcook Corner, where coal has been reported to occur; but the seams are all apparently too small to be workable, and the basin in which they lie, between lower Carboniferous limestone and gypsum, is very narrow.

During the past summer two companies began to work the iron ores of the East River at Pictou. One of these, under the management of Mr. H. V. Leslie, of New York, has begun the construction of a railway from Sunnybrae to New Glasgow, which is projected to extend to the harbor of Liscomb, on the Atlantic coast. The second company, under the management of Mr. Graham Fraser, of New Glasgow, has also surveyed a line of railway from the iron mines to the I. C. R., near the fork of the East River, and vigorously pushed the development of the mining areas. The mining has been done on a large vein of excellent limonite, which follows the contact of Silurian and Cambro-silurian rocks with Carboniferous limestone in the valley of East River. The same company is also mining a vein of excellent red hematite at Newton Mills, Stewiacke, and another near Maitland. Other discoveries of red hematite have lately been made in the hills at the head of French and Sutherland Rivers, in Pictou county. Mr. Fletcher was assisted during the summer by Mr. M. H. McLeod, and for nearly three months by Mr. Archibald Cameron. Field-work was begun about the end of May and continued to the middle of December. Mr. Faribault continued his explorations on the gold-bearing series of rocks in Colchester and Halifax counties, and reports as follows:—

"The district surveyed lies westward of that surveyed in 1884 and northward of that surveyed in 1887 and 1888. It comprises, in Halifax county, the whole of the basin watered by the Musquodoboit River and the head waters of the West Sheet Harbor, Tangier, Ship Harbor and Gay's River; and, in Colchester county, the south branch and the south-eastern tributaries of the Stewiacke River and the St. Andrew's River.

Narrow basins of lower Carboniferous rocks extend along the Musquodoboit, Gay's, Stewiacke and St. Andrew's Rivers, containing large deposits of gypsum and limestone, and lie uncomformably upon the sharply folded auriferous rocks of the lower Cambrian. The folding of these latter rocks, and more especially the anticlinal folds, were carefully examined and traced out, on account of their close relation to the richest auriferous belts. The Caribou and Moose River gold mining districts are situated in the region examined. They are now extensively worked, with steady, good returns. Auriferous quartz veins have also been opened up on Fish River, Gay's River and the south branch of the Stewiacke River, but none of them have so far been worked to any extent."

Mr. Faribault was assisted, as in the previous year, by Messrs. A. Cameron, J. McG. Cruikshank and P. A. Faribault.

An area of some 350 square miles has been surveyed. The season's work extended from the 16th of May to the 1st of October.

Cost of season's work by Messrs. Fletcher and Faribault, about $2,000.

Mining and Mineral Statistics.

Mr. Brumell was occupied during the winter and spring in preparing the report on the Mining and Mineral Statistics of Canada for 1888. About 3,000 circulars were sent out, and were followed by about two thousand five hundred letters asking for the returns. Fifteen hundred were received.

The work was under the supervision of Mr. E. Coste, M. E., till March, when he obtained leave and eventually resigned his position. A summary statement of the totals of the mineral production for 1888 was published in March, and the detailed report, completed by Mr. Brumell, was published and issued in October, and forms Part S, Vol. IV., of the Annual Report of the Survey.

Of the past summer's work Mr. Brumell reports as follows:

"I left Ottawa on 27th August last to visit the various places in southern Ontario, where boring operations were in progress. The counties visited were Welland, Lambton and Essex, in all of which drilling is being actively carried on.

In Welland county a company has been in operation since the month of June last, and had, at the time of my visit, completed one well, which attained a depth of 846 feet, and had begun a second. From the first well a flow of gas of 1,000,000 cubic feet had been obtained, though subsequent to my visit this well was shot, and the flow increased to about 1,750,000 cubic feet.

An accurate log and specimens were obtained of this well and also of others in the Niagara Peninsula. In August last eight wells had been completed in the Peninsula. Of these three are at Port Colborne, two at Niagara Falls South, and one each at Thorold, and at St. Catharines and in the Township of Bertie. A very small flow of gas was obtained in the well at St. Catharines and at Thorold, while from the wells of Port Colborne there is a total production of about 50,000 cubic feet per diem. It is understood that the burning spring at Niagara Falls is being supplied with gas from one of the wells recently sunk at that place.

At Bertie and Port Colborne the gas was obtained from the upper beds of the Medina formation, which is reached at these places at a depth of 735 and 730 feet respectively. At Niagara Falls the gas comes from a depth of 201 feet, at which depth the bore is in the lower beds of the Niagara shales, while at Thorold and St. Catharines the flow is obtained from the lower part of the Trenton series, in the former place at a depth of 2,394 feet, or 489 feet in the Trenton limestone, and at the latter in a sandstone at a depth of 2,185 feet, or 13 feet below the limestones of the Trenton series.

Two more wells have been drilled in the townships of Bertie and Humberstone, to a depth of 851 and 836 feet respectively, having a flow of gas of about 500,000 cubic feet per diem each, the flow in both cases being from the Medina sandstone.

In Lambton county the oil fields of Enniskillen township are still being extensively drilled upon. A number of drillers living in Petrolia and Oil Springs were interviewed, and logs and information regarding wells throughout the province were obtained from them.

In Essex county exploration for gas is being continued. It has, however, been obtained in quantity, but in one well, namely, "Coste No. 1," which has a daily flow of 10,000,000 cubic feet. This well, drilled to a depth of 1,031 feet, is situated in the township of Gosfield, lot 1, concession 3, eastern division. Wells had recently been completed at and near Kingsville and at Comber, and drilling was, in September, being carried on at Amherstburgh, Essex Centre, Marshfield, Kingsville, Leamington and Blytheswood. The well at Marshfield, being sunk for Messrs. Walker & Sons, of Walkerville, will be watched with considerable interest, as it is the intention of the firm to carry this drilling down as far as the Trenton limestone.

Logs and specimens of drillings were obtained of most of the wells in the county. In order to further work out the underground geology of the province in connection with the boring operations, elevations were obtained of many of the wells, their relative levels to the nearest railway station being generally obtained. Accurate instrumental measurements were made when necessary.

About 150 logs or records are now on fyle in this office, which number is constantly being supplemented as operations continue.

Mr. Brumell returned to Ottawa on 3rd October, after having, in addition to the counties named, visited and obtained information in regard to borings at London, Brantford, Hamilton, Toronto and Whitby. Since his return he has been preparing the circulars for the Mining and Mineral Statistics for 1889, and in constructing from the data he obtained during the summer, and from all other available sources, maps and sections on which it is proposed to show the location of the numerous borings that have been made, or are now in progress in Ontario; also the depth of each boring, and the nature of the strata passed through, and the strata in which gas, oil or water was obtained.

Mr. E. D. Ingall, M.E., Associate of the Royal School of Mines, has now been appointed to succeed Mr. Coste, and will henceforth be in charge of the Mineral Statistics Division, and be assisted by Mr. Brumell.

Chemistry and Mineralogy.

The report handed me by Mr. Hoffmann on the work carried on in the Chemical Laboratory also embraces that in connection with the Mineralogical Section of the Museum, to the arrangement of which he has devoted much time and care.

Mr. Hoffman reports as follows :—

"The work carried out in the Chemical Laboratory during the past year was of an almost exclusively economic character, and embraced—

1. Analyses of coals, lignites and other fossil fuels.
2. Analyses of iron and copper ores.
3. Analyses of limestones and dolomites.
4. Analyses of mineral and other waters.
5. Gold and silver assays.
6. Miscellaneous examinations.

The number of mineral specimens received for examination amounted to 472. A large number of these were brought in by visitors desirous of having them identified and obtaining information in regard to their economic value, and this information was communicated either at the time of their calling or, where a more than cursory examination was called for, subsequently by letter. The number of letters written, most of which partook of the nature of reports, amounted to 205.

Mr. E. D. Adams, in the capacity of Assistant Chemist, rendered good service up to the time of his leaving for field work in July.

Mr. R. A. A. Johnston has, as Junior Assistant Chemist, diligently applied himself to the work entrusted to him. In addition to the gold and silver assays, he has, as opportunity afforded, made further analyses of limestones and dolomites, besides carrying out a great many minor examinations.

In the Mineralogical Section of the Museum a large amount of work has been carried out in the way of labelling and re-adjusting specimens. The manuscript catalogue of the scientifically arranged collection of minerals is, as stated in my last report, completed, and that of the economical collection of rocks and minerals is now almost so. Apart from the replacement of numerous specimens, already represented, by more typical ones, the collection has been augmented by the addition of some 140 others, including the following presentations:—

Allan, W. A., Ottawa, O.:—
Hematite, from the west half of lot 28, range 5, of the township of Oso, Addington county, O.

Allison, J. F., per Dr. G. M. Dawson:—
Chalcopyrite, from the British Columbia Copper Company's mine, South Similtamen River, B. C.

Bedard, —, per Dr. Ells:—
Roofing slate, from Bedard's quarry, lot 5, range XV., of the township of Cleveland, Richmond county, Q.

Boulanger, Horace, J. P. for Keewatin and Chief Factor in charge at Norway House, per Mr. J. B. Tyrrell:—
Serpentine, from the extreme north end of Reindeer Lake, N. W. T.

Brock, S. R, Alwyn, Ottawa county, Q.:—
Phlogopite, from the township of Alwyn, Ottawa county, Q.

Brown, John R., St. Alice Hotel, Harrison Hot Springs, B. C.:—
Iron ochre, from Silver Creek, Harrison Lake, twenty miles north of Harrison Hot Springs, B. C.

Breels, Joseph, East Templeton, Ottawa county, Q.:—
Fluorite, from lot 15, range 1, of West Templeton, Ottawa county, Q.

Chambers, R. E., Truro, N. S.:—
Limonite, three miles from Brookfield station, Colchester county, N. S.

Chapman, C., Prescott, O.:—
Huronian quartzite, three polished slabs of; from the north shore of St. Joseph Island, Lake Huron, O.

Dickson, W. H., Ottawa, O.:—
Apatite and graphite, from lot 28, range VI., of the township of Buckingham, Ottawa county, Q.

Furlonge, W. H., Port Arthur, O.:—
Native silver, from Silver Mountain mine, township of Lybster, district of Thunder Bay, O.
Argentite, from the Beaver mine, Rabbit Mountain, district of Thunder Bay, O.

Marion, Rev. Father, Douglas, Renfrew county, O. :—
Magnetite, from lot 24, range II, of the township of Stafford, Renfrew county, O.

McKay, J. W., Kamloops, B. C. :—
Molybdenite, from near the head waters of the South Fork of Spuzzum Creek, Fraser River, B. C.

Poole, H. S., Stellarton, N. S. :—
Altered bitumen, from the falls measures, immediately overlying the Acadia seam at Westville, Pictou county, N. S

Russell, A. L., Port Arthur, O. :—
Native silver (two specimens) from Silver Mountain vein, mineral location, range 56, township of Lybster, district of Thunder Bay, O.
Native silver with sphalerite from Silver Hill, near Silver Mountain, district of Thunder Bay, O.
Argentite, from Silver Mountain vein, mineral location range 56, township of Lybster, district of Thunder Bay, O.
Argentite, from Rabbit Mountain mine, township of Gillies, district of Thunder Bay, O.

Saunders, Wm., Ottawa, O. :—
Altered bitumen, from Queen Charlotte Island, B. C.

Stewart, G., West River, Sheet Harbor, N. S. :—
Native gold in quartz, from the Killog mine, Sheet Harbor, Halifax county, N. S.

Trethewy, T. H., Port Arthur, O. :—
Native silver (two specimens) from Silver Mountain, district of Thunder Bay, O.

Wertheim, Ed., Desjardins, P. O., Q. :—
Asbestus (chrysotile), from south half of lots 27 and 28, range XII., of the township of Coleraine, Megantic county, Q.
Samples ot mill-board, steam-packing, &c., manufactured from the asbestus of this locality.

Wilson, —, per Dr. G. M. Dawson :—
Magnetite, Rivers Inlet, B. C.

Mr. R. L. Broadbent has rendered most efficient service in the mineralogical section of the Museum. Indeed, but for the interest and assiduity he has displayed in the work, the progress achieved could hardly have been hoped for. Iu the early part of the year, Mr. C. W. Willimott was occupied in making up collections of minerals and rocks for various institutions. Of such collections, the following have been sent out in the course of the year :—

	Specimens.
To W. G. Kidd, Public School Inspector, Kingston	13
Public School, Upper Sumas, B. C.	87
Bishop's College, Lennoxville, Q. (Supplementary)...	32
Manitoba College, Winnipeg (Supplementary)	35
Town Council, Sault Ste. Marie, O.	112
Bourget College, Rigaud, Q. (Supplementary).	40
High School, New Westminster, B. C.	112
Iberville Convent, Iberville, Q.	112
Mrs. A. Frechette, Ottawa, O., (fragments)..............	70
Rev. D. Borthwick..............	25

During the summer he visited the townships of Leeds, Garthby, South Ham, Grenville, and several of the townships in Ottawa county, in the province of Quebec. A large quantity of material was obtained for the purpose of making up collections for educational purposes, as also numerous interesting specimens for the Museum.

PALÆONTOLOGY AND ZOOLOGY.

Of these divisions of the Survey's field of operations Mr. Whiteaves reports as follows :—

Advance sheets of the letter press of pages 151-184 of the second part of "Contributions to Canadian Palæontology" were printed and distributed in July, 1889. A similar edition of pages 185-196 of the same publication was printed and distributed in August. The manuscript of the pages last mentioned, which consists of a descriptive report on the fossils of the Niobrara-Benton formation of the Duck and Riding Mountain district in Manitoba, for the most part collected by Mr. J. B. Tyrrell, in 1887, was all written during the present year. The entire part, which consists of 107 pages large octavo, illustrated by fifteen full-page lithographic plates, was issued in August, 1889. About one-half of the letter press of the third part of the "Contributions to Canadian Palæontology" has been written. This part is intended to contain a descriptive report on the fossils collected by Mr. McConnell in 1888 and 1889, from the Devonian rocks at several localities in the Mackenzie River basin. A paper entitled "Descriptions of Eight new Species of Fossils from the Cambro-silurian rocks of Manitoba," has been written for the transactions of the Royal Society of Canada for 1889. Three hundred advance copies of this paper, which consists of nine pages quarto of letter press, illustrated by six full-page plates, were printed and distributed in November. A preliminary examination has been made of a rather large series of fossils collected by Mr. J. R. Tyrrell, during the summer of 1889, from the Cambro-silurian rocks at Swampy, Big and Deer Islands, in Lake Winnipeg, at Grindstone Point, on the west side of the lake, and at the mouth of the Little Saskatchewan; also of a number of fossils recently obtained by Mr. R. G. McConnell, from the Cretaceous rocks of the Peace River and its tributaries, Lesser Slave Lake and the Athabasca River. A short visit was made to Thetford, Ont., in September, and some fossils of interest were collected from the Devonian shales and limestones of that neighborhood.

In the upper flat of the Museum a new upright glass case, seven feet five inches high, six feet five inches long, and two feet nine inches broad, has been constructed for the reception of the fine collection of Dinosaurian and Mammalian remains recently made by Mr. Weston, from the Laramie and Tertiary formations at various localities in the North-West Territory, and all the specimens in this case have been provisionally labelled. In the same flat a small glass case has been made, in which has been exhibited a named series of the fossil plants collected by Mr. McConnell in 1888, from the Tertiary rocks of the Mackenzie River, 20 miles above Bear River, recently described by Sir William Dawson.

In the Department of Zoology a large collection of the mammalia birds, reptiles, &c., of British Columbia, has been received from Professor Macoun. Seventy-seven additional specimens of fifty-nine species of Canadian birds, and nineteen specimens of sixteen species of Canadian mammals, most of which were collected by Professor Macoun, have been skilfully mounted by Mr. T. Herring during the year. These have been carefully labelled and arranged in their proper places in the zoological cases. Two large upright glass cases (each 7 feet high, 6 feet 5 inches long, and 3 feet 6 inches broad, with plate glass shelves) have also been constructed for this flat of the Museum. One of these is now filled with a collection of the mammalia of Hudson's Bay and Strait (including a pure albino wolf from that district, which has recently been mounted), and the other with a choice series of seals from the Atlantic and Pacific coasts of Canada, and with a fine head of the walrus. The specimens in each of these cases have been re-labelled re-arranged.

The number of official letters received during the year is 330, and and the number written 283.

From the 1st of January to the end of June, Mr. T. C. Weston's time has been employed in museum work, in the sections devoted to palæontology and ethnology. Many new specimens have been added to some of the fossil cases, and a large number of labels written. Numerous additional specimens, also, have been placed on exhibition in the room devoted to ethnology, among which are about seventy implements or other objects of Indian manufacture, recently collected for the survey by Dr. Franz Boas, in British Columbia. On the 1st of June Mr. Weston left Ottawa for the Red River, N.W.T. From the Laramie sandstones near Calgary, some fine specimens of fossil plants were obtained, which have since been identified by Sir William Dawson, and are now labelled and exhibited in their proper place in the Museum. The Red Deer River, eight miles below the crossing of the Calgary and Edmonton road, was reached on the 13th of June. Four days were spent preparing boats for the journey down the river, and in collecting fossil plants from the Laramie sandstones and argilities of the Blind Man River. On the 17th of June the journey down the Red Deer was commenced, and in a short time the great coal seams in range 24, township 28, were reached. The confluence of the Red Deer with the South Saskatchewan was reached on the 14th of July. Between this point and Tail Creek, a distance of about 250 miles, the rocks were examined in a number of places, and a fine series of vertebrate remains was obtained from the Laramie and Belly River deposits. Among these are the right and left side of the jaw of a Deinosaur (probably *Lœlaps*) vertebræ, limb bones, teeth and claw cores. The Battleford and Swift Current crossing was reached on the 19th of July. Ten miles below this, at the mouth of Swift Current, there is a large exposure of the Pierre, from which a small but interesting collection of fossil shells and reptilian remains was obtained. After this the White River beds of the Cypress Hills were re-visited and a few fine fossil bones were collected, among which is a large portion of the right ramus of the lower jaw, apparently of an *Elotherium*. On the return journey to Ottawa, a few days were spent searching for fossils among the Animikie rocks of Port Arthur and Rossport, but none were found. Ottawa was reached on the 21st of August. From 2nd September to the 16th several fossiliferous localities in the Eastern Townships of the province of Quebec were examined, various specimens of interest (including examples of *Salterella* from two new localities) were obtained for the Museum. The remainder of the year has been occupied by Mr. Weston in preparing, labelling and arranging for exhibition in the Museum the collections received during the summer.

With the exception of two months spent in Europe, on leave of absence, a considerable portion of Mr. H. M. Ami's time has been occupied in the examination of numerous collections of fossils recently made by members of the staff at various localities in the provinces of Quebec and New Brunswick. Separate lists of the species from each locality in the province of Quebec, have been prepared by Mr. Ami, which have been incorporated into Dr. R. W. Ells' second report on the geology of a portion of that province, and a systematic list of the whole, by Mr. Ami, has been printed as a supplement to that report. Similar lists of fossils collected at various places in northern New Brunswick and adjacent areas in Quebec and Maine, have also been made by Mr. Ami, which have since been published in Prof. L. W. Bailey and Mr. McInnes' report on the geology of that region. A paper "On a Species of *Goniograptus* from the Levis Formation, at Levis, P.Q.," written by Mr. Ami, has been published in the seventh number of the third volume of the "Canadian Record of Science," and another paper, consisting of additional notes on the same species has been published in the eighth number of that volume. These papers are illustrated by an octavo plate, skilfully executed by Mr. L. M. Lambe. Some progress has been made in the manuscript of a report on the fossils contained in the Cambro-silurian exposures and outliers in Central Ontario along the line of contact with the Laurentian area to the north. Labels for the species of fossils enumerated or described in recent palæontological publications by Mr. Whiteaves, Prof. T. Rupert Jones, Dr. G. J. Hinde and Mr. E. O. Ulrich, and for other specimens mostly of recent addition to the Museum, have been prepared for the printer by Mr. Ami. By permission of the Director, and on special application, the types of a few Canadian species and some other specimens have been sent for examination to Professors James Hall, T. Rupert Jones and H. A. Nicholson, to Dr. G. J. Hinde and Mr. C. D. Walcott, but all of these specimens have since been returned. Named sets of duplicate fossils are being made up by Mr. Ami for distribution to educational and other public institutions in Canada. One of these sets has been despatched to the Historical and Scientific Society of Manitoba, at Winnipeg, and it is hoped that six similar ones will be distributed at an early date.

In the Palæontological work of the office Mr. L. M. Lambe, the artist to the Survey, has also rendered most efficient service. All the drawings required for the illustration of the palæontological publications issued by the Survey during the year have been made by him, and he has either effected or superintended their reproduction in a most satisfactory way. He has also made a number of drawings of fossils, which are as yet unpublished, and all the figures which have been used to illustrate Sir William Dawson's paper on the fossil plants collected by Mr. McConnell in the Mackenzie River basin, published in the transactions of the "Royal Society of Canada" for 1889, are from his skilful pencil. In addition to this Mr. Lambe has materially helped in the elucidation of the characters and specific relations of many of the fossils which have been entrusted to him to draw.

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

Dr. Selwyn:—

Fifteen specimens of fossils from the Cambrian and Cambro-silurian rocks of the Strait of Belle Isle and Newfoundland.

Dr. G. M. Dawson:—

About forty fossils from the southern part of the interior of British Columbia.

Also a few skins of small mammals and birds.

J. F. Whiteaves:—

About 100 specimens of fossils from the Hamilton shales at and near Thetford, Ont.

Prof. Macoun:—

Skins of 358 birds and seventy-three mammals from British Columbia; also a collection of reptiles, butterflies, shells, &c., from the same province.

Dr. R. W. Ells:—

About 100 slabs, containing graptolites, from the Cambro-silurian rocks near Lake Memphremagog, P.Q.

Prof. L. W. Bailey:—

Fifteen specimens of *Obolus pulcher*, Matthew, from the lower Cambrian rocks at Caton's Island, N.B.

J. B. Tyrrell:—

About 5,000 fossils from the Cambro-silurian and Devonian rocks at various localities on Lakes Winnipeg and Winnipegosis.

R. G. McConnell:—

Forty specimens of fossils from the Devonian rocks of the Peace River and 200 from the Cretaceous rocks of the Peace and Athabasca Rivers.

T. C. Weston :—

Fifty specimens of fossils from the Quebec group of the province of Quebec. Thirty specimens of vertebrate and 300 of invertebrate fossils from the Cretaceous rocks of the South Saskatchewan. 200 specimens of invertebrate and the same number of vertebrate fossils, including a fine series of Dinosaurian remains, from the Laramie of the Red Deer River, N.W.T. Seventy specimens of fossil plants from the Blind Man River, N.W.T.

W. McInnes :—

About 100 fossils from Tuladi Falls, Rimouski River, and a few from Notre Dame du Portage, P.Q.

H. M. Ami :—

A number of fossils from the Trenton and other formations near Ottawa; also arrow heads and fragments of pottery from near Casselman, Ont.

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

By presentation :

G. R. White, Ottawa :—

Skin of a female Ruddy Duck (*Erismatura rubida*) from the Ottawa River.

Rev. G. W. Taylor, Stewarton, Ont. :—

Eggs of twenty-four species of Canadian birds, mostly from British Columbia. One specimen of a crab (*Echidnocerus cibarius*) from Vancouver Island.

James Fletcher, Ottawa :—

Eggs of thirty-two species of Canadian birds, and photograph of egg of the Great Auk (*Alca impennis*).

W. A. D. Lees, Ottawa :—

Eggs of nineteen species of Canadian birds. Specimen, in the flesh, of the Mole Shrew (*Blarina brevicauda*), from near Ottawa.

F. E. Trudeau, Ottawa :—

Mounted specimen of the American Raven (*Corvus corax sinuatus*) shot at Lake Edward, P.Q.

James Davidson, West Templeton, P.Q. :—
Specimen, in the flesh, of an Ermine (*Putòrius ermineus.*)

Philip Cox, Newcastle, N.B. :—
Pair of the Hudsonian Chickadee (*Parus Hudsonicas*), from the Miramichi River, N.B.

Joseph Edwards, Ottawa :—
Specimen, in the flesh, of the Northern Hairy Woodpecker (*Dryobates villosus leucomelas*), from Blue Point, Lake St. John. Specimen of the Hoary Bat (*Atalapha cinerea*), from the Rideau River, in the flesh. A Brown Creeper (*Certhia familiaris Americana.*) A male House Wren (*Troglody tes œdon*), both in the flesh; also two eggs of the Horned Lark (*Otocoris alpestris*), and two of the Flicker (*Colaptes auratus*), all from near Ottawa.

The U. S. Geological Survey (per C. D. Walcott) :—
Fourteen species of fossils from the Lower Cambrian rocks of Newfoundland, &c.

J. Heron, Billing's Bridge :—
A female Woodchuck (*Arctomys monax*), in the flesh.

J. H. Bartlett, Ottawa :—
Female Jumping Mouse (*Zapus Hudsonius*), from Billing's Bridge, in the flesh.

W. C. Bedingfield, Ottawa :—
Nest of the Ruby Throated Hummingbird (*Trochilus colubris*), from Kemptville.

H. M. Ami, Ottawa :—
One Brown Bat (*Scotophilus fuscus*), in the flesh.

D. Herring, Toronto :—
Skin, since mounted, of a female Buffle Head (*Charitonetta albeola*) ; do of a female Green-winged Teal (*Anas carolinensis*); do of a female Blue-winged Teal (*Anas discors*), and do of a female Black-throated Green Warbler (*Den droica virens*) ; all from near Toronto.

S. Herring, Ottawa :—
Pair of the Whip-poor Will (*Antrostomus vociferus*), from near Toronto.

W. McRae, Twin Glen, Carleton Co., Ont.:—
Rattle of a large Rattle Snake from Arkansas.

Dr. C. A. White, Washington, D.C.:—
Three specimens of *Astarte Packardi*, White, from the Sauranodon beds ("Jurassic") at Aurora, Wyoming.

Alex. Jacques, Ottawa:—
Piece of oak of the "Royal Savage," a culverin and musketoon ball, each of which were taken out of a beam on the church at Plattsburgh, and pieces of Indian pottery found near that city.
Piece of sound wood found 116 feet below the surface of the ground at Polk Co., Indiana.

W. J. Baylay, Ottawa:—
Female Sharp-shinned Hawk (*Accipiter velox*) shot at Aylmer, P.Q., in the flesh.

E. G. White, Ottawa:—
Specimen of the American Crow (*Corvus Americanus*), in the flesh.

R. A. A. Johnston, Ottawa:—
Albino Chipmunk (*Tamias striatus*) from Uxbridge, Ont.,,—mounted.

Sir William Dawson, Montreal:—
Sixteen specimens of ten new species of fossil sponges, one example of *Butotrephis pergracilis*, Dawson, and nine of *Linnarssonia pretiosa*, from Métis, P.Q.

Prof. R. J. Hill, Austin, Texas:—
Thirty-one specimens of *Terebratula Wacoensis*, Rœmer, from the Washita limestone west of Austin, Texas.

Rev. Hector Currie, Thetford, Ont.:—
Twelve specimens of fossils from the Hamilton shales near Thetford.

Rev. W. H. Barris, Davenport, Iowa:—
One specimen each of three rare species of fossils from the Hamilton formation near Alpena, Michigan.

R. R. Rowley, Curryville, Pike Co., Missouri:—

One hundred and three specimens of twenty-four species of fossils from the Burlington and Kinderhook formations at Pike Co., Miss.

By Exchange.

From the Manitoba Historical and Scientific Society, Winnipeg, per C. W. Bell (President).

Four fossils from the Cambro-silurian rocks of East Selkirk and Stony Mountain, and two from the Cretaceous rocks of the N. W. T.

From Prof. T. F. Calvin, Iowa City:—

Thirty-two species of fossils from the Devonian rocks of Iowa and Missouri, one from the Niagara limestone of Iowa, two from the Hamilton shales of Ontario, and six from the Cretaceous of Montana

By Purchase.

Semi-albino Red-tailed Hawk (*Buteo borealis*); semi-albino Song Sparrow (*Melospoza fasciata*); male Grasshopper Sparrow (*Ammodramus savannarum passerinus*); female Wilson's Warbler (*Sylvania pusilla*); and albino or nearly albino variety of the Red Squirrel (*Sciurus Hudsonius*); all from Hyde Park Corners, Ont.

Albino American Crow (*Corvus Americanus*), shot near Whitby, Ont.

Remarkable colour variety of the American Robin (*Merula migratoria*), shot near Ottawa.

Male Murre (*Uria troile*), shot near Wakefield, P.Q.

Male Coot (*Fulica Americana*), shot near Toronto.

Sixty-four specimens of fossils from the Silurian and Devonian rocks of western Ontario.

Skeleton of a large Snapping Turtle (*Chelydra serpentiua*), obtained at Markham, Ont., and prepared by M. Jules Bailly, Montreal.

In the section of entomology, Mr. Fletcher reports that the collections have been regularly examined since they have been in his charge, and are now in a good state of preservation, no instance of injury by insects, mould or accident having occurred.

Mr. Fletcher further reports as follows:—

The collections have been considerably augmented by donations, and by the labours of different members of the staff of the survey, who have brought from distant localities a number of insects of rarity and interest, many of which were previously unrepresented in the cabinets.

Since Mr. Fletcher had charge of the collection, (1887) the following additions, made by members of the staff, have been examined, identified and prepared for the cabinets.

1. By Professor Macoun, at Nipigon, in the Rocky Mountains, in Vancouver Island, in Prince Edward Island and on the mainland of British Columbia.

2. By Dr. G. M. Dawson, in the Yukon District, and in the interior of British Columbia.

3. By Messrs. McConnell and Ogilvie, in the Mackenzie River district.

4. By Mr. Frederick Bell, at Fort Simpson, Mackenzie River, and presented for the museum to Mr. McConnell.

5. By Mr. J. B. Tyrrell, in Manitoba.

6. By Mr. A. P. Low and Mr. J. M. Macoun, at Hudson Bay.

7. By Mr. J. S. Cotter, at Moose Factory, Hudson Bay, and presented to Mr. Low for the museum.

8. By Mr. T. C. Weston, in the North-West Territory.

Of these collections by far the most important were those made by Professor Macoun, Dr. Dawson and his assistant Mr. McEvoy.

It is true that most of the above mentioned collections consisted largely of specimens in a poor state of preservation; but they included many rare insects, amongst the more important of these are the following:—*Oeneis Macouni* and *Nemeophila Selwyni*, both new species discovered by Professor Macoun, at Nipegon, *Papilio Machaon* var. *Aliaska*, collected by Dr. Dawson, on the Laird River, and by Mr. Ogilvie, on the Mackenzie River, *Erebia discoidalis*, collected at Fort Simpson, Mackenzie River, by Mr. Frederick Bell, *Colias Nastes*, brought from Hudson Bay by Mr. Low, *Colias Interior*, from Nipegon and Prince Edward Island, collected by Professor Macoun. A fine series of *Lycœnia Couperi* was brought from British Columbia by Dr. Dawson. The specimens in the best preservation were those collected by Mr. James McEvoy and by Messrs. James and William Macoun.

In addition to the above, fine collections of insects belonging to various orders have been presented to the museum by Mr. T. E. Bean, of Laggan, North-West Territory.

All the specimens bear dates and localities of their capture, which materially enhance their scientific value.

During the past year several students have examined the collections.

Mr. Fletcher is at present engaged in the preparation of a small collection representing the insects of Canada only, which is for exhibition in open cases in the hall of the museum, and which it is believed will be of interest to visitors.

Botany, Etc.

During the greater part of the winter Professor Macoun was confined to the house by sickness, but with the aid of his assistant, Mr. J. M. Macoun, the office work was carried on and the specimens that had been collected during the summer were named and mounted. He was also able, before leaving for the field, to make good progress with the catalogue of Canadian birds, referred to in the summary report for 1888.

On the work of the past summer, Professor Macoun reports as follows:—

"On the 30th of March last, accompanied by my assistant, I started for British Columbia, and reached Vancouver, 4th April. Next day we commenced work, and between that date and 12th August, with the aid of one man, we collected birds, mammals, reptiles and insects, and also made a complete collection of the flora from the coast to the Eagle Pass in the Gold Range, a distance of nearly 400 miles on the Canadian Pacific Railway. This being the first season of my duties of naturalist, we devoted much more time to general natural history than to botany. Our season's work ended at Griffin Lake, on Eagle River, after we had lived at an altitude of 7,000 feet for ten days, and collected as much of the mountain flora and fauna as time and means would permit.

The total cost of the exploration was $1,377.21.

"Since our return to Ottawa we have been engaged in sorting, naming and arranging the collections of the season. Satisfactory progress has been made up to 31st December; forty species of plants new to science have been examined and named, and others are still to be determined.

Mr. Pearson's paper on Canadian Liverworts is now passing through the press, and will be followed by Part V. of the Catalogue of Canadian Plants, and by the Catalogue of Canadian Birds already mentioned.

These papers were placed in the hands of the printer last spring, so that they might be in type before my return.

During the past three years I have spent much time in collecting and working up the mosses of the Dominion, and with the aid of European specialists, hope during 1890 to complete the work and publish a full list of them, forming Part VI of the Catalogue of Canadian plants.

Many hundred species of plants have been received from Newfoundland, and from every province in the Dominion, for identification, the largest number being from Newfoundland, Quebec and New Brunswick.

While in British Columbia we collected over 1,400 species of plants, in which were included more than 15,000 specimens; 431 skins of birds and mammals, representing 141 species were secured. Nearly 100 reptiles were collected and preserved in alcohol, and several hundred insects, which are now being determined by specialists.

All work in connection with the herbarium and the distribution of specimens has been done by Mr. Jas. M. Macoun. During the past year there were mounted and placed in the herbarium 4,406 sheets of specimens. Of these 3,592 sheets were of flowering plants and 814 of cryptogams. Of the flowering plants 1,987 sheets were Canadian, 1,079 from the United States, 340 from Australia and 186 from Europe. The cryptogams mounted were, with few exceptions, Canadian; 5,960 sheets of specimens were sent to public institutions and to private individuals in exchange for desiderata; 3.593 of flowering plants and 2,167 of cryptogams. These included 400 sheets to the University of Copenhagen, in exchange for which plants from Greenland were sent; 432 sheets to Columbia College; 445 sheets to the British Museum; 293 to the National Museum at Washington; 200 to Miss R. Marson, Lausanne, Switzerland; 200 to J. B. Ellis, Newfield, N.Y.; 100 to Prof. L. M. Underwood, Syracuse, N.Y. For all of these, specimens have been sent us in exchange, but besides these several hundred specimens were sent to McGill University, the Department of Public Instruction, Quebec, Harvard University, the California Academy of Sciences, the University of Nebraska, and a set of Canadian grasses to Prof. Scribner, of Knoxville, Tenn., U. S.

Since my last report 448 letters of sufficient importance to copy were written in connection with our work and about the same number were received."

While the collections of Natural History specimens are rapidly growing larger and increasing in value, no greater space is being given for their disposal, and while the danger from fire is constantly increasing the absence of any fire-proof room or building renders it impossible to take any precautions to insure their safety. The room now occupied by Professor Macoun is so crowded with inflammable material that a spark, or the dropping of a match, would in a few moments cause the destruction of specimens of inestimable value, which could never be replaced, and such a fire would endanger the whole building.

MAPS.

Maps in course of preparation and lately published, December, 1890.

	Area in square miles.
Yukon district, North-West Territory, and adjacent northern part of British Columbia (3 sheets), published 1890, scale eight miles to one inch..........	
Index Map of above, published 1889. Report B. 1887-88..........	
Big River, Great Whale River, &c., E. coast Hudson's Bay (unpublished), scale eight miles to one inch..........	
British Columbia, part of Southern Interior (Dr. Dawson), in draughtsman's hands, scale four miles to one inch..........	6,400
Kootenay district, British Columbia (Dr. Dawson), in draughtsman's hands, scale eight miles to one inch..........	11,000
North-Western Manitoba Preliminary Map, published. Report E, 1887-88, Mr. Tyrrell, scale eight miles to one inch..........	12,000
Northern Manitoba, in draughtsman's hands (Mr. Tyrrell), scale two miles to one inch..........	5,000
Northern Manitoba, in draughtsman's hands (Mr. Tyrrell) scale eight miles to one inch..........	20,000
Western Ontario, lake of the Woods (5 sheets), No. 2, ready for engraver shortly, scale two miles to one inch..........	2,000
Western Ontario, Rainy Lake Map (No. 3), published Report F, 1887-88, scale four miles to one inch..........	3,456
Western Ontario, Hunter's Island Map (No. 7), in hands of draughtsman, scale four miles to one inch..........	1,450
Ontario, Sheet 130 (Sudbury Mining District), Dr. Bell, in hands of draughtsman, scale four miles to one inch..........	3,456
Ontario, Sheet 115, ready for draughtsman, scale four miles to one inch.	3,456
Ontario, General Map (in progress), scale four miles to one inch..........	
Quebec, N.E., ¼ sheet (E. Township map), in hands of draughtsman, scale four miles to one inch..........	4,500
Quebec, S.W., ¼ sheet (E. Township map), in hands of draughtsman, scale four miles to one inch..........	4,500
Quebec, N.W., ¼ sheet (E. Township map), partly in hands of draughtsman, scale four miles to one inch..........	4,500
Quebec, Lièvre River and Templeton phosphate region (Ottawa county), scale forty chains to one inch, Mr. Ingall, ready for engraver in about two months..........	260

	Area in square miles.
Quebec, New Brunswick, ¼ sheet 17 N.E., published 1887-88, and ¼ sheet 18 S.E., in hands of draughtsman..........	
Nova Scotia, ¼ sheet 11 N.W., and S.W., in engraver's hand, scale four miles to one inch..........	
Nova Scotia, ¼ sheet 4 N.E. and S.E. (Mr. Fletcher), drawn on scale of one inch to one mile..........	
North-West Territory, Mr. McConnell's traverses on the Liard, MacKenzie and Porcupine Rivers, in the draughtsman's hands, scale eight miles to one inch..........	

LIBRARY.

The Librarian, Dr. Thorburn, reports that from 2nd January to 31st December, 1889, the number of copies of the Geological and Natural History Survey publications, comprising annual reports, parts of same, special reports and maps distributed was 9,199. Of these 8,032 were distributed in Canada; the remainder, 1,167, were sent to foreign countries as exchanges to scientific and literary institutions and to individuals engaged in scientific pursuits.

Every year the list of our exchanges is increasing, so that, as a consequence of this the operations of the Survey are being more widely known and its publications more sought after.

There have been received during the year 2,367 publications, including books, transactions, memoirs, periodicals, pamphlets and maps. In addition to these 51 books were purchased and 38 periodicals were subscribed for, on geological, mineralogical and natural history subjects. For a considerable time past the space allotted to the Library has been found to be altogether insufficient, and, consequently, many of the books, which are frequently required for reference, have had to be stored away in other parts of the building, to the great inconvenience of those wishing to consult them.

The number of books bound during the year has been 162.

There were sent out during 1889, by the Librarian, 1,511 letters, and 1,256 were reeeived by him, thus showing the large and increasing interest taken in the work of the Survey.

The number of volumes in the Library is now about 8,000, and of pamphlets 3,000.

The sales of the Survey publications during the year to 31st December, have amounted to $2,909.57.

VISITORS.

The number of visitors to the Museum during the year from 1st January to the 31st December, was 18,300, being an increase of 886, as compared with the previous year.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The strength of the staff at present employed is 47, viz., professional 32, ordinary 15.

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

Mr. Eugene Coste, Mining Engineer, resigned.
Mr. Jno. McMillan, Field Explorer, "
Mr. F. D. Adams, Assistant Chemist, "
Mr. M. O'Farrell, Caretaker, superannuated.
Mr. E. D. Ingall, appointed Mining Engineer.
Mr. Thos. Burke " Caretaker.
Mr. Allan McKinnon " Messenger.
Mr. R. G. McConnell, promoted from 2nd to the 1st class.
Mr. E. R. Faribault, " 3rd to the 2nd class.

The amount available for the fiscal year ended the 30th June, 1889, was:—

	$ cts.	$ cts.
Civil list appropriation	....	45,900 00
General purpose appropriation	....	60,055 91
The expenditure may be summarized under the divisions named as follows:—		
Civil list salaries	43,319 56	
Wages of temporary employés	15,396 17	
Exploration and survey	24,095 11	
Printing and lithography	12,585 13	
Purchase of specimens	67 75	
Purchase and binding of books and purchase of instruments	1,437 69	
Laboratory apparatus and chemicals	514 47	
Stationery and mapping materials, and Queen's Printer	1,087 33	
Incidental and other expenses	2,104 75	
	100,607 96	
Less—Paid in 1888	3,259 42	
	97,348 54	
Add—Advances to field explorers	6,026 93	
	103,375 47	
Unexpended balance, Civil list appropriation	2,580 44	
	105,955 91	105,955 91

The correspondence of the branch shows a total of 7,100 letters sent and 5,860 received.

In my summary report for 1887, page 14, a report to be prepared by Mr. Warren Upham, of the United States Geological Survey, on the Glacial Lake Agassiz, was mentioned.

The report and accompanying maps were received only on the 19th of December, too late to be incorporated in the last Annual Report. I am now in correspondence with Mr. Upham respecting it, and I hope it will soon be ready for the printer.

I have the honor to be, Sir,

Your obedient servant,

ALFRED R. C. SELWYN,

Director.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON A PORTION OF THE

WEST KOOTANIE DISTRICT,

BRITISH COLUMBIA,

1889,

BY

GEORGE M. DAWSON, D.S., F.G.S.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
WILLIAM FOSTER BROWN & CO.
1890.

G. M. DAWSON, PHOTO., JUNE 22, 1889. "THE DOMINION ILLUSTRATED," ENG. & PR., MONTREAL.

HOT SPRINGS, KOOTANIE LAKE, FROM THE SOUTH.
Showing mica-schists of Shuswap series in the foreground.

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

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith a report of a geological reconnaissance in the southern part of the West Kootanie District, British Columbia. The field-work, of which this report gives the main results, occupied about a month in the early part of the summer of 1889.

I have the honour to be,

Sir,

Your obedient servant,

GEORGE M. DAWSON.

OTTAWA, March 18, 1890.

NOTE.—The bearings given in the first part of this report refer to the true meridian, unless otherwise specially noted. In the detailed description of mining regions forming the concluding part of the report (p. 45 B *et seq.*) the bearings refer to the magnetic meridian. See foot-note, p. 46 B.

REPORT

ON A PORTION OF THE

WEST KOOTANIE DISTRICT,

BRITISH COLUMBIA,

1889,

BY GEORGE M. DAWSON, D.S., F.G.S.

INTRODUCTORY.

Discoveries in West Kootanie.

Within the past three years, numerous discoveries of valuable ores have occurred in the West Kootanie district,* and this district appears likely to be the first in which metalliferous mining on an extensive scale will be initiated in the province of British Columbia. As nothing was known of the geological structure of the southern part of the West Kootanie district, where a number of the more important discoveries of ores have been made, it was considered desirable that the writer should undertake a geological reconnaissance of that part of the district, with the special purpose of ascertaining the character and mode of occurrence and association of the ore-deposits, and of estimating their prospective importance. The present report embodies the results obtained with reference to these points. The field-work upon which it is based, occupied little more than a month, extending from June 10th to July 12th, 1889; and while this time proved to be sufficient for the purpose of visiting the several mining camps, as well as for some general examinations along the routes followed, it did not admit of

Object of present report.

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*The name here written Kootanie, has been and is rendered in a variety of ways. Without exhausting the subject, the following versions may be quoted:—Arrowsmith's general map of British North America, 1811, *Coo-too-nay*. Arrowsmith's maps of 1850 and 1854, Palliser's official map printed in 1865, and on earlier preliminary maps published in connection with Palliser's expedition, also on the map accompanying Alex. Ross's book on the first settlers on the Columbia River (1849), and many others—*Kootanie*. On the joint maps of the Boundary Commission between British Columbia and the United States, on Trutch's map of B. C., and in recent maps published by the Government of B. C.—*Kootenay*. As applied to a station on the Northern Pacific Railway—*Kootenai*. There is perhaps little to choose between these various renderings, no one of which represents the true pronunciation of the Indian word, but I can see no reason to alter the older spelling, which has been used in former reports of the Geological Survey and is here adopted.

detailed or close work, which, when the district shall have been further developed and rendered more easily accessible throughout, will become necessary.

Area traversed.

Starting from the line of the Canadian Pacific Railway at Revelstoke, it was necessary in order to reach the more important localities on and near Kootanie Lake, to follow the Columbia River and Arrow Lakes to the mouth of the Kootanie River, and to travel thence overland to Kootanie Lake. The West Arm, together with the shores of the entire northern half of Kootanie Lake, were also examined. This region thus passed through, though to a certain extent overrun during the placer gold mining excitement about twenty-three years ago, has remained comparatively little known till the late discoveries have drawn the attention of numerous 'prospectors' and mining men to it. Mr. Amos Bowman, in the interest of the Geological Survey, had made a somewhat hurried traverse of the Columbia River and Arrow Lakes, in the autumn of 1884, while leaving his field of work to the west His sketch of the river and lakes had, however, remained unpublished, and even the principal geographical features of the region are laid down on the published maps in an extremely imperfect and sketchy manner.

Surveys made.

Advantage was therefore taken of the journey here reported on, to carry out running surveys along the line of route. The lakes were measured by patent boat-log, while distances on the rivers and trails were estimated, and the whole checked by a number of astronomical observations for latitude and longitude. The work done by the Dominion Lands Branch has been utilized for the country in the vicinity of the railway, while the surveys of the Boundary Commission are employed for a belt along the forty-ninth parallel. Certain parts of Mr. Bowman's traverse have also been adopted, as stated on the face of the map, and the through distance from the Columbia to Kootanie Lake depends on a line surveyed some years ago for railway purposes by the 'Ainsworth Co.' With these exceptions, however, the geographical features here published depend on surveys made by myself. No geological description of the district has previously been given.

General Features.

Mountain systems.

The West Kootanie district as a whole, is rugged and mountainous in character. It comprises the southern portions of the Selkirk and Columbia or Gold ranges, but these mountain systems are not here so definite or regular in trend as to admit of precise separation. As a matter of convenience the mountains to the west of the Arrow Lakes may be described as belonging to the Columbia or Gold Range,* those

* Here used in a limited sense. The name Gold Ranges is often applied as a general one to the second great mountain system of the Cordillera, counting from the east.

between the Arrow Lakes and Kootanie Lake may be referred to as representing the Selkirk Range proper, while those to the east of Kootanie Lake are regarded as forming the Purcell division of the Selkirk system.

Trend and character of ranges.

The general trend of the constituent mountain-ridges or subordinate ranges is here, as usual, about north-north-west by south-south-east; but few of these are so continuous or so straight as are most of the minor ranges composing the Rocky Mountains proper in their corresponding part. In the Rocky Mountains this regularity depends largely upon the lines of outcrop of the great thickness of well bedded Palæozoic rocks of which they are composed, while in the southern part of the West Kootanie district, great areas consist of massive granitic rocks, which do not, as a rule, give rise to parallel ranges of mountains. Thus, when viewed from a considerable elevation, the appearance of this region is that of a rough, irregular mountainous country, in which the highest points are grouped toward the centres of blocks of mountains which are circumscribed and divided from each other by the valleys of the larger streams and lakes. Wherever straight, escarpment-like mountain-ridges appear, there is reason to suspect the existence of the stratified rocks which overlie the granites, and which are elsewhere described in this report. The height of a great number of the higher summits, reaches or exceeds 8000 feet, while some probably attain an altitude of 9000 feet or more. Considerable fields of snow remain throughout the summer on some of the mountains over 8000 feet in height. While the general altitude of the timber-line may be stated as about 7000 feet, the woods are always open and park-like above 5000 feet, and rocky or exposed slopes above this level, as well as many broad mountain tops, are almost entirely destitute of trees. Elsewhere the country is generally wooded, and in the lower and more sheltered valleys much good timber is to be found. Of timber suitable for mining purposes, an ample supply may be obtained almost anywhere.

Elevation of mountains.

Important valleys.

The most remarkable physical feature of the district is found in the two long and deep valleys which traverse it with north-and-south bearings, one of which is occupied by the Columbia River and Arrow Lakes, the other by Kootanie Lake. These valleys do not strictly conform to the general trend of the mountain systems, and while some portions of them are due to excavation occurring along the line of outcrop of certain parts of the stratified rock series (as subsequently noted), their origin as a whole is a question of considerable difficulty. These two main longitudinal valleys are connected by the equally remarkable transverse valley which holds the West Arm of Kootanie Lake, together with the short length of the Kootanie River, by which the lake discharges into the Columbia.

Drainage system.

A glance at a general map of the south-eastern part of British Columbia, will show that the whole drainage system there, tributary sooner or later to the Columbia, is of an extraordinary character. The Columbia itself, rising between the Rocky and Selkirk mountains, in latitude 50° 12′, flows northward to the Great Bend, and then, turning sharply round, flows nearly due south to the point at which it crosses the forty-ninth parallel. The Kootanie, on the other hand, rising in the heart of the Rocky Mountains, in lat. 51° 15′, flows southwardly, passing within a couple of miles of the lake in which the Columbia heads, and subsequently turning to a north-westward direction, empties into Kootanie Lake, from which it issues to the west, and after a short further course joins the Columbia at Sproat's Landing. It is probable that at different times during the Tertiary period streams have flowed along, and helped to erode these great valleys, draining in different directions, in accordance with the relative elevation and depression of various parts of this and contiguous regions. Till all the circumstances have been fully studied, the present drainage system can, however, only be characterized as perplexing.

Columbia River.

River south of Revelstoke.

The Columbia River, from Revelstoke, where it is crossed by the Canadian Pacific Railway, runs in a south-south-eastward bearing to the head of the Upper Arrow Lake. The general course of the river is direct, and the distance from the bridge at Revelstoke to the head of the lake in a straight line, twenty-seven miles. Following the sinuosities of the river in detail, the actual distance is nearly thirty miles. The height of the river at Revelstoke above sea-level is, according to the railway levels,* 1437 feet; that of the lake, determined barometrically by the writer within small limits of error, is 1390 feet. The difference, 47 feet, divided by the length of the river, gives a descent of 1·56 feet to the mile; but this is not uniformly distributed, as in addition to local irregularities in strength of current, the lower portion of the river, with a length of about nine miles, is relatively slack. This lower reach of the river was estimated to have an average flow at the rate of about three miles an hour, while the whole upper part averages probably about four miles an hour or rather more, and is characterized by numerous islands and side channels or "sloughs."

Bordering mountains

The valley is continuously bordered on both sides by parallel ranges of mountains, the summits of which are pretty uniform in height, averaging nearly 6000 feet above the river; and though several streams

* Revised according to the best available information.

join the river in this part of its course, there are no large or important lateral gaps south of those of the Illecillewaet and Eagle Pass. Several of the summits in these bordering ranges, however, considerably exceed the general altitude above given, notably Mount Begbie, situated about nine miles south-east of Revelstoke and six miles back from the river, with a height of 8834 feet above the sea. The higher points of the inner ranges of the Selkirks are not seen from the river valley, in consequence of the height of the bordering range on its east side, which, moreover, is closer to the river and slopes more steeply down to it than the range on the west. The latter spreads out toward the base into rocky ridges and hills. With the exception of Mount Begbie, none of the mountains in sight from the river are remarkably rugged in outline.

The flat bottom of the valley, through which the river winds, has a general width of a mile to a mile and a half. Most of the flat land, for eleven miles below Revelstoke, lies on the east side of the river, but is rather low, and, though wooded, is said to be in great part liable to overflow at high stages of the water. Further down, the flats are alternately on the east and west sides of the valley till within about six miles of the mouth, when both sides of the river become bordered by a certain width of flat land. Altogether, the valley should afford a not inconsiderable area of land susceptible of cultivation when cleared. **Character of valley**

The valley, as well as the slopes of the mountains generally, is well wooded, and so far but a small proportion of the timber has been destroyed by fire. The trees most abundant are spruce, cedar and cottonwood, with some white pine, hemlock and birch, while alder fringes the borders of the river and the sloughs. The cedar is here the most valuable timber, and many of the trees are of considerable size. In a number of places along the east side of the valley, the tracks of snow-slides are apparent, but these are confined to the higher part of the mountains and do not come down to the flat land of the bottom of the valley. **Timber.**

Upper Arrow Lake.

The Upper Arrow Lake extends nearly due south from the point at which the Columbia enters it, with a length of thirty-six miles and a half and an average width, nearly uniformly maintained, of about two miles. Adding to the above measurement the length of the North-east Arm, which runs off in the direction indicated by its name beyond the mouth of the Columbia, the total length of the lake may be given at about forty-six miles. **Dimensions.**

The North-east Arm of the lake has a length of about ten miles, with an average width of about a mile. The angle between the Arm **North-east Arm.**

and the Columbia is occupied by steep and rough mountains, which rise abruptly from the shore of the Arm, and toward its head reach heights of 6000 feet or more above the lake. The slopes on the opposite, or south-east side of the Arm, are more gradual, and its lower part is separated by a promontory, of a few hundred feet in height only, from Thumb Bay. Two streams enter at the head of the Arm. One, known as Fish Creek, coming from the north-eastward, and according to report running nearly parallel to the Illecillewaet toward its head. This is said to be comparable to the Illecillewaet in size. The second stream comes from the south-east, and is smaller, but is of importance as being that up which a railway heading for the north end of Kootanie Lake would probably run. Neither the valleys of these streams nor the mountainous country which they drain has been explored, though traversed here and there by prospectors, and it is consequently impossible to do more than indicate on the map their probable courses. Being anxious to reach the principal mining camps without undue delay, I did not go to the very head of the Arm, which is therefore merely sketched on the map as it appeared from the furthest point reached. Some mining claims have been taken up in the mountains to the north of the Arm as well as on Fish Creek, and good looking specimens of argentiferous galena have been brought from these.

Streams entering the Arm.

Thumb Bay.

Thumb Bay, just alluded to, is an indentation in the east shore of the lake, immediately south of the North-east Arm. The country about it is rather low and may afford some fair timber and possibly even some arable land. A projection corresponding to this bay occurs on the opposite side of the lake, and is known as Bannock Point.

Character of main lake.

With the exception of these irregularities in outline about its north end, the lake as a whole is so direct in its course and so uniform in character as scarcely to require any detailed description. For about twenty-two miles from its upper end, the view to the westward is bounded by a rather massive range of mountains, the summits of which are shattered and rugged and carry some snow throughout the summer. The highest points are from five to eight miles distant from the lake and reach elevations of about 8000 feet. The intervening country is occupied by wooded mountains and ridges of lesser altitude quite down to the lake shore.

Entering streams.

At about twenty-two miles from the head of the lake, on the west side, Fosthall Creek comes in, and is probably the most important feeder from that direction. It rises in the southern termination of the mountain range just described, to the south of which, for some miles, no high mountains are in sight from the lake, but a hilly country, gradually rising to the west, extends to the valley of Mosquito Creek or possibly further. To the south of this, and opposite the south end of the lake, is another rather conspicuous and isolated group of mountains, of which Saddle Mountain is the culminating point.

The east side of the lake is in general rather closely bordered by mountains, which do not show any striking peculiarities, and if at a greater distance inland they rise to peaks like some of those of the opposite side, these were concealed by the lower ranges fronting on the lake, One considerable brook enters the lake on the south side of Thumb Bay, and at six miles from the lower end of the lake a small river named the Koos-ka-nax flows in. This name, meaning 'long point,' is descriptive of the delta-flat which has been formed by the stream. The flat, in the form of a low terrace, has considerable dimensions between the shore and the bases of the mountains. It appears to bear some fairly good timber, and though the soil where seen, was rather sandy, may afford room eventually for a few farms. Another stream of comparatively small size, flowing in a mile and a half south of the last, is known as the Na-kusp. It comes from a low and rather wide valley which is reported to be used by the Indians as a pass to Slocan Lake. Streams on East side.

The southern end of the Upper Arrow Lake is narrowed in toward its outlet by the actual encroachment of the bordering mountains on the hollow which it occupies, and not merely by the accumulation of detrital materials. The homogeneous structural valley occupied by the lake to the north, here appears to become subdivided and is continued or replaced by several less regular and relatively unimportant valleys, of which that of the Na-kusp is one. These run off among mountains of some height, and, at no great distance from the end of the lake, must begin to drain toward Slocan Lake; the discharge of the Upper Arrow Lake taking place to the westward, at right angles to the general trend of the lake. Southern end of lake.

The beaches along the Upper Arrow Lake are in general narrow and rocky, and its shores are frequently for some miles continuously formed of solid rock. Some fine sandy and gravelly beaches are, however, to be found, and one need seldom be at at a loss for a convenient and attractive camping place. The depth of the lake is evidently great, but the time at my disposal did not warrant much enquiry on this point. Of two soundings made at selected localities, one, twelve miles from the lower end of the lake and rather over half a mile off the east shore, showed 490 feet; in the other, one mile south of Thumb Bay and half a mile distant from the same shore, no bottom was found at 720 feet. At the north end of the lake a rather extensive shoal has been formed at the mouth of the Columbia River. The dimensions of this shoal are indicated by the presence of numerous snags, consisting of trees which have been under- Character of shores and depth.

mined by the river and brought down it in times of flood, but which, owing to the quantity of rocky matter attached to their roots, have become anchored on this submerged delta. This shoal reaches nearly across the mouth of the North-east Arm, and will doubtless in the course of time separate this Arm from the main lake. Another shoal area, also marked by snags, occupies the narrow funnel-shaped southern end of the lake where the river flows out, extending for perhaps half a mile.

Seasonal rise and fall.

The season of high water in the lake, depending upon the rise of the Columbia, is that in which the melting of the snows upon the more lofty mountains is proceeding most rapidly, which occurs generally in the early summer. Owing to the relatively inconsiderable snow-fall of the preceding winter, the high-water of 1889 was not as well marked as usual. In June the water stood six feet below a distinct high-water mark which had frequently been attained in previous years, while persons familiar with the lake stated that the winter low-water stage was at least twelve feet below the same datum. The ordinary seasonal rise and fall may therefore be stated as about twelve feet.

Hot spring.

Eleven miles from the head of the Upper Arrow Lake, on the east side, is a somewhat remarkable hot spring. It is situated about a third of a mile back from the lake, on a rather steep wooded mountain-slope and at a height of about 400 feet, but may readily be found in coasting the lake by means of a conspicuous vertical cliff which forms the shore of the lake just a mile to the north of it. The water flows from two principal sources within a few yards of each other, and there are said to be several other smaller springs in the vicinity, which were not seen. The water from the two sources just mentioned forms a small brook, which runs down the mountain side to the lake. I had no means of accurately ascertaining the volume of the discharge, but estimated it to be about 300 gallons a minute. One of the springs issues among partly cemented, stony drift material, the other from a crevice in the solid rock. The temperature of both, carefully taken on June 13th, proved to be 123·5° F. The water emits a rather strong smell of sulphuretted hydrogen, and a scanty deposit, apparently siliceous, occurs on stones over which it flows. The taste is not disagreeable, and the quantity of saline matter held in solution is evidently small. In the stream of hot water flowing from these springs a copious growth of green, yellow, red and white confervoid matter is found.

Orifice of spring.

Little solid rock is seen near the springs, but that forming the orifice of one of them is a fine-grained grey gneissic material containing a good deal of black mica. This, at the lips of the orifice, has been decomposed by the long continued action of the hot water to a depth of half an inch or rather more, the rock being bleached and its felspar completely kaolinized. The rocks seen on the shore of the lake opposite the spring, are all much shattered and jointed, and it is probably in consequence of this shattering of the rocks that the springs have found issue at this place.

The Connecting River.

The river connecting the Upper and Lower Arrow Lakes is eighteen miles in length. As already noted, it turns, immediately on leaving the upper lake, to a westerly direction, crossing the axis of a high and well marked range of granitic mountains. After flowing in this direction for about nine miles, it meets another wide valley parallel to that of the upper lake. It then bends at a right angle to the southward, and follows this valley for the second half of its length, turning again to the westward for a distance of about two miles to join the head of the lower lake. The wide valley just referred to, is, to the north, occupied by Mosquito Creek, a tributary stream of some size which is reported to rise in a couple of lakes, though its upper part is not known. In a southward direction from the connecting river, the same valley is continued in a direct line, for some miles, by that of Trout Creek, but at no great distance splits up into several smaller and narrower valleys, which run out among the high ridges and crests of the Valhalla Mountains. The valley of the river between the Upper and Lower Arrow lakes, is rather more than a mile in width throughout, with flat bottom-lands or low terraces, twenty feet or more in height, between the banks of the river and the mountains on both sides. Its width is not notably increased where it corresponds with a portion of the longitudinal valley just described. The river touches a point of solid rock at one place only, two miles from its mouth, and evidently represents an old deep hollow now filled with glacial drift or other still later deposits. The flat land bordering the river, with that running up the Mosquito Creek valley, should afford in all a not inconsiderable area susceptible of agricultural occupation. Character of valley.

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The connecting river itself is, generally speaking, a wide, tranquil stream, easily navigable by steamers. There are, however, two little rapids, one of which, eight miles from the upper lake, appears only at low water. The second, two miles from the lower lake, is swifter, and the channel is said to be somewhat crooked at low water. The river

Lower Arrow Lake

The Lower Arrow Lake has nearly the shape of a bow, lightly bent and with the convex side to the west, the two ends lying almost exactly in a north-and-south line. The lake is fifty-one miles in length, and Form and dimensions.

much narrower than the upper lake, averaging about a mile in width, seldom exceeding a mile and a half, and tapering gradually toward both ends. The head of the lake lies between high and rugged mountains, and no wide stretches of low land border it anywhere, but the mountains about it generally are considerably lower than those seen from the upper lake and along the connecting river. They are also more rounded and flowing in outline, though often rough and rocky in the details of their slopes. The mountains, however, again become higher and rise more steeply from the lake toward its southern end. The entering streams have very often formed low, sandy, delta-points, and here and there narrow flat borders or lower hills appear capable of affording some farming land if cleared. Bluff, rocky shores are, however, frequent along this as well as the upper lake. The shores of the lake, together with the surrounding country and mountains, are almost everywhere wooded where not too steep and rocky to afford a foothold for trees, but the forest is generally more open in character than that met with in the vicinity of Revelstoke. Fine groves of cottonwood occupy some parts of the shores and low sandy points along the lake, but as a rule, the timber seen was not of very great size or of superior quality. Where the lake turns eastward near its southern end, its northern banks show a good deal of open grassy country. The most attractive and park-like portion of this country is commonly named the 'Deer Park,' and is frequented by great numbers of deer, when in winter their higher pastures in the mountains become covered with snow. At the 'Painted Rocks,' a few miles below Deer Park and on the same side, there is a considerable number of Indian pictographs, roughly done in red paint on precipitous or overhanging surfaces.

Lake-shores and surrounding country.

Entering streams

No large streams enter the Lower Arrow Lake from the east side, which was that more particularly examined by me, and it is evident that the country in that direction, must, at no great distance from the lake, drain toward the Slocan or to Pass Creek. On the opposite side, however, are several streams, some of which might be called small rivers, and occupy notable valleys. Of these, Whatshan River, ten miles and a half from the north end of the lake, drains, by one of its branches, a lake reported to be eighteen miles in length. Eight miles further south is Sanderson Creek, the valley of which is said to contain some good land. Either this stream or a western branch of the Whatshan heads close to the upper part of the Kettle River, and as the country between the Lower Arrow Lake and the Kettle River is not roughly mountainous, their valleys might afford good routes toward Cherry Creek. The upper part of Mosquito Creek seems also worthy of

Low valleys to west.

examination in this connection. South of Sanderson Creek, three or four streams of minor importance fall in, after which comes Bowman Creek, with a considerable valley which appears to lead westward toward Kettle River. South of this, Dog Creek and two or three other insignificant streams complete the list.

Depth of lake.

The depth of the Lower Arrow Lake, though considerable, is evidently not so great as that of the upper lake, the deepest water found in three soundings at selected localities being 460 feet. This was obtained midway up the lake and near the middle between its shores. At twelve miles from the head, and again in the centre of the lake, the depth was 125 feet only. At ten miles from the lower end and nearer to the north (which is here the steeper) shore, the depth was 170 feet.

Elevation of lake.

The barometer readings taken on the Arrow Lakes, checked by station-readings at Kamloops and Spokane Falls (the latter obtained through the kindness of General Greely, United States Chief Signal Officer), though sufficient to give a good approximate value for the general elevation of the lakes, were not sufficiently numerous nor exact to determine accurately the difference of level between the two lakes. The observations taken on both lakes have, therefore, been combined in a common mean, and a difference of ten feet allowed as between the upper and lower lakes, This is probably very near the fact, the level for the lower lake thus arrived at being 1380 feet. The seasonal fluctuations of the lower lake are much greater than those of the upper, and evidence was found of a rise of twelve to fourteen feet above the actual level in June last. In consequence of the narrowness of the ends of this lake, its smaller sectional area as compared to the upper lake, and the considerable volume of water passing through it, a distinctly perceptible current exists in several places round the ends of the more prominent points.

Seasonal fluctuations.

Columbia River below the lakes.

From the southern end of the Lower Arrow Lake, the Columbia flows due east ten miles, in an almost perfectly direct course, to Sproat's Landing, where it turns to the south, and in less than a mile is joined by the Kootanie River. This part of the valley is somewhat narrow, and is uniformly bordered on both sides by rather steep mountains of moderate height and rounded form. The current of the river to Sproat's Landing is also nearly uniform, its rate being probably about four miles an hour. Just below Sproat's Landing, between that place and the mouth of the Kootanie, is a pretty strong rapid, which is said to have a crooked channel, somewhat difficult of ascent by steamers at low water. The elevation of the Columbia River at Sproat's Landing is approximately 1375 feet. The water of the river where it issues from the lower lake, though much clearer than where it enters the head of the upper lake, does not even then exhibit the blue transparent lucidity of the Kootanie.*

Below Sproat's Landing the river was not examined by me, but according to Mr. Bowman's traverse (which is employed for this portion of the map and has been previously referred to), after making one large and wide bend to the westward, it returns in an easterly direction and crosses the forty-ninth parallel into Washington, nearly due south of the Landing. The distance by river from Sproat's Landing to the international boundary is about thirty miles. Thence to the Little Dalles is a further distance of about fifteen miles, and the river is continuously navigable by steamers of good power to this point.

General Remarks.

Length of water route.

In reviewing what has been said of the Columbia River and Arrow Lakes in the preceding pages, it will be found that the total distance by water from Revelstoke to Sproat's Landing, is one hundred and forty-five miles and a half, of which eighty-seven miles and a half is lake and the remaining fifty-eight miles river. Respecting the character of this water-way as a means of communication, I may state that it is likely to prove of much greater importance and utility than I had supposed before examining it. A steamer was put upon it and was used by miners at the time of the Big Bend excitement as long ago as 1866, and again, during the construction of the Canadian Pacific Railway, a second steamer was built, by which men and supplies were taken north. During the past summer it was continuously navigated by two small steamers, running between Revelstoke and Sproat's Landing, named the 'Dispatch' and 'Marion' respectively. Neither of these possess more than very moderate engine power, yet little difficulty has been experienced in ascending any part of the river. These steamers, together with those before alluded to, are stern-wheel boats, which are better suited than any others for the navigation of rivers like that part of the Columbia between Revelstoke and the upper lake.

Steamers.

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* It has not been considered necessary to include mention of the various astronomical determinations of position made during this reconnaissance, which have been employed in the construction of the map. Sproat's Landing has been employed as a principal point. My observation spot here was situated a mile above the 'town,' and about 300 yards above Mr. Sproat's house, on the bank of the river. The position depends on the following observations :—

By meridian altitude of sun, ...Lat. = 49° 19′ 46″
By observations on Polaris,.......... " = 49° 19′ 54″

Mean Lat. adopted.............. 49° 19′ 50″

By chronometer and observations June 9th and July 8th, 1889—Long. 33′ 52·5″ east of observation point at Revelstoke, on bank of river in garden of Government building.

This is, I believe, the second year during which the 'Dispatch' has been on the route, and her captain, Mr. Robert Sanderson, is very familiar with the lakes and adjacent country. In travelling from Revelstoke to the Landing I employed an ordinary row-boat, this being more suitable for the purposes of examination and survey; but on returning took passage on the steamer, and obtained a number of useful notes from Mr. Sanderson.

The river from Revelstoke to the head of the upper lake is generally run down by the 'Dispatch' in two hours and a half. Several places on this length of river are generally found pretty shoal in the first trips made in early spring, when the water is lowest; and there are also a number of places where the removal of snags and 'sweepers' would be an advantage, particularly at low water, when it is necessary to follow the deepest channel throughout. The shoal already referred to as existing at the mouth of this part of the river, is sometimes troublesome after a sudden fall in the level of the water. At such times Mr. Sanderson has occasionally found no channel deeper than twenty-two inches across it, but in the course of a few days a channel always scours out to a depth of about five feet. The river connecting the two lakes affords a channel of not less than three feet throughout, even at the lowest observed stages of water, but there are several bars across which at such stages it is necessary to select a course with care. In the river between the lower lake and the Landing there is always an ample depth of water, and though some bouldery reefs appear at low stages, there is sufficient room to pass these in the channel. It would thus appear that a steamer for this route should be a stern-wheeler with good power, built to draw not more than four feet, and not loaded down over three feet when the water is low. Character of navigation.

No statistics are available respecting the total annual precepitation of rain and snow at Revelstoke, but the appearance and character of the forest and vegetation generally, indicates that it is very considerable. In travelling southward by the river and lakes evidence of the same kind proves a constantly decreasing rainfall and humidity of the atmosphere, and the climate of the southern end of the lower lake with that of Sproat's Landing and its vicinity, may be characterized as rather dry. Rainfall.

The trees forming the forest near Revelstoke have already been noted (p. 9 B). The Douglas fir (*Pseudotsuga Douglasii*) was first observed near the shore about the head of the Upper Arrow Lake, but may occur on the slopes of the mountains near Revelstoke. The western larch (*Larix occidentalis*) was first seen about midway down the upper lake, and thereafter was noted as generally abundant. Juniper (*Juniperus Virginiana*), assuming an arboreal form, is found on Trees.

rocky beaches on both lakes, but less abundantly toward the head of the upper lake. The yellow pine (*Pinus ponderosa*) appears for the first time near the head of the Lower Arrow Lake, and is increasingly abundant thereafter, becoming the characteristic tree of the southward-facing slopes near the Deer Park. Syringa bushes (*Philadelphus Lewisii*) appeared, about half way down the lower lake, growing in quantity on rocky slopes and in full bloom on the 16th of June.

Kootanie River.

The valley. The lower reach of the Kootanie River, and the West Arm of Kootanie Lake, from which it flows, occupy an important and continuous valley which runs off from that of the Columbia at Sproat's Landing in an east-north-easterly direction. This valley lies almost directly transverse to the main direction of the mountains and to that of the wider valleys occupied by the Arrow lakes and Kootanie Lake. The distance from the mouth of the Kootanie at Sproat's Landing to the main, or north-and-south portion of the Kootanie Lake, by this valley, is thirty-nine miles, the river occupying about twenty miles, while the West Arm of the lake takes up the remaining nineteen miles. The recently laid out town of Nelson, is situated about two miles from the outlet of the West Arm and on the south side of the Arm. It is at present reached by a fairly good pack-trail from Sproat's Landing, the distance between these points by trail being about twenty-one miles.

Sproat's Landing to Slocan River. On leaving Sproat's Landing, the bank of the Kootanie is reached in about half a mile, and the trail follows the north side of the valley for some distance. The river near its mouth is often bordered by rock on both sides and is very rough and rapid, and the trail for some miles runs along a rocky broken side-hill, but as the valley widens it leaves the immediate bank of the river and traverses terrace-flats, some of which reach a height of about 300 feet above the water. At about eight miles and a half from Sproat's Landing the Slocan River is reached and crossed by a good ferry. A large accumulation of heavy boulders occurs in the valley just below the mouth of the Slocan.

Ward's Ferry. After leaving the Slocan, the trail runs for rather more than a mile across a level and wide wooded flat, when the Kootanie River is crossed by a second ferry in a wide and slack part of its course. From this point (Ward's Ferry) the trail continues on the south side of the river, at a variable distance from it. The valley retains the same uniform trough-like character, and, as in its lower part, is uniformly bordered by rather steep wooded or rocky mountain-slopes.

Falls and rapids. Below Ward's Ferry, the river is almost everywhere swift and there are numerous rough, wild rapids, but the lowest fall occurs at about a mile above Ward's. The river is here divided into two channels, the water on one side falling vertically a distance of about thirty feet, on the other coming down a steep chute with great velocity. These are known as St. Agnes Falls, and they limit the ascent of the salmon on the Kootanie. The falls were formerly a noted salmon-fishing place for the Salish Indians and the limit of these people to the east, the country beyond belonging to the Kootanie tribes. The fall on the north side is a very picturesque and striking feature, its beauty being enhanced by the clear, blue colour of the water. Fine trout may be taken in the basin below it, in almost unlimited quantity at certain seasons. Within a couple of miles above the falls, two other notable falls occur, named the Pillar and Geyser Falls respectively, and between the highest of those and the end of the West Arm the river forms several strong rapids.

Eastern limit of Salish Indians.

Between Ward's Ferry and Nelson several streams enter the Kootanie from the Toad Mountain range on the south. These are known as Rover, Forty-nine, Eagle and Sandy creeks, and just before reaching Nelson Cottonwood-Smith Creek is crossed. This is larger than any of those first mentioned, and flows from a deep valley which bounds Toad Mountain on the east and runs through to the head waters of Salmon River. Several small streams enter the Kootanie from the north in this part of its course, the most important, with a valley about nine miles in length, coming in just at the head of the river.*

Tributary streams.

Whatever may have been the origin of the transverse valley which now serves as the outlet of Kootanie Lake to the Columbia, it is evident, speaking of that portion of it now occupied by the river, that its rocky bed is little if at all below the present level of erosion. This is particularly apparent on the lower part of the river, about the falls, and again near the outflow of the river from the lake, where the banks of the river are frequently formed of solid rock. Had the valley been much deeper than it now is and filled only with drift deposits due to the glacial period, the difference of level between the Columbia and Kootanie Lakes (amounting to 356 feet†) would long since have enabled the river to cut down its bed to such an extent as to drain much of the Kootanie Lake.

Valley not deeply filled with drift.

Though entirely unsuited for navigation by reason of its rapids and falls, this part of the Kootanie is capable of affording, at the falls, an almost unlimited amount of water-power for milling or other purposes. The quantity of arable land contained in the valley is inconsiderable,

Water-power.

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* By meridian altitude of sun, the latitude of observation point on lake-shore in front of Nelson is 49° 29′ 54″.

† According to levelling by C.P.R. Survey, kindly communicated by Mr. H. Abbott.

as even the greater part of the terrace-flats is either sandy or stony. There are, however, some wooded flats with silty soil which will no doubt eventually be cleared and cultivated. There has been in the aggregate a considerable quantity of fair to good timber in this part of the valley, but the greater portion has unfortunately been destroyed by fire.

Vegetation. For a few miles above the mouth of the river, the north-west bank is open and its vegetation is indicative of a dry climate, like that of the Lower Arrow Lake. Here *Clarkia pulchella*, a plant seldom elsewhere found in British Columbia, was collected. *Balsamorrhya sagittata* was also noted. Further up the valley the rain-fall is evidently greater. The forests consist chiefly of Douglas fir, hemlock, cedar and larch, with occasional specimens of yellow pine and other trees. The western yew (*Taxus brevifolia*) was also occasionally seen in damp spots, as a small tree with trunk a foot in diameter. On the river-flats and terraces in the immediate vicinity of Ward's Ferry, there occurs a greater number of species of coniferous trees than I remember to have seen together elsewhere in the Province. The list includes cedar (*Thuya gigantea*), yellow, black and white pine (*P. ponderosa*, *P. Murrayana* and *P. monticola*), larch (*Larix occidentalis*), Arboreal juniper (*Juniperus Virginiana*), Douglas fir (*Pseudotsuga Douglasii*), hemlock (*Tsuga Mertensiana*) and Engelmann's spruce (*Picea Engelmanni*).

The handsome malvaceous plant, *Sphæralcia rivularis*, was noted in abundance near Ward's Ferry, though rarely seen elsewhere in British Columbia. As denoting the progress of the season it may be added that the service-berry, flowering-raspberry and large blueberry (*Amalanchier alnifolia*, *Rubus Nutkanus* and *Vaccinium myrtilloides*), were found with ripe fruit on June 20th.

Slocan River. As already mentioned, the most considerable tributary received by the Kootanie, between the lake and the Columbia, is the Slocan. This stream, where crossed by the ferry near its mouth, is very rapid and strong, with a width of one hundred and eighty feet. From Mr. Archie McDonald, who had been engaged in prospecting on the Slocan, the following notes were obtained. It will be found that the distances as given by him do not correspond with those of the map, as his estimates doubtless include the various sinuosities of the route necessarily followed. An attempt has been made to indicate the portion of the river and lake on the map in relation to the other known features. The length of the river from its mouth to the lake in which it rises, Mr. McDonald estimates at forty miles. At eighteen miles up, a branch comes in from the west, by the valley of which the Indians cross over to Deer Park on Lower Arrow Lake—distance, say, twenty miles.

The greater part of the length of the river is swift, and can be ascended only by poling, but one reach of eight miles occurs, and another of four miles, just below the lake, where the current is quite moderate. Two extensive log-jams exist which necessitate portages. The lake is said to be twenty miles in length, with steep, bluffy banks on the west side and flat land on the east, for the first half of its length. On the upper part of the lake, flat land occurs on the west and steep slopes on east. From the head of the lake a pass leads to the lower end of the Upper Arrow Lake, the distance across being stated at about eighteen miles. There is also said to be a pass used by Indians from the vicinity of Slocan Lake to the West Arm of Kootanie Lake. High mountains carrying some snow in summer were seen about the head of Slocan Lake, but no glaciers were observed on them. **Slocan Lake.**

General aspect of surrounding country. The steep and generally uniform slopes of the lower mountains, which border the deep valley of the Kootanie River, prevent any general view of the higher and more distant summits from being obtained; but from one of the eastern points of Toad Mountain a somewhat extensive outlook was gained, though the atmosphere was unfortunately at the time somewhat obscured by smoke. From this point, with an altitude of 6990 feet, it was estimated that the general height of the summits of mountains in view on all bearings except to the south-westward (where the distant view was cut off by other summits of Toad Mountain) was about 6000 feet above sea-level. This height is maintained with considerable uniformity, and at or about it rather extensive rocky or partially wooded plateau-like areas occur in some places. Above this general level, however, higher and rougher peaks rise, usually about the central parts of the blocks of mountainous country which lie between the several larger valleys occupied by rivers and lakes. One of the most important of these culminating ranges, with wild ragged outlines and carrying much snow, was seen on a north-west bearing at a distance of about thirty-five miles. This was evidently the southern aspect of the Valhalla Mountains, previously noted as lying to the east of the head of Lower Arrow Lake, between that lake and the Slocan valley. It is probable that several peaks in these mountains reach a height of 8500 feet. The mountains between the Slocan valley and that of Kootanie Lake, culminate in a second central alpine region of about 8000 feet in height, in addition to which there is another partially isolated group of mountains near the headwaters of Coffee Creek, some points in which may attain a height of 9000 feet. The Ymir Mountains, to the south of the West Arm of Kootanie Lake, after their first abrupt rise from the lake-shore, continue rising gradually in wooded slopes, till, on a bearing about due east from Toad Mountain, they attain heights of about 8000 feet, and form together a considerable area of rather rough, rocky ridges and summits, among which more or less snow remains during the summer.

Southward from Toad Mountain, several mountains on different bearings reach heights of about 8000 feet, but there is no conspicuous range of high mountains. Through this mountainous region the deep valley of Salmon River may be seen running nearly due south for many miles. As before mentioned, the head-waters of this river and that of Cottonwood-Smith Creek nearly inosculate to the east of Toad Mountain. The exact height of the watershed in this valley was not ascertained, but it is probably about 1200 feet above the lake, or 2930 feet above sea-level.

Toad Mountain

Toad Mountain is a name of very recent origin, dating only from the discovery of the Hall Brothers' silver mine. The mountain so called, forms the eastern end of a high region which lies to the south-east of the Kootanie River, and of which several points surpass 8000 feet in elevation. It is drained on the south by tributaries of the Salmon River, on the north by Cottonwood-Smith Creek and other streams previously mentioned which fall toward the Kootanie. The trail by which the Hall Brothers' and other claims, situated at heights of 5700 to 6300 feet above sea-level on the mountain, are reached from Nelson, follows Cottonwood-Smith Creek and a branch of that stream known as Give-out Creek. A second trail, running westward from this, falls into the Kootanie River trail near Forty-nine Creek. The various mining claims visited on this mountain, together with the character of its rocks, are noted subsequently.

Timber line.

The slopes of the mountain are in general densely wooded and some good timber occurs in the valleys. Above 5000 feet the forest becomes more open and of smaller growth, and though trees are still found at a height of about 7500 feet, they are here stunted and this height may be assumed as approximately that of the timber-line. *Pinus albicaulis* is abundant on the higher points of the mountain, where also *Xerophyllum tenax* was observed, with a number of alpine flowers, common to most mountains of the Province.

Kootanie Lake.

West Arm.

The West Arm of the Kootanie Lake, from its outlet, extends about nine miles and a half north-eastward, beyond which it turns to an east-north-east direction for a similar distance, when it opens, at Queen's Bay, on the main lake. The average width of the first half of the Arm slightly exceeds half a mile. The second half is somewhat wider, but more irregular in width. A number of small streams enter the Arm on both sides. All these streams have formed sandy delta-flats of

G. M. DAWSON, PHOTO., JULY 2, 1889. "THE DOMINION ILLUSTRATED," ENG. & PR., MONTREAL.

WEST ARM OF KOOTANIE LAKE, FROM NELSON.

Granitic mountain to the left.

greater or less size at their mouths. In this way the area of the waterway is diminished to such an extent as in some places to produce rather strong river-like currents. The Arm is evidently nowhere very deep, but even in the various narrows affords at all stages of water a sufficient depth for any steamers likely to be employed upon the lake.

Valley of the West Arm. The valley occupied by this arm of the lake is identical in character with that of the Kootanie River below, but is here flooded. In the first half of its length, its width between the slopes of the opposite mountains is less than a mile, but it becomes wider on approaching the main lake. The bordering mountains rise with steep slopes in the first instance to heights of 1500 to 3000 feet above the lake, beyond which the slopes generally become more gradual and much higher points are seen up some of the valleys of the entering streams. Along the eastern half of the Arm, there appears to be some arable land, though the soil is usually sandy. Certain areas here and there might also be reclaimed by dyking swampy land. Much of the timber, which in places is of very fair quality, has already been destroyed by fire.

Character of outlet. The immediate cause of the flooding of the valley now occupied by the West Arm, is the blocking of the valley at the western extremity of the Arm, by a mass of rough bouldery wash which has been brought down by the large stream previously alluded to as entering from the north at that point. This causes a little rapid, which is the beginning of the lower part of the Kootanie River, and has a width of from 300 to 400 feet, according to the height of the water. Its south border is formed by rocky bluffs, against which the wash from the stream just mentioned has been projected. It has been proposed to lower the general level of the Kootanie Lake by removing the obstruction here described, and this is no doubt possible. Should, however, such reduction exceed a few feet in amount, several of the narrows in the West Arm would be converted into shallow rapids, thus rendering the Arm unfit for navigation; while to achieve any important lowering of the level of the lake, each of these obstructions would in turn have to be removed. The remarks made on a previous page, together with the known great depth of the Kootanie Lake, show that if even the whole of the loose material now found in the valley of the West Arm and Kootanie River were removed it would not result in the draining of Kootanie Lake.

The main lake. Having thus described the West Arm of Kootanie Lake, a few notes may now be given on the main lake, which occupies one of the longitudinal valleys of the mountain ranges, and is comparable in this respect to the Upper and Lower Arrow lakes, though more important than either of these. Its total length is abont sixty-four miles. In form it is nearly simple and straight, lying on a bearing which departs a few degrees to the west of north. Its height above the sea is approximately 1730 feet, and its average width, which is preserved with considerable uniformity, about two miles. The West Arm joins the lake a little to the south of its centre, the distance from the mouth of this arm to the north end of the lake being thirty-eight miles. This part of the lake is shown upon the accompanying map according to the results of my survey. The southern portion of the lake, which has never been surveyed in detail, is represented in broken lines, according to the Map of the Eastern Part of British Columbia, compiled by direction of the Hon. F. G. Vernon, Chief Commissioner of Lands and Works, 1888. With the exception of the West Arm, the most important interruption to the general outline of the lake is Crawford Bay, which occurs on the east side, opposite the entrance of the arm, and is separated from the main lake by a low hilly point or peninsula.

Hot Springs camp.

The Hot Springs, or 'Warm Springs,' mining camp, is situated on the west side of the lake, eight miles north of the West Arm. Here, chiefly comprised within a tract about six miles in length, between Coffee and Woodberry creeks, a large number of mining claims have been taken up. These are noticed in detail on a subsequent page. Several stores and houses have been established on the shore of the lake, and a town-site, which has been named 'Ainsworth,' has been laid out. Three miles north-east of Hot Springs, on a small peninsula on the opposite or east side of the lake, is situated the Hendryx mining camp, and elsewhere in the vicinity of the lake isolated mining claims have been recorded.

The distance by water from Nelson, near the extremity of the West Arm, to Hot Springs, is twenty-six miles.

Character of lake-shores and surrounding country.

The whole northern part of Kootanie Lake, and, so far as could be observed from distant views, the southern part as well, may be described as closely bordered by mountains, which, as a rule, slope up more or less steeply from the lake-shore without any intervening flat land, to heights often of 6000 feet above it. On closer inspection, however, it is observed that the axial lines of the dominant and higher ranges tend to cross the line of the lake obliquely in its northern part, in consequence of their more westerly trend. Many of the mountains are somewhat rugged in outline and show much bare rock, and very abrupt rocky hills and bluffs often front directly on the shores. Cliffs of some height occur in several places along the margin of the lake, the most conspicuous being situated on the east shore about sixteen miles north of Hot Springs. Many fine sandy or gravelly beaches are, however, also found, particularly at the mouths of entering streams. The general aspect of the lake is in fact not unlike that of the Upper Arrow Lake, save that the mountains are here crowded more closely upon the shores. The depth of the lake is evidently very great, and though no soundings were made by me upon it, statements reported lead to the belief that it considerably exceeds the Upper Arrow Lake in this respect.

Kootanie River

The principal feeder of the Kootanie Lake, is of course the river of the same name, which, after a long southward course between the Rocky Mountains and the Purcell Range, passes between the south end of this range and the Cabinet Mountains in Montana and Idaho, and turning to a northerly direction adopts the continuation of the Kootanie Lake valley, and falls eventually into the south end of the lake. A few miles beyond the north end of the lake, the valley becomes more or less interrupted by hills, and bifurcates, the branch valley to the west bringing in the Lardo* River, that to the east the Duncan River. The first-mentioned valley trends toward the head of the North-east Arm of Upper Arrow Lake, and is reported to afford a good pass. The second, so far as known, trends nearly due north, and is more nearly in the line of that of the lake. It holds a second lake, reported to be of considerable size, known as Upper Kootanie Lake, and unwaters the western slopes of the axial range of the Selkirk Mountains. The united streams of the Lardo and Duncan, where they enter Kootanie Lake, form a fair sized river, but not one such as to be navigable for steamers of any kind.

Lardo and Duncan rivers.

North end of lake.

The flat land at the north end of the lake, runs on for about five miles with about the same width as the lake itself, before the previously described bifurcation of the valley occurs. The border of this land on the lake, consists of wide grassy marshes, on which a considerable quantity of swamp-hay might be cut. Further back, groves of cottonwood and willows occur, and rising above these, at a distance of about a mile or so, coniferous trees appear, and it is probable that beyond this point the land is not subject to flood. The action of the waves in the shallow water at the head of the lake, has produced a rather remarkable ridge or bar of sand which runs almost completely across it, at a short distance out from the edge of the meadows. This, at the date of my visit, was bare, with a channel running continuously behind it.

Other streams.

Fry River, seven miles and a half from the north end of the lake, on its east side, and Caslo River, eighteen miles from the same point on the opposite side, are the only other important affluents in the northern half of the lake. One or both of the streams flowing into Crawford Bay may be of importance, but were not seen. There are, in addition, many smaller streams with short courses among the neighbouring mountains, but these do not require special mention.

* Also written Lardeaux.

Seasonal rise and fall.

Notwithstanding the considerable area of Kootanie Lake (about 135 square miles), it is subject to great changes in level. In the latter part of June, 1889, the water had fallen a few feet from its highest stage of that year, in which the annual rise had been exceptionally small. Evidences were, however, found of extreme high-water stages, occasionally reached, about fourteen feet above the actual water-level. In consequence doubtless of the great depth of the lake, it seldom freezes over any considerable part of its area, the interruption to navigation from ice upon it being much less than that on the Arrow lakes.

Hot Springs.

The hot springs from which the mining camp previously referred to takes its name, constitute a remarkable feature. They are situated on the immediate shore of the lake and within the town-site of 'Ainsworth.' Unlike the hot springs on Upper Arrow Lake, these give rise to a copious calcareous deposit, which extends for about 300 feet along the edge of the lake, and forms a little terrace with a height at the front of about twenty feet, and sloping gradually up toward the foot of the hill. At the southern end, a lower floor of the deposit, nearly on the level of the lake-shore, presents a number of basin-like pools with well marked rims, into which the water trickles. The principal visible flow occurs on the summit of the little terrace, where there is one main orifice with several surrounding smaller ones. There are as well, however, several outflows along the edge of the water, where the terrace has been cut into a rough low cliff, and there are very probably others also beneath the surface of the water of the lake. It is thus impossible even to guess the volume of water rising from these springs, but that afforded by the principal orifice on the terrace was roughly estimated at about sixty gallons per minute. The temperature of the water on June 25th, was found to be 101·5° F. It has a slightly saline and rather pleasant taste. The calcareous deposit is a porous travertin of a cream colour, which forms more or less parallel on concentric layers.

Vegetation.

The vegetation characterizing the vicinity of Kootanie Lake resembles that of the Lower Arrow Lake and the lower part of the Kootanie River. The yellow pine and larch were found quite to the north end of the lake, and may extend some little distance beyond it. The yew was observed forming a small tree in several places. In the lower valleys, and also probably in many high though sheltered valleys among the mountains, considerable quantities of good timber, particularly cedar and white pine, exist.

Climate.

In regard to the rainfall and general humidity of the atmosphere in the region to which this report relates, it is evident that in consequence of the variety and prominence of its physical features, nothing certain can be affirmed till continuous observations at a number of stations have been made. Meanwhile, the character of the natural vegetation, and especially that of the forest growth, is sufficient to indicate these climatic features in a general way. No part of the region which was traversed seems to possess a humidity equal to that of the vicinity of Revelstoke and the valley of the Illecillewaet. This district of humid atmosphere and great precipitation, as we travel southward, appears to fall back to the eastward, associating itself with the higher ranges of the Selkirk and Purcell mountains, so that a line drawn from the head of Upper Arrow Lake to the north end of Kootanie Lake, and thence in a south-south-easterly direction, would separate the more humid from the drier parts of the region. It is evident, however, that each of the more important and higher mountain masses becomes to some extent a separate centre of precipitation and moisture, while the lower and wider valleys are relatively dry.

Rainfall and degree of humidity.

Routes and Means of Access.

The immediate need of a means of transport for the rich ores of the vicinity of Kootanie Lake, may render appropriate a few words on the question of prospective railway routes, as affected by the physical features of the district. The navigation of the lakes and rivers has previously been referred to. (p. 17 B.)

Railway routes.

No special difficulties present themselves in the way of a railway line to connect Sproat's Landing on the Columbia with the West Arm of Kootanie Lake. The distance measured along the river-valley, as already stated, is about twenty miles. The greater part of this route may, in fact, be described as easy work, though in the first three or four miles from the mouth of the Kootanie some moderately heavy work along the rocky side-hill would be necessary. The river might also require to be crossed once or twice in order to allow the best line to be followed. As I believe a survey of this line is now actually in progress, it is unnecessary to refer to it in further detail.

The most advantageous permanent railway connection for the Kootanie Lake country would, however, undoubtedly be one from Revelstoke, on the Canadian Pacific Railway, direct to the lake. Such a line would follow the Columbia valley for twenty-seven miles, the North-East Arm of Upper Arrow Lake for about ten miles, and thence the Lardo River pass for about forty-eight miles to the north end of Kootanie Lake, making a total length of about eighty-five miles. From Revelstoke to the head of the Upper Arrow Lake, such a line would be easily constructed along the continuous flats on the east side of the river, with the exception of one portion less than two miles in length, where rocky bluffs come out to the river. Thence, following the north-west side of the North-east Arm, no great difficulty would be encountered except in one length of about a mile, where most of the road-bed would require to be cut out along a cliff and one short tunnel would probably be necessary. It is possible, that by taking advantage of the shallow delta of the Columbia, the Arm might be crossed at its mouth, and a better line obtained on its opposite side, but the depth, as well as the width of the deep part of the channel which exists between the delta edge and the south shore is unknown. I am unable to supply any notes on the character of the route from the head of the North-east Arm to Kootanie Lake, but the summit in this pass is reported as not of great height and to be situated near the Arm, while the Lardo valley is described as being favourable. The flat land at the mouth of a small stream two miles from the head of Kootanie Lake, on the west side, would afford a suitable terminal point for such a railway, with bold water and good shelter from southerly winds. Should it be contemplated, at a later date, to extend the line along the shore of the lake to Hot Springs, a good deal of rocky side-hill and numerous bluffs fronting on the lake would have to be passed, the character of the work much resembling that on the east side of the Salmon Arm of Shuswap Lake. A further extension to Nelson would entail rough work of the same character as far as Queen's Bay, beyond which either shore of the West Arm would afford an excellent route.

General Geological Features of the West Kootanie District.

Nature of observations made.

The geological structure of the region covered by the reconnaissance here reported on, is extremely complicated, and the information obtained is not sufficient to admit of a systematic or satisfactory description of the rocks occurring in it. The Gold, Selkirk and Purcell mountains have not yet been studied in detail in any part of their extent, and the formations entering into their composition differ widely, if not in age, at least in lithological character and degree of alteration from those found in the Rocky Mountains proper, on one side, and in the Interior Plateau region of British Columbia on the other. As it is probable that more consecutive and detailed observations on the structure of the ranges above named will shortly be made, including as a first step a section across them on the line of the Canadian Pacific Railway, I shall here refer merely to the more salient features, and in particular to those which have been noted in connection with the occurrence of the ore-deposits. These appear to possess some immediate practical importance in affording clues to the origin and habitus of the ore-deposits, and are thus likely to prove of service in connection with the prospecting and development of the region.

Shuswap series

While in the Rocky Mountains proper, in corresponding latitudes, neither granites nor crystalline schists are brought to the surface, in the region here reported on both occur in abundance. The oldest stratified rocks found here, consist of mica-schists and gneisses, the former often coarsely crystalline and frequently garnetiferous, the latter usually characterized, so far as observed, by a preponderance of orthoclose felspar, and generally grey in colour and not very coarse in grain. With these are associated hornblende-schists, hornblendic mica-shists and hornblende-gneisses, as well as coarsely crystalline marbles, which are often spangled with mica- and occasionally with graphite-crystals. These marbles, with calcareous gneisses, are particularly abundant toward the observed base of the series, and constitute an important feature of the rocks on Kootanie Lake. The mica-schists and gneisses are also often siliceous, and pass in some places into nearly pure quartzites, which were found in greatest development in the vicinity of the marbles.

From their highly crystalline character, and from analogy with other not far remote sections, such, especially, as those of the Shuswap Lakes, these rocks are regarded as Archæan.

Adams Lake series.

Overlying these rocks, at Hot Springs, is a great thickness of grey and green schists, which are seldom coarsely crystalline. No detailed lithological examination has yet been made of these rocks, but of the green schists a great part is believed to consist of diabase-schist, while felspathic chloritic, hornblendic and micaceous schists are included in the series. Some grey quartzite-schists, with micaceous division planes, are also found, with numerous other varities of rocks intermediate in composition between those above noted. Micaceous schists are particularly abundant in the vicinity of granitic intrusions, and in such cases rocks are occasionally met with, which can not be clearly separated from those of the preceding series. As a rule, however, the general appearance even of the highly altered representatives of this series is somewhat different, and their crystallization is less perfect and finer in grain. While there is reason to believe that this series is unconformable on the last, no distinct evidence of unconformity has been discovered, and it is not known whether this circumstance is due to original pseudo-conformity in deposition, or to the intensity of the forces which have acted in folding the two series, and thus forcing them into an appearance of paralellism.

Series No. 5.

The rocks just described, are overlain by beds, which consist largely of massive limestones of grey or blue-grey colour, as a rule, but locally converted into white, or nearly white, fine-grained marble. These are interbedded to some extent toward the base with grey schistose rocks like those of the last series, and are found to be underlain, at Hot Springs, by a fine-grained conglomerate, which has been rendered schistose by pressure, and shows mica on its division-planes. With the limestones are associated black schistose argillites, with lustrous surfaces, on which more or less mica is often found to have been developed. These argillites constitute an important part of this group, but with respect to the relative volume of the argillites and limestones no certain data were obtained.

Constitution of Adams Lake series.

The grey and greenish schistose rocks constituting the second group may, with confidence, be affirmed to be essentially composed of altered volcanic materials, and their present schistose character may probably be regarded as in the main due to the enormous pressure to which they have been subjected during the movements of the earth's crust, which resulted in the uptlift of the mountains of the region and the extrusion of the great masses of granite here everywhere found. The original character of the material of the schists might not have been ascertained from the somewhat cursory examination of the district to which this report relates, though transitional stages in the passage of distinctly volcanic products into these schists occur on Toad Mountain, where the direct effect of pressure has been less and the alteration due to the heat of the later granitic masses has been greater. As stated below, however, the same schistose series occurs on Shuswap and Adams lakes; and in the vicinity of the last named lake and in the country between it and the North and South Thompson rivers, the actual passage of the schists, on their line of strike, into massive volcanic materials, chiefly consisting of diabase-agglomerates and amygdaloides has been studied.

Section at Hot Springs.

The most instructive general section met with, of the stratified rocks of the West Kootanie district, is that afforded by the shores of Kootanie Lake, near and to the north of Hot Springs, taken in conjunction with that on the trail which ascends the mountains behind Hot Springs. Some details of this are referred to in connection with the metalliferous deposits of that locality. It is sufficient to indicate the general order of superposition of the three sets of beds just described and to show that the total thickness of stratified rocks is very great, but owing to local complications the actual volumes of the respective members could not be ascertained, except in the case of the first or lowest. This was found to have an approximate thickness of 5000 feet. Taking as a standard of campārison the section met with and measured in 1888, on the lower part of Adams Lake, and adding to it the above thickness of series 1 on Kootanie Lake, the following outline of the arrangement and respective thickness of the rocks of this part of the Gold and Selkirk ranges may be given, the order being descending.—

General section

			FEET.
		6. Greenish and grey schists, with many beds of limestone, (generally altered to marble) in the lower part..	2,000
		5. Limestone or marble, often banded with siliceous layers, and associated with considerable volumes of black glossy argillites and some grey schists..............	2,500
Adams Lake Series.		4. Chiefly greenish schists, varying considerably in texture, and with some grey-green and grey schists......	4,050
		3. Chiefly grey schists, varying in texture like the last, and including some green-grey and greenish schists...	8,650
Nisconlith Series.		2. Black, shaly or schistose argillites, with much dark-coloured limestone in thin beds, both argillite and limestone often more or less micaceous. Thickness not definitely known, say............................	1,000
Shuswap Series.		1. Mica-schists, gneisses and marbles, completely crystalline and often highly siliceous........................	5,000

The following remarks may be made in explanation of the above general section. No. 6 includes the highest beds seen on Adams Lake, and was not recognized in West Kootanie, where No. 5 is found on the mountain-slopes to the west of Hot Springs forming the highest member of the local section. Nos. 4 and 3 are so similar in general character, and blend so completely in the Adams Lake section, that it is proposed to unite them under the general provisional name of the Adams Lake series. Both grey and green schists referable to this series occur in the Hot Springs section, but the total thickness is there either smaller than on Adams Lake, or is only shown in part. No. 2 is not found in the Hot Springs section, but is believed to be represented by the argillites of the south-east shore of Upper Arrow Lake and elsewhere in West Kootanie. This is provisionally designated as the Nisconlith series, from a locality on the South Thompson. No. 1 is not well shown on Adams Lake, but is found in its vicinity extensively developed about Little Shuswap Lake. As above stated, however, the thickness assigned to this member of the section is derived from observations on Kootanie Lake. No distinct evidence of uncomformity has been found throughout the entire section, but this lowest series may be provisionally referred to the Archæan under the name of the Shuswap series.

Explanation of section.

The total thickness of beds represented in the general section is very great, aggregating at least 23,200 feet. In 1877 the same rocks were examined by me on Great Shuswap Lake, and the general section

Total thickness.

constructed as a result of this examination, corresponds pretty closely with that here given, though the dividing lines between the several component members were not always drawn in precisely the same places. The total thickness met with on the Greet Shuswap Lake was estimated at about 32,200 feet.*

Probable age of rocks.

The stratified rocks of the Gold and Selkirk ranges, above referred to, have not yet been closely studied from a lithological point of view, and no attempt is therefore made in this report to do more than broadly characterize them by their more evident features. Neither is it possible, as yet, to speak with any certainty as to the geological periods to which these rocks should be referred, as no fossils have been obtained from them. It is believed, however, that the whole of these rocks above those of the Shuswap series (No. 1), are in all probability Palæozoic in age, and analogy with what is known elsewhere in British Columbia, suggests that they may eventually be referred to various systems, including the Carboniferous and extending downward to the Lower Cambrian.

Granites.

A large part of the West Kootanie district is occupied by granites and granitoid rocks, the main area of which (so far as observed) includes the whole basin of the Lower Arrow Lake, and extends thence eastward nearly to Queen's Bay on Kootanie Lake. Besides this great granitic area, there are several others of smaller dimensions, as indicated on the map, as well as numerous dykes and eruptions too small to be separately shown. It is in fact probable, that about one-half of the entire region here reported upon is occupied by granites and granitoid rocks. The granites differ considerably in appearance and composition, and appear to be referable to at least two and probably to three distinct periods, though it is as yet impossible to define the respective areas of these. The granites which are supposed to be of the greatest age, were found in some places underlying the lowest beds of the gneissic and mica-schist or Shuswap series. They appear to be closely attached to this stratified series, if not connected with it in origin; and in texture and composition, as seen in hand specimens, can often scarcely be distinguished from some of its homogeneous gneisses. They are generally rather fine-grained, and are believed to consist for the most part of muscovite-biotite-granite, though much further investigation would be required before it can asserted that this is their characteristic composition.†

Oldest granites.

* Report of Progress Geol. Surv. Can. 1877-78, p. 96 B.

† Thin sections of these, and of some other rocks here mentioned, have been subjected to a preliminary microscopic examination by Dr. A. C. Lawson, with the object of ascertaining by what names they may be appropriately designated.

Granites of this character form an extensive area south of Thumb Bay on Upper Arrow Lake, and were again seen on the north side of Queen's Bay in small exposures in contact with gneiss.

Hornblende-granites.

The granites which, however, occupy by far the largest area, are of coarser texture, generally grey, passing to black in colour, and are characterized by black mica, with frequently much black hornblende. They may be described, as a whole, as hornblende-granites, but occasionally pass into mica-syenite. In some localities they are not infrequently coarsely porphyritic with large twinned orthoclose felspar crystals, while sphene is often present as an accessory mineral.

These granites are evidently intrusive and of later date than the stratified rocks, which are altered by them at contacts. They appear to have a rather intimate connection with the occurrence of metalliferous deposits in adjacent areas of the stratified rocks, and the conditions which have resulted in the formation of the metalliferous veins probably occurred for the most part at the time of their intrusion.

Red granites.

Granites of the third and most recent class are largely displayed along the east shore of the lower part of Lower Arrow Lake, where they continuously characterize a considerable area, but are also found in spurs and dykes cutting through the coarse grey granites. They are pink or reddish in colour and consist largely of orthoclose felspar, with black mica and hornblende. The proportion of quartz contained varies widely, as does also the coarseness of texture, in the various specimens.

Occurrence of ore-deposits.

With the foregoing description of the general geological character of the district as a basis, a few words may now be added on the relations of the ore-deposits to the various rocks. Some further details bearing on the same important question will be found in the sequel, in connection with the descriptions of Toad Mountain, Hot Springs and Hendryx. 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. These exceptional veins traverse a hard dark-grey mica-syenite, and differ in character from the other ores, consisting of auriferous iron-pyrites in a quartz gangue. They are of particular interest in showing that the granitoid as well as the stratified rocks of the district may merit the attention of the prospector.

Ore-deposits at Hot Springs.

The ore-deposits found in the lowest stratified deposits, or gneissic and mica-schist rocks included in the Shuswap series (No. 1), so far as yet determined, consist principally of galena, with some blende, pyrites and other accessory minerals, and are rather low-grade ores in respect to silver. These deposits include those of Hendryx, and the lower tier of veins at Hot Springs, extending from the shores of the lake back to the line of the "Spokane" claim. All the richer argentiferous ores of Hot Springs are included in the zones characterized by the green and grey schists, and that of limestones and argillite schists, embraced in series Nos. 3, 4 and 5. This difference in richness in the veins is, I believe, to be attributed to the influence of the country-rock upon them; though possibly also in part due to the greater proximity of the veins in the higher rocks, to the edge of a granite mass which is found near the summits of the mountains behind Hot Springs. While, therefore, the north-western extension of the limestones and black schists from the Hot Springs localities, constitutes the most promising region for further prospecting in that vicinity, it is not probable that all parts of the outcrop of these and of the underlying green and grey schist series will prove equally rich in metalliferous deposits, but rather that such places will be found localized here and there upon this belt of rocks, where other conditions necessary to the formation of veins have coöperated.

Ore-deposits at Toad Mountain

The area of stratified rocks in which nearly all the metalliferous deposits of Toad Mountain have been found, appears to be surrounded on all sides by granite. The rocks represented are believed to be those of the Adams Lake series, (Nos. 3 and 4,) but they are here seldom so schistose in character as at Adams Lake and Hot Springs, and frequently occur as little-altered diabases or diabase-porphyrites, while in immediate contact with the granite they are occasionally converted into pyroxenites, containing more or less hornblende and mica. In some places the amygadoidal structure which has originally characterized some of the diabases is still clearly apparent. The alteration of the stratified rocks of this vicinity appears, in fact, to be due chiefly to the heat of the adjacent granitic rocks at the time of the extrusion of these, and they have been subjected to less alteration by pressure. Concurrently with this difference, it is found that the contained ores also differ in charater from those afforded by the veins traversing the rocks of the same age at Hot Springs. At Toad Mountain, copper ores are more, and galena is less abundant, while the percentage of silver is frequently very high.

The somewhat peculiar auriferous deposit of the Cottonwood mine, on the east end of Toad Mountain, is separately described in the sequel.

Metalliferous diabase series.

In the Summary Report of the operations of the Geological Survey for 1888, the following remarks were made in connection with the description of the metalliferous deposits of the vicinity of Stump Lake, south of Kamloops:—"The country-rock consists of altered volcanic materials, probably of Palæozoic age, and may be generally characterized as a diabase-porphyrite, the most characteristic material in this place being a rock of green and green-grey colour with coarse porphyritic crystals of plagioclase and pyroxene. * * * The occurrence of these ores in the green, altered volcanic rocks, which, under slightly varying forms, occupy so large an area of the southern interior of British Columbia, is a feature of peculiar interest, inasmuch as it leads to the belief that these wide-spread rocks become a metalliferous series when the other conditions are favourable. What these precise conditions are, beyond the existence of fissures in which the segregation of metallic minerals has occurred, we are yet unprepared to say. Massive granite rocks occur a few miles to the west of the mineral belt of Stump Lake, and while a similar rock may underlie the surface at no great depth in the mineral belt, there is nothing to indicate that the ores partake of the nature of contact deposits."

Series 3 and 4 of the West Kootanie section, as previously explained, evidently represent rocks originally of volcanic origin, very similar to, if not actually of the same age with, those of the vicinity of Stump Lake. Like them they are referable to the great, green predominently-diabase portion of the Palæozoic strata of British Columbia, and the fact now ascertained, that these rocks are also among those which hold rich ores in West Kootanie, adds further confirmation of their economic importance. The resemblance is closer as between the rocks of Toad Mountain and those of Stump Lake, under similar conditions of metamorphism, than between the Stump Lake rocks (which are seldom schistose) and those of Hot Springs. On Toad Mountain, some diabase-porphyrites practically identical in character with those of Stump Lake occur.

Ore-bearing rocks of Stump Lake and Kootanie.

A few notes on the distribution of the various rocks spoken of in the foregoing pages, so far as this was investigated on the route followed, may here be added.

The rocks seen in a few places in descending that part of the Columbia between Revelstoke and the Upper Arrow Lake, are chiefly light-coloured mica-schists and gneisses, which are generally highly quartzose. No massive granitic rocks were seen, and the appearance of the mountains on both sides of the valley favoured the belief that they also were composed of similar strata. As rocks of the same kind appear along the line of railway at least as far east as Albert Cañon Station, and as the general strike of the rocks met with along the river crosses the line of the Columbia valley obliquely, with north-west by south-east bearings, it is probable that these rocks spread over a rather wide area on both sides of the river in this part of its length. The dips observed on the river are generally northerly, but some are in the opposite direction. All these rocks are referable to the Shuswap series or No. 1. of the general section.

Rocks along river below Revelstoke.

In Sproat Mountain, in the angle between the river and north end of the lake, similar rocks occur with northerly dips and form a bold

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Rocks on North-east Arm.

southward-facing escarpment. The strike runs nearly due east, parallel to the direction of the lower part of the North-east Arm, but at about four miles up the Arm, on the north shore, darker and finer grained calcareous mica-schists appear. These were also seen on the opposite side of the Arm at this place, and though the Arm was not followed to its head, it is probable that it has been principally excavated along the strike of these softer rocks, which are supposed to represent the Nisconlith series (No. 2) in a rather highly altered state. Some of the mountains on the north side of the Arm, show evidence of a compressed anticlinal, overthrown in a southward direction, and it is quite possible that the crest of this anticlinal is coincident with a line of reversed fault, such as those which have been described by Mr. McConnell in the Bow Pass.*

Veins containing argentiferous galena have been found in the mountains on the north side of the Arm, but these were not visited.

Thumb Bay to Half-way Creek.

The south side of the lower part of the Arm is composed of the fine grained granites, of what is supposed to be the oldest series. This rock also forms both sides of Thumb Bay, and extends along the east shore of the lake to a point seven miles south from the mouth of the river. At this point, to the south of the granite, rocks of the same character with those seen on the river recur, and continue along the east shore of the lake to a point about five miles south of Half-way Creek. They consist as before of fine grained gneisses, with mica- and hornblende-schists, the last-named rock being, however, rather infrequent. The strikes and dips are very irregular along this part of the lake, and some of the mountains to the eastward, near Half-way Creek, appear to be composed of granite.

Half-way Creek to south end of lake.

Following the rocks last described to the southward and striking along the lake-shore, are thin-bedded fine-grained micaceous and hornblendic schists, often calcareous. The dips are generally eastward in direction, and at the high rocky bluff, known as 'Cape Horn,' a mass of grey granite interrupts these stratified rocks for a short distance. Immediately to the south of this granite cliff, the stratified rocks, however, reappear, consisting of argillite-schists with some thin layers of dark-coloured limestone. They are here only occasionally distinctly micaceous. From this point to the south end of the lake, the rocks observed along the east shore consisted of similar argillites, more or less micaceous in places. Though somewhat irregular, the strikes show a distinct tendency to turn to a south-eastward bearing, running off toward the high mountains of the Valhalla group. Quartz veins were observed in several places cutting these rocks, but specimens

* Annual Report Geol. Surv. Can., 1886, p. 31 D.

collected from one of the largest and most promising looking of these proved on assay to contain neither gold nor silver.

Reference of rocks

All the rocks described to the south of those of the gneissic and mica-schist series (No. 1) may with probability be referred to series No. 2 of the general section; while the mountains through which the river breaks after leaving the lake appear for some miles to be again composed of the rocks of series No. 1, with easterly dips. Though the west shore of the Upper Arrow Lake was not examined, it is probable that at least the entire lower portion of the lake-basin has been excavated along the outcrop of the softer strata of series No. 2.

Rocks of connecting river

At about six miles west of the lower end of the Upper Arrow Lake, the river which connects this with the Lower Arrow Lake enters a great granitic area, which, with small exceptions, includes the whole of the Lower Arrow Lake, the lower part of the Kootanie River and nearly all the West Arm of Kootanie Lake. A line joining the eastern edges of the granite rocks on the connecting river between the Arrow Lakes and on the West Arm of Kootanie Lake, will be found to run in a south-east direction and to cut Slocan Lake, as approximately placed on the map. This agrees with the description received of the rocks of Slocan Lake, and it is probable that such a line as that indicated will be found to outline the extent of the granite on this side, approximately. Its extent to the southward and westward is as yet unknown.

Lower Arrow Lake

The granite met with on the lower part of the river connecting the Arrow lakes, and near the head of the lower lake, is a coarse grey hornblendic granite with crystals of sphene. Grey granites continue along the east shore of the lake to a point nearly opposite Sanderson Creek, beyond which, for eight miles southward, are pink and reddish granites, believed to be referable to the latest period of eruption. The lithological character of these granites has already been referred to (p. 33 B). Further south, the granitic rocks are for the most part again of grey or greenish-grey colour, but for a distance of about four miles to the north of Deer Park, considerable masses of pinkish granite recur.

The west shore of this lake, as of the Upper Arrow Lake, was not closely examined; but the width of the lake being small, it was often possible from the east shore to recognize its granitic character. It is probable that this shore also is chiefly, if not entirely, formed by granitic rocks, and the mountains on both sides of the lake appeared to be of the same character. Pink granite occurs on the west as well as on the east side of the lake, and characterizes considerable areas opposite the previously-noted principal occurrences of the same rock on the east shore.

The Columbia to Sproat's Landing

Grey hornblendic or micaceous granitic rocks continue along the river between Lower Arrow Lake and Sproat's Landing. These were in several places observed to possess more or less gneissic structure, but as they are similar in composition to the adjacent granites and not clearly separable from these, it is quite probable that this appearance is due to the foliation of the granite itself. These obscurely foliated rocks are quite different in appearance from those of the Shuswap series (No. 1) of the general section.

It is possible that some of the granitic rocks met with on this part of the route, particularly on the lower part of the Lower Arrow Lake and along the river, may include areas of the older granites, though none such were distinctly observed.

Sproat's Landing to Kootanie Lake

As already noted, the rocks met with between Sproat's Landing and Nelson are all granitic, with the exception of certain schistose rocks having a width of about two miles, which are crossed by the trail near Ward's Ferry. These constitute the eastern extremity of the stratified rocks with which the ore-deposits of Toad Mountain are associated, and are described in connection with these. The granites are grey, and usually more or less markedly hornblendic in composition. These, together with those on the West Arm of Kootanie Lake, appear to be all referable to what has been spoken of as the granite of the second period. The exposures along the West Arm show, however, a greater degree of variety in composition and texture than usual, including some coarse-grained hornblendic granites, with large porphyritic crystals of orthoclase felspar, some varieties characterized by abundant black mica, and others unusually fine in grain. Granitic dykes or veins are also found cutting the main masses in some places. The mountains on both sides of the Arm, as shown by their appearance and the material brought down from them by small lateral streams, are probably all granitic.

West Arm to Hot Springs

The position of the eastern edge of the great granite area on the West Arm was not exactly determined, in consequence of the absence of exposures near the shore toward the eastern extremity of the Arm, but is approximately shown on the accompanying map.

At the north point of Queen's Bay of Kootanie Lake, fine-grained granites, passing into granitoid gneisses of similar character and scarcely separable from these, are met with. Thence northward to Hot Springs similar gneissic rocks, not generally very distinctly bedded, are associated with a larger volume of mica-schists, which are often garnetiferous, and with some hornblende-schists. The shore follows the strike of these rocks, which dip regularly westward at low angles and are referable to the Shuswap Series. The overlying members of the section, as seen in the vicinity of Hot Springs, are described on p. 47 B, in connection with the ore-deposits of that place.

Generally speaking, and with trifling exceptions, the main strike of the rocks for twenty-seven miles northward from Queen's Bay is parallel to the direction of the lake, or nearly due north-and-south, with prevailing westerly dips. There can be little doubt that this part of the basin of the lake has been excavated principally along the outcrop of the lower calcareous, and therefore less resistent portion of the Shuswap series.

The north end of the lake, with a length of eight miles, takes a more westerly bearing. The rocks are here considerably disturbed and irregular, with some evidence of faulting, to the influence of which the changed trend of this part of the lake may perhaps be attributed.

Rocks at Hendryx and northward.

On crossing the lake from Hot Springs to Hendryx, the rocks of the peninsula there are found to consist of coarse mica-schists, marble and quartzite, with westward dips at angles of 20° to 60°. The mountains to the east were not examined, but are, I was informed, composed of granite, with which information their appearance accords. The granite gradually approaches the shore of the lake as this is followed northward, and appears in dykes and considerable masses, breaking through the schists on the shore for half a mile or more before the main area of granite reaches the water's edge. This occurs at about six miles from Hendryx, where a coarse grey micaceous granite appears. Thence northward, granitic rocks form the shore for four or five miles, to a conspicuous high cliffy point, where their edge again retires from the shore, but continues to run northward nearly parallel to it and not far inland for nine miles, or to Fry River. Thence it turns off in a north-eastward direction among high mountains, and is not again seen.

Granites and bordering rocks.

The bluff or cliffy point just referred to, itself consists largely of granite; but it includes as well, and in great quantity, large and small masses of the stratified rocks, which have been caught up by and embraced in the edge of the granitic intrusion. The narrow strip of stratified rocks which to the northward separates the granite from the shore, is broken and traversed in all directions by granite dykes from the main mass. These dykes are well shown in the face of some of the cliffs which here occur along the lake. The stratified rocks consist of mica-schists, quartzites and marbles, resembling those of Hendryx. Much of the granite brought down by Fry River, differs in character from that elsewhere seen in the region in containing numerous aggregations of small black tourmaline crystals. From the quality and size of fragments of this kind the parent rock must cover a considerable area, and its position can not be far back from the shore.

Beyond Fry River, the strike of the schistose rocks takes a decided turn inland, in conformity with the direction of the edge of the granite mass. Beyond this point, and to the head of the lake, (still following the east shore,) the rocks are considerably disturbed, and exposures were found near the head of the lake of black argillites, which are probably referable to series No. 2, though it is impossible to say in exactly what way they are brought in here. These are the only rocks met with on either side of the part of the lake examined, which do not appear to belong to No. 1, of the general section, the Shuswap series.

Head of lake to Hot Springs.

On crossing to the opposite or west shore of the lake, at its head, high cliffs are found, composed of practically horizontal beds of mica-schist, quartzite and white or grey marbles of medium grain; but in the wash brought down by the first brook to the south, there is much grey, greenish and black schist, rendering it probable that Nos. 2 and 3 of the general section occur here, at no great distance inland among the mountains. The rocks seen along the whole west shore from this point southward to Hot Springs are referable to the Shuswap series. They consist of the usual association of coarsely crystalline, glittering mica-schists, with hornblende-schists, quartzites and marbles. For about ten miles from the head of the lake, the direction of dip is rather irregular and the angles are quite low, but beyond this there is little divergence from a general westerly direction in the dip. From about eight miles north of Caslo River, to that river, the strike of the rocks shows a somewhat more westerly bearing than usual, cutting the shore obliquely, and it is probable that along this part of the shore most of the strata concealed by the lake between Hot Springs and Hendryx are represented. Among these rocks beds of marble of various texture are abundant, and their existence throws additional light on the connection between the rock-series and the position of the lake-basin, which has already been alluded to.

Glaciation and Superficial Deposits.

In the course of the reconnaissance here reported upon, some observations on the evidences of glaciation and on the superficial or drift deposits of the country traversed were made. These were necessarily confined to localities visited in connection with other work, and are therefore somewhat fragmentary. As being the first for the district, however, and inasmuch as they include some facts of special interest, they are here put on record.

High glacination.

The only locality in which glaciation of rock surfaces was observed at great heights, was the summit of Toad Mountain. Here, on the outlook point not far from the eastern end of the mountain (see p. 21 B), at a height of 6990 feet above the sea, distinct though light glacial striation was found on projecting points of rock, in bearings between S. 6° and S. 33° E. The mountain from this point slopes away on northerly bearings toward the great Kootanie valley and on the south to the basin of Salmon River. The glaciation was situated within a few feet of the very summit of the isolated point, and some of it near the edge of a precipitous descent of several hundred feet, where the crest of the mountain breaks down toward the north to a cirque in which is the head of Give-out Creek. Several isolated points of Toad Mountain, with elevations a few hundred feet greater than that here described, occur within two to four miles to the south-westward, but the nearest extensive mass of higher mountains in that direction is situated about ten miles off. In a northerly direction, the nearest important groups of higher summits was estimated to be about twenty miles distant, and at a greater distance somewhat higher mountains occur in various bearings. None of these are, however, so much superior in altitude (as the description on p. 21 b will show) as to suggest or even to admit of a proximately local origin for the glaciation on this point.

Local circumstances.

On hard rock-surfaces situated about 800 feet lower, and nearly a mile east of the summit just referred to, similar distinct, though not very heavy glacial striation, was again found, running S. 36° E. This place is also situated on the watershed ridge between the Kootanie River and Salmon River. It would appear that the somewhat more easterly bearing here found may be explained by a deflection to the eastward of the ice which has produced the striation as it passed southward round the base of the higher point.

The Cordilleran Glacier.

The whole tendency of the evidence as examined into on the spot and here briefly described, leads to the belief that this glaciation is due to the action of what I have elsewhere named the great Cordilleran Glacier, at about the maximum stage of the glacial conditions in this part of the continent. Though glaciation evidently due to this Cordilleran Glacier has been found by me in one place at a height greater than that now recorded, at some distance to the north and west in the interior of British Columbia, * the importance of these observations, lies in the circumstance of their southern position taken in conjunction with their great height. The latitude of this part of Toad Mountain is about 49° 25′. In almost exactly the same latitude, but about one hundred and seventy miles further west, on Loadstone Peak, south of the Tulameen River, glaciation again obviously referable to the Cordilleran Glacier was found at a height of 6370 feet in 1888.

Scanty drift deposits.

Superficial deposits are scanty on the higher parts of Toad Mountain and most, if not all, of the material observed might have had a local origin. This was noted not only in the vicinity of the watershed

* Compare Geological Magazine. Decade III., Vol. V. (1888), p. 347 and Vol. VI. (1889), p. 350.

ridge, but also on the higher parts of the western slopes, and again near the extreme east end of the mountain, in the vicinity of the "Cottonwood" mine. Here, doubtless in consequence of the pyritous and schistose character of the rocks, decomposition has often affected them to a depth of ten feet or more, and in such places the soft rusty rock forms the actual surface on which the vegetation is rooted.

Glaciation at lower levels.

In the lower parts of the region examined, glacial striation and grooving were frequently observed, and in all cases appeared to follow the direction of the main valleys in a southerly sense. Evidence of this kind, clearly the result of the movement of glacier-ice, was found on the Columbia between Revelstoke and Upper Arrow Lake, going south-south-east with the valley, on the North-east Arm going south-west, or down the Arm, and along the main lake, in a number of places, going south down the valley. Similar glaciation occurs in many places along Lower Arrow Lake, but more particularly in the north-and-south part of the lake. Below this lake, along the river to Sproat's Landing, no glacial striation was seen on such rock-surfaces as were examined; nor was such striation observed along the Kootanie River or on the West Arm of Kootanie Lake, though it is quite possible that a more complete examination might lead to its discovery in these places. Heavy glaciation is frequently apparent along the shores of the north part of Kootanie Lake, for about fifteen miles southward from its head, the direction, as in the cases already cited, being straight down the lake, or southward. Farther south on the lake, as far as the mouth of the West Arm, the rocks near the water were not observed to be striated, but at Hot Springs, surfaces showed well marked striation on the slope of the hill at about 400 feet above the lake, the direction being, as before, southward. As already stated, the southern half of Kootanie Lake was not seen by me, and no observations can therefore be quoted from it. Further inspection of the higher parts of the mountains about this and the Arrow lakes would doubtless yield many additional facts of interest.

Boulder-clay.

Well characterized boulder-clay can not be said to have been recognized in the entire region covered by this report, though the stony clays found covering the lower slopes of Toad Mountain near Forty-nine Creek probably represent this deposit. Most of the superficial deposits cut into by the rivers or seen near the lakes are stratified sands and gravels, which often include boulders, but can seldom if ever be called true boulder-clay. Speaking generally, no great accumulations of superficial deposits occur along any of the lakes here reported on, the immediate valleys of which are in fact rather remarkable for the absence of such materials, though not more so than those of the Shuswap Lakes, Adams Lake and other lakes similarly situated with these in relation to the Selkirk and Gold ranges. Well-defined terraces, though here and there recognisable, are therefore seldom seen along these lakes. Thus near Sproat's Landing a very distinct terrace occurs at about 250 feet above the river, and terraces at the same or nearly the same level, recur at intervals on the lower part of Lower Arrow Lake, in the valley of the river between this and the Upper Arrow Lake and on that lake. Terraces.

In the valley of the Kootanie, between Sproat's Landing and Nelson, superficial deposits are, however, much more important, and often take the form of terraces more or less well marked. A wide terrace at Ward's Ferry has an elevation estimated at 400 feet above the river. On the West Arm of Kootanie Lake, more or less irregular, small terraces occur at the mouths of entering streams, with levels about 100 feet above that of the lake. These may possibly represent the same level with that of the terrace at Ward's Ferry.

Without here entering into any generel discussion of the complex question of the glaciation of the Cordilleran region, it may be stated that the glacial striation of the summit of Toad Mountain appears to be referable to the period of maximum accumulation of ice, during which almost the entire country was covered by the great Cordilleran Glacier, moving slowly southward. Even at this time, the lower parts of the ice probably flowed more or less perfectly in accordance with the directions of the leading valleys, but the glaciation now actually seen in the lower parts of these valleys, is probably due to a later stage, during which the glacier-mass, being much reduced, became broken into tongues which occupied the various main valleys. In conformity with observations elsewhere made in the province, * it may be supposed that a second advance of the ice, of minor importance, broke the continuity of its retreat, and in this case the southern extremities of the present basins of the Lower Arrow and Kootanie lakes may approximately represent the limit of that advance, after which a comparatively rapid dissolution of the ice occurred, so rapid as not to allow sufficient time for the obliteration of these hollows by the accumulation of detritus after the ice had left them. † It is thus quite possible that at a time when tongues of glacier-ice still extended as far as the southern ends of the Lower Arrow and Kootanie lakes, the transverse valley by which the river now flows between these lakes, was comparatively, if not altogether, free from glacier-ice, and that at this time the deposits now forming the terraces by which it is characterized were laid down. In the same way, at a still later stage, it may be Condition during glacial period.

* See Quart. Journ. Geol. Soc. 1878, p. 39 *et seq.*

† Compare Report of Progress, Geol. Surv. Can., 1877-78, p. 153 B.

supposed that glacier-ice filled the hollow of the Upper Arrow Lake, and descending also by the Mosquito Creek valley extended some way down the basin of the Lower Arrow Lake, while the crooked and in part transverse valley now occupied by the connecting river, remained open, and was occupied by a lake in which the drift materials through which the river has since cut were deposited. In this case, it is likely that if these lake deposits were removed, it would be found that a deep continuous erosion connects the basins of the upper and lower lakes.

Lake basins.

Though the southern end of Kootanie Lake was not visited, it appears probable, from the low, flat land here flooring the part of the valley which extends beyond the lake, that this end of the lake has since the glacial period been to a considerable extent curtailed by deposits brought down by the Kootanie River. The southern end of the Lower Arrow Lake, however, from the small width of the valley at this place and the occurrence of solid rock here and there in the flat between the bounding mountains, appears to be a true rock basin. While it cannot be affirmed that this basin was not excavated by the action of the glacier-ice by which the whole valley of the Arrow Lakes was at one time filled, it appears to me more probable that it, as well as the basin occupied by Kootanie Lake, is chiefly due to subaërial and river erosion which occurred previous to the glacial period; such erosion having taken place at different times, and under varying differential conditions of elevation of the land surface. The same explanation seems to be the most tenable one with respect to the basins of many other lakes in British Columbia, as well as in the case of the numerous fiords of the coast, with which the long lakes occurring in the mountainous regions of the interior appear to be strictly analogous in character.

Transport of material.

From an economic point of view, the principal importance of a study of the conditions of the region in the glacial period, depends upon the light which such study throws upon the probable origin of loose masses of ore which may be found. Such masses may have been carried by the ice during this period for considerable distances, and a knowledge of the direction of the ice-movement may thus become at any time of interest. The subsequent transporting action of rivers and streams must, however, also be taken into account, as well as that of the general tendency of detached fragments of rock to move down hill from their points of origin, under the influence of gravitation or that of occasional floods due to exceptional storms or other causes, which may in the course of time remove such fragments to long distances.

Details of Mining Districts and Mining Claims.

*Hot Springs Mining Camp.**

Early discoveries.

The first mining claims were taken up at this place in 1883 by Thomas Hammill, afterwards murdered at Hendryx. These claims were situated near the shore of the lake and were named the "Lu-lu" and "Spring." Later in the same year claims known as the "Surprise," "Morning Star" and "Evening Star" were staked, further back from the lake and nearly on the line of what is now known as the Spokane vein. The ores discovered at this time were, however, rather low in content of silver,† and it was not till the find of rich ores in Toad Mountain became generally known, in the spring of 1887, that an impetus was again given to prospecting and high-grade ores were discovered in this vicinity.

Area of discovery.

Nearly all the principal deposits since found here, some of which have been developed to a considerable extent, are included in an area extending, from south to north, between Coffee Creek to Woodberry Creek, a length of about six miles; from east to west, from the lake shore to the vicinity of the "Sky Line" claim, a width of little over two miles. The number of actual discoveries of considerable bodies of good ore already made in this comparatively limited area is remarkable, and new finds are still occurring from time to time.

Character of country.

From the edge of the lake, the country rises to the west in a long irregular slope, which, as seen from a distance, presents a series of step-like ascents, produced doubtless by the irregular denudation of a series of beds of unequal hardness. This step-like appearance, though also observed to the northward, along the same side of the lake, is here much more marked than elsewhere. The region has originally been densely wooded, and in some of the hollows excellent cedar and white pine timber is still to be found, but since the occupation of the 'camp' most of the original forest has been burnt off, either accidentally or with the object ot facilitating prospecting. A fairly good trail has been made from the lake shore to the "Number One" mine, a distance of about two miles in a straight line, in a west-north-west bearing, the height above the lake attained at this point being about 2520 feet. The course of the trail is, however, exceedingly sinuous, and besides the numerous sharp zig-zags necessary to overcome the steeper parts of the ascent, it makes a long sweep to the southward and another to

* The expression "Mining Camp" is here used in its Western sense as a convenient and generally recognized term for a mining district of limited area, more or less definitely separated from others.

† See Annual Report Geol. Surv. Can., 1885, p. 26 M.

the northward before reaching the "Number One." Smaller trails and tracks branch off in various directions to other claims, and by one of these the ascent of the main slope may be continued in a southwesterly direction from the "Number One" mine to the "SkyLine" at an appromixate height above the lake of 3460 feet. No attempt has yet been made toward the construction of a waggon road, and such ore as has been sent out has been carried down to the lake shore on horses or mules.

General relations of rocks.

The best general section of the rocks of the vicinity was obtained along the main trail, measurements being made by pacing, but as there are considerable intervals in which no rock-exposures occur, this still leaves much to be desired. The general strike of the rocks, which is preserved with considerable regularity, is nearly due north-and-south, but about half-a-mile below the "Number One" mine it turns gradually to a nearly north-west bearing, a change which, however, is probably local in character. The dip of the rocks is, almost without exception, to the westward, at an average angle of perhaps 45°. The inclination is, however, considerably less near the shore of the lake and probably also in the vicinity of the "Number One" mine, while further up, near the "Sky Line," and in the vicinity of the edge of a granite mass to the west, the beds are much disturbed and crumpled, and often nearly vertical.

Section at Hot Springs, lowest rocks.

On the shores of the lake, the rocks are coarsely crystalline, glittering mica-schists, often garnetiferous and in thin flaggy beds, dipping S. 77° W.<20°.* Rocks of the same character and referable to the Shuswap series of the general section, are seen in a few places and appear to be continuous, for a distance of a little more than a quarter of a mile back from the lake, measured at right angles to the strike. A belt of green schists is then crossed, with a width of about 700 feet, and with westward dips at angles of 45° to 50°. A trail going southward toward the "Little Donald" claim, branches off a short distance before the west edge of the green schists is reached, and between this trail and the west edge of these schists, the beds have irregular and sometimes very high dips. To the west of this belt of green schists, the rocks appear for the most part again to consist of rather coarse mica-schists, to the vicinity of the "Spokane" mine, a further distance of 1300 feet measured as before directly across the strike. The "Spokane" mine is situated near the brow of a steep, step-like ascent of about 200 feet, at the foot of which runs a strong body of 'barren quartz' and silicified rock, together with a wide dyke of augite-

* The bearings given in this and following pages are magnetic, it being supposed that such compass bearings may prove more serviceable to the miners and prospectors than true bearings. The magnetic declination here is about 24° E.

andesite, with large porphyritic crystals of black pyroxene and glassy felspar. It appears probable that some faulting may occur near this line, and that the strata so far described in ascending from the lake may form a single synclinal fold, overthrown to the eastward, of which the belt of green schists marks the axis.

Beyond the "Spokane" mine, considerable intervals occur in which no rock-exposures are seen near the trail, but the rocks appear to consist almost entirely, for a width of 2800 feet across the strike, of greenish schists, which though fine-grained, are often distinctly hornblendic in character. The angles of dip observed are nearly uniform, and it is probable that the thickness of these schistose beds is here about 2350 feet. One bed of hard grey, somewhat schistose and slightly micaceous quartzite, of forty or fifty feet in thickness, was noticed in this schist series not far west of the "Spokane" mine. Another rock of peculiar character was found near the upper part of this series of schists, possibly forming its upward termination and immediately underlying the limestones next above. This is a grey, rather fine-grained schistose conglomerate, of which the schistose surfaces are often highly micaceous, and in which numerous small garnets occur. This entire series of schists, though not distinctly separable into greenish and greyish members, and though more highly altered and much less in thickness than those of the Adams Lake series in its typical locality, is supposed to represent that series. Green and grey schists.

Overlying these generally-green schists, is an important bed of limestone, the upper and western line of which is found on the trail at Cooper's cabin. It occupies a width, measured across the strike, of 600 feet, and has a possible thickness of 530 feet, though from its massive character and the crumpled appearance in some small exposures where bedding can be seen, this is very uncertain. It is chiefly grey and fine-grained, though occasionally marble-like. This limestone, together with the rocks overlying it and forming the whole upper part of the Hot Springs' section, are supposed to represent series No. 5 of the Adams Lake section, though the considerable volume of greyish schists found between the limestone and that at the "Number One" mine is not precisely parallel on Adams Lake. Limestones

The section between Cooper's cabin and the "Number One" mine is very imperfectly exposed, but the rocks met with are chiefly greyish schists, often rather micaceous (though quite different in appearance from the mica-schists of the lake-shore), with one or more rather important belts of black glossy argillites. Micaceous quartzite-schist occurs among the grey schists in places. The width occupied by these rocks, measured across the strike from the line of Cooper's cabin to that of the "Number One" mine, is about 2900 feet, and the thickness of rocks represented may be about 2600 feet.

Probable synclinal.

In the vicinity of the "Number One" mine, limestone is again found, and is supposed to represent a second and higher zone of this rock. It is conjectured that this may occupy the centre of a synclinal fold, the eastern side of which is regular and rather wide. The disturbed and often vertical black argillite-schists near the "Sky Line" in the vicinity of the edge of the bordering granite to the west, may represent the return on the west side of the synclinal of the similar rocks alluded to in the foregoing paragraph. It would, however, require much detailed examination to fully work out the structure of this section.

Connection of ore-deposits with rocks.

That a considerable amount of importance attaches to the arrangement of the various rocks comprised in the section at Hot Springs, is evident from the observed dependence in character of the ore-deposits on that of the country-rock. The general direction of the veins is nearly north-and-south, being nearly or in some cases exactly parallel with the strike of the rocks. Some of these, like the "Spokane," appear to dip also at the same angle with the enclosing beds, but in other cases, to the west of this, the metalliferous veins cut across the bedding of the rocks to a greater or less extent, and may be expected to change in character when followed in depth into country-rock of another kind. The number of well defined veins which occur has not yet been ascertained. Some of the lodes are said to have been followed for several miles, but while it is evident that belts producing similar ore and exhibiting veins of like character and appearance have thus been traced out, it is not yet certain that any single vein runs continuously for such distance. This can not, in fact, be certainly ascertained till much further work has been done. The lowest tier of deposits, included in the mica-schists of the Shuswap series, may be stated to yield ore averaging from 20 to 40 ounces of silver to the ton, while further up selected ore, in lots of several tons, has yielded from 85 to 300 ounces to the ton, the richest deposits being those associated with the limestones and black argillites.

Character of ore-deposits.

The ore is principally argentiferous galena, which, in the lower veins contained in the harder rocks, has usually become decomposed to a very limited depth only from the surface; but in the limestones the decomposition has often extended to a considerable depth, and has resulted in the production of soft rusty 'carbonate ores,' filiform native silver or 'wire silver,' together with tetrahedrite are also found in some of these richer deposits. The veins which, like the "Spokane," follow the bedding of the mica-schists, are the most regular, while, as might be anticipated, those contained in the limestones are not nearly so uniform in size and tend apparently to assume the character of mineral-impregnated belts of rock in which occasional large masses or 'chimneys' occur. This is apparent in claims such as the "Sunshine" and "Number One." In the latter, where most work has been done, there is comparatively little true gangue associated with the ore, but zones of the limestone itself have become shattered and more or less highly charged with ore throughout. The ore even penetrates the limestone itself in the vicinity of the main deposit, and thin plates of native silver are found in joints, particularly in those parts of the rock which immediately overlie the larger masses of rich ore.

Importance of the district.

The importance of the Hot Springs vicinity as a producer of silver and lead may, I believe, be stated to be assured by the number of deposits already known, and by the richness in silver of the ores from many of these which have been partially developed. Should only a small proportion of the numerous claims prove eventually to be as valuable as many of them now appear to be, the output of ore can not fail to become very considerable within a few years.

Mining claims at Hot Springs.

The following notes relate to such of the claims as I was able to inspect personally last June. While those include several of the best known and most promising properties, numerous others are not mentioned, as it was impossible to visit all in the time at my disposal. The notes here given may, however, serve to afford some information as to the general mode of occurrence of the ores. The claims first described are those met with on or near the main trail, in order of ascent from the lake, and ending with the "Sky Line." After these, some claims to the south of the main trail are noted. A considerable group of claims situated some distance to the north of the main trail, including the Gallagher and others, was not visited by me.

Jeff. Davis Claim.—Height above lake 690 feet.* Very little work has been done upon this deposit, which, at the surface, appears to consist of an irregular shattered belt of rock, silicified and charged with ore, rather than a well defined vein. Veins running through this, contain galena in considerable quantity, in some places with a width of six inches of nearly pure ore. The ore is considerably decomposed at the surface, but is occasionally found to include a little copper-pyrites. This claim was first taken up in 1883 and has since been relocated several times. Several other claims supposed to cover extensions of the same deposit, have been staked to the north and to the south.

Spokane Mine.—Height above lake 1120 feet. This is situated on a very well defined vein, which runs between the beds of a medium

* The heights, assigned to this and other claims were barometrically determined with approximate accuracy.

Mining claims at Hot Springs continued.

grained, grey, silvery mica-schist. The course of the vein is the same as the strike of the beds, or N. 43° W. It dips to the south-westward at an angle of about 60°. The vein, as seen on the surface, is from one to two feet in thickness and is largely composed of galena, associated with a little iron-pyrites and quartzose gangue. A shaft has been sunk to a limited depth on the vein, following its dip, and a good deal of exploratory work has been carried on. The shipments during 1889 amounted to forty-four tons, which yielded at the rate of 35 ounces of silver to the ton. The following claims are supposed to be upon the continuation of the "Spokane" lode, and there is little doubt in this case, from the remarkable regularity of the deposit, that most of them are actually situated on the same lode. Claims to the southward: "Mæstro," "Little Phil," "Black Diamond," "Little Donald," "Paymaster," and one or more in addition of which the names were not ascertained. Claims to the northward: "Trinket," "Maple Leaf," and others beyond Cedar Creek, which, owing to the amount of cover in the valley of the creek, can not be certainly traced into connection with the "Spokane."

Sunrise Claim.—Height above lake 1920 feet. The country-rock is here limestone, forming the lower part of the important limestone belt already described. The ore-deposit, so far as it has been exposed by surface-work, appears to be rather irregular in character, the ore reticulating through the limestone for a width of twenty feet or more, where best exposed. The direction of the general run of the ore at this place appears to be from N. 20° W. to N. 30° W., or nearly transverse to the strike of the rocks, which, however, turns more to the westward a short distance further north. A considerable body of ore is seen on the "Sunrise," most of it rusty and decomposed, forming the so-called 'carbonate ore.' This, however, contains numerous irregular masses of unaltered coarse-grained galena, which holds also a little iron-pyrites. To the southward, along the strike of the rocks, the "Coronation" and "Black Chief" claims, with several others, have been taken up. To the north are the "Ohio," "Sweden," and a number of other claims.

Sweden Claim.—This is situated about 1200 feet northward from the last-described, the "Ohio" claim intervening. A shaft has been sunk here to a depth of forty feet, in which the width of the vein is stated to average three feet. The upper part of the deposit is completely decomposed, forming a soft rusty mass of 'carbonate ore.' From the shaft, unaltered ore consists of galena, with zinc-blende and some iron-pyrites. The gangue is calcite, with a little quartz.

Tiger Claim.—Height above lake 1790 feet. This lies still further to the northward, on the edge of the wide valley of Cedar Creek. It is spoken of as being on the continuation of the last deposit, but the connection is not definitely traced. The vein here follows the bedding of the rock, running N. 65° W., with a southerly dip of about 60°. The vein is overlain by rather fine-grained, grey, micaceous schist, and underlain by limestone, and appears to be about three feet wide. The ore is considerably decomposed and resembles that of the "Sweden," consisting of coarse, crystalline galena, with some iron- and copper-pyrites.

Mining claims at Hot Springs continued.

Number One Mine.—Height above lake (at shaft) 2510 feet. More development work has been carried out on this claim than on any other at Hot Springs. During the past year (1889) it is stated that 130 tons of selected ore has been shipped, the return in silver being at the rate of 85 ounces to the ton. Several substantial houses have been erected and other improvements made. A shaft had been sunk on the ore to a certain depth, at the time of my visit, and an adit run in for the purpose of intersecting the shaft, but I am unable to state what progress has been made in these workings up to date. The ore occurs in grey limestone, which is often rather shaly, and just above the shaft glossy black argillites are seen in the hill. The deposit appears to be somewhat irregular and 'pockety' in character, as is usually the case in limestone country-rock. Its general run is supposed to be about N. 15° W., and ore presumably representing a continuation of the same deposit, has been uncovered at several places, extending for a length of about 400 feet. At the surface, the ore is completely decomposed, forming a soft rusty mass, which is excavated by pick and shovel. In depth it is found to consist of galena and blende, writ a little iron- and copper-pyrites. Native (wire) silver is not infrequent, and it is probable that some tetrahedrite or ruby-silver ore also occurs, minutely disseminated. The metalliferous constituents of the ore are usually disseminated in small crystalline aggregations, the gangue consisting of more or less altered and silicified limestone and sometimes of quartz. Many little cavities lined with quartz crystals are found in the mass, and in some instances the metalliferous minerals penetrate the limestone irregularly for considerable distances. The mode of occurrence of the ore at this place and elsewhere in the limestone country, is such as to suggest that systematic exploration with the diamond drill will in future prove to be of essential service in tracing out and exploring for the more important deposits. Claims upon which ore has been found, and which are supposed to cover portions of the northern continuation of the "Number One" deposit are, the "Columbia," "G. B. Wright," "Black Bear," "Della" and "Kate."

Della Claim.—This is the only one of the claims just enumerated

Mining claims at Hot Springs continued.

which was visited. It is situated at a distance of nearly a mile in a north-westward direction from the "Number One," at an elevation of 2490 feet above the lake. From the "Della," sixteen tons of ore is stated to have been shipped during the past season, yielding about 105 ounces of silver to the ton. An opening about fourteen feet in depth had been made on the outcrop at the time of my visit, but the vicinity is so much covered by soil and undergrowth that little could be seen of the relations of the ore. Black glossy argillites, however, outcrop on the up-hill side of the ore, which is evidently in considerable body, though its width could not be ascertained. Where excavated it is almost completely decomposed and resembles the upper part of the "Number One" deposit, but contains more galena in proportion. Some iron-pyrites was also seen.

Sky Line.—This claim is situated nearly a mile from the "Number One;" in a direction about S. 30° W., and at a considerably greater elevation, being approximately 3460 feet above the lake. It was discovered just about the time at which I reached Hot Springs, and it so happened that I was unable to find the point at which it had been uncovered. Specimens of the ore obtained at the surface, consisted of rather fine-grained, grey, siliceous rock which had become porous from the weathering out of its metalliferous constituents, but had no rusty appearance. In an unaltered state the ore might probably resemble some of the more siliceous portions of the "Number One." Under date January 24, 1890, Mr. J. Anderson informs me that a shaft has been sunk on this deposit to a depth of one hundred feet, where the ore appears to be unaffected by surface action and shows more galena. It also occasionally holds native silver and some copper-pyrites with sulphuret of silver or tetrahedrite. This claim is situated close to the eastern edge of the granite, which bounds the mining field to the west. An experimental shipment of twelve tons of ore has yielded about 300 ounces of silver to the ton. The ore is said to occur at the junction of argillite and limestone, the argillite forming the hanging wall.

The following claims situated to the south of the main trail were visited.—

Little Donald.—Height above lake 1120 feet. This has already been alluded to as being on the southern extension of the "Spokane" vein, it is distant about a mile from the "Spokane" mine. The country-rock is mica-schist, dipping S. 70° W. $<$ 45°. The vein here dips at an angle of about 40° and an incline had been run down on it for about fifty feet, with a drift to the north of about forty feet at the date of my visit. The shaft was full of water at the time, but was afterwards cleared and carried down to seventy-five or one hundred feet when the quantity of water coming in led to the temporary suspension of operations. The vein is reputed to average from six to nine feet in thickness. The ore consists chiefly of galena in coarsely crystallized form, and is not decomposed far from the surface. The gangue is chiefly calcite and dolomite and the fact that very high assays are occasionally obtained, indicates that some of the richer silver ores, such as tetrahedrite or argentite are present in places. During the summer of 1889, sixty-six tons was shipped, yielding 95 ounces of silver to the ton.

Mining claims at Hot Springs continued.

Krao Claim.—Height above lake 1390 feet. Some shipments were here first made of ore obtained from cavities in limestone, which constitutes the country-rock. These were said to run high in silver. After going down about forty feet, at this place, a second opening was begun at about one hundred and fifty feet from the first, where the vein was better defined. A shaft was begun near the vein and was down about twenty feet last June. It has since, I believe, been carried to a depth of seventy-five feet. The vein appeared near the surface to be from six to eight feet wide, but with rather irregular walls. The limestone has the appearance here of a greyish or bluish marble and dips S. 60° W. $<$ 80°, which the vein also appears to follow. The ore consists chiefly of rather massive, coarsely crystalline galena, more or less decomposed, but occasional finds of native silver are reported. During the season eleven tons of ore was shipped, yielding at the rate of 90 ounces to the ton. Several claims supposed to cover the southern continuation of the same lode as far as Coffee Creek, or for a distance estimated at 7500 feet, are said to show well in ore. These are the "Crow Fledgling," "Now Then," "Crescent" and "Eden."

United Claim.—Height above lake, 1500 feet. Situated about 1500 feet to the north-west of the "Krao." This was a new discovery at the time of my visit, and had been uncovered for about fifty feet only. The foot-wall, which was exposed, consists of greenish schist, dipping south-westward at an angle of about 40°, and the vein appeared to be parallel to its bedding. Its thickness, as uncovered, was from three to five feet. Part of the ore consists of coarsely crystallized galena, part of very fine-grained galena.

Arkansas Claim.—An opening known by this name has been made in this vicinity on what appears to be a considerable deposit. There is a good showing of galena and rusty vein-matter.

Black Chief.—Height above lake, 1690 feet. Small prospect-holes only had been opened upon this deposit, showing galena and rusty vein-matter with much quartz. The dip of the vein is about S. 78° W < 20°. Pure galena is said to assay 46 ounces of silver to the ton.

Mining claims at Hot Springs continued.

As previously stated, a great many claims upon which more or less ore has actually been found were not visited by me. Of these, one of the most important is that known as the "Gallagher," to the north of Cedar Creek, from which, during the past summer, thirteen tons of ore was shipped, which is reported as yielding 126 ounces of silver to the ton. This is one of a considerable group of claims in the same vicinity. The notes given above, while incomplete, may serve to give some idea of the present appearance of this new district. The various claims in the present incipient stages of work, change more or less in relative importance and appearance every month, as the work of development goes on, and thus render very minute description or enumeration of little practical importance.

Hendryx Mining Camp.

The peninsula on the east side of Kootanie Lake, nearly opposite Hot Springs, has become known as Hendryx, from the name of the very energetic manager of the Kootanie Milling and Smelting Co., by which company most of the work so far done here has been carried out. The rocks here met with have already been described as belonging to the lower part of the mica-schist series, or Shuswap group of the general section (p. 92 B). The ore is comparatively low-grade as regards silver, and will probably require the erection of smelting works on the spot before it can be profitably utilized. Its profitable shipment under the present conditions is quite out of the question.

Discovery of ore.

The deposits of galena at this place are said to have been discovered by the botanist Douglas as long ago as 1825. In later years they have been taken up and abandoned several times, the country being too remote for their utilization or development.

Character of deposit.

The ore-deposit, though as above stated low in content of silver, assays giving from 15 to 40 ounces to the ton only, is very large and striking in appearance. It seems to run in a general north-and-south direction through the entire length of the little peninsula, and is covered by three claims, known, from south to north, as the "Kootanie Chief," "Blue-bell," and "Comfort." The lode is shown at intervals, partly in natural exposures and in part in strippings, through all three claims, or for a total length of about 4000 feet. Though varying much in appearance from place to place, and also in the upper and lower parts of the deposit as seen in single exposures, its general character is very similar in all. The ore consists of a mixture of iron- and copper-pyrites, galena and blende, contained in a quartzose gangue, which is often more or less cavernous and crystalline. Portions of considerable thickness occur throughout, which are almost pure galena, while in others iron-pyrites preponderates, and these two minerals are usually associated in a finely or coarsely granular mass.

Width and peculiarities of ore-deposit.

Though generally speaking very constant in its direction, the thickness of the lode appears to vary considerably. Thus on the southern point of the peninsula ("Kootanie Chief" claim) the main ore-mass has an average thickness, so far as can be seen, of about twelve feet. In a cross-cut made on the "Bluebell" claim, the ore is reported to be about eighty-six feet thick, and from the material on the dump, must here consist chiefly of galena. In a general way, the lode closely follows the strike of the containing rocks, which consist of mica-schists, marbles and quartzites. That the lode is not, however, always in strict parallelism to the bedding, is shown by the fact that the bed above it is in some places marble, in others mica-schist. Also by the circumstance that parallel zones of ore occur at some distance from the main mass. It should be added, that while the general run of the ore appears to be persistent and continuous, as above stated, there are evidences of small displacements by faulting, while masses of marble or limestone also occur in it, and irregular spurs of ore were observed to run off, as though at times the ore had replaced parts of the adjacent marble.

At the south point of the peninsula, the ore and containing rocks dip S. 80° W. $<$ 60°; at the "Blue-bell" openings, S. 73° W. $<$ 45°, and near the north end of the "Comfort" claim, S. 80° W. $<$ 20°.

A considerable amount of prospecting and development work has been done on the "Blue-bell" claim, and an adit is now being run in from the vicinity of the lake-shore with the object of tapping the vein at a considerable depth and affording a satisfactory beginning for regular work. This, at latest advices, had reached a length of over 300 feet. The work done on the "Kootanie Chief" and "Comfort" claims has been confined to stripping and surface trenching.

Toad Mountain and Vicinity.

Insular Area of bedded rocks

The greater number of the discoveries of metalliferous deposits made on Toad Mountain and in its vicinity, are included within the limits of an apparently isolated area of stratified rocks. This area runs nearly east-and-west, extending, from the head of Cottonwood-Smith Creek, westward to the vicinity of the lower fall of the Kootanie River at Ward's Ferry. Its length, in the direction above indicated, is about eleven miles, while its average breadth may be about two miles. While, however, its northern boundary may be considered as being shown with approximate accuracy by the line on the map, its southern edge was not examined by me, but depends on statements received from others. The rocks surrounding this area are everywhere, so far as observed, grey granites.

Lithological character.

The stratified rocks here met with differ considerably in appearance from those found in the vicinity of Hot Springs, but, as already mentioned (p. 34 B) it is supposed that they represent, for the most part, the greenish and grey schists of the Adams Lake series. The differences found between these rocks and their supposed representatives at Hot Springs is paralleled elsewhere in the Province, and appear to depend chiefly on the greater amount of pressure and consequent crushing to which the rocks of the last-named locality have been subjected. It is principally to action of this kind that the markedly schistose character of the rocks of Hot Springs is attributed. The outlier constituting the stratified area of Toad Mountain, has apparently been more affected by heat and hydrothermal action consequent on the extrusion of the granite, and while schists resembling those of the grey and green series at Hot Springs are not wanting here, they are subordinate in importance. Connected with this difference in the mode of alteration of the rocks, rather than with any original diversity in the mineralogical composition of the country-rock, is no doubt the well-marked difference in the ores of the two places.

The rocks characteristic of this outlier, though presenting many varieties which will eventually be found worthy of more minute investigation, may be described as consisting for the most part of stratified volcanic materials of Palæozoic age. These are generally of greenish or grey colour, and appear, for the most part, to be diabase in lithological composition. Diabase-porphyrite is not uncommon, and notwithstanding the considerable degree of metamorphism which the strata have suffered, some distinctly amygdaloidal diabases are still to be found. Hornblende-schists and rather massive pyroxenite-like rocks with some hornblende, also occur, especially in the immediate vicinity of the granite. When the rocks assume a distinctly schistose character, as in certain belts near the "Cottonwood" and "Silver King" mines, it is sometimes clearly apparent that the schistose structure does not entirely correspond with the original bedding, but crosses it at an angle. Near the western extremity of the stratified area, where the rocks are more closely surrounded by the granite than elsewhere, they are found to have suffered more than the usual amount of change. They consist of fine-grained gneissic, hornblendic and micaceous schists, often greenish in colour, owing to the development of epidote. Here also a thin bed of limestone converted to a coarsely crystalline marble was observed. In addition to the rocks of volcanic origin, beds of blackish argillite, more or less pure, were found in some places, but these hold a subordinate position in the series.

The general direction of the strike of the rocks in this area is nearly parellel to the longer axis of the area itself, while the majority of the dips are in a southward direction, usually at high angles or nearly vertical, though toward the west end decreasing to 40° or even to 20°. Strike and dip.

Much-altered fragments of the stratafied rocks are frequently found enclosed in the mass of the granite near the line of junction. The granite near this line is also generally much jointed and often greenish from the development of epidote, which is specially abundant along the jointage-planes. Junction with granite.

The occurrence of this isolated area of stratified rocks, together with that of the smaller but similar mass on the east side of Cottonwood-Smith Creek, renders it probable that additional similar areas yet remain to be found elsewhere in the great granite region. Should such be discovered they may prove to afford further deposits of ores like those of Toad Mountain. Other stratified areas.

The following notes refer to the claims visited by me on Toad Mountain and in its vicinity, last June. These comprise the principal properties upon which more or less work has been done.— Mining claims, Toad Mt.

Silver King Mine.—Height above lake (at houses) 4310 feet. This property, sometimes known as the "Hall Brothers' mine," is the most important so far known, and its discovery led directly to the recent interest and developments in this region. It was accidently found late in the autumn of 1886, but nothing was done toward opening it up till the next spring. Toad Mountain, previously one among many undesignated summits, received its somewhat peculiar name at the same time. The mine is now reached by a fairly good, though often steep trail, the distance from Nelson being about five miles in a straight line. The property consists of three claims, each 1500 feet in length. Of these two, named the "Silver King" and "Kootanie Bonanza," are laid out along the run of the principal vein, the third, known as the "American Flag," lies alongside, to the north, and is supposed to cover a second parallel vein.

In ascending the mountain by the trail, granite continues for some distance from Nelson, but is replaced by the stratified rocks previously described, probably near the point at which Give-out Creek is crossed by a bridge. Greenish diabases, both massive and schistose are characteristic, but about quarter of a mile southward from the houses

Mining claims Toad Mt. continued.

at the mine, these are followed by a grey decomposed quartz-porphyry, which, from its appearance and mode of fracture along jointage-planes, simulates granite when seen from a distance.* The rocks in the immediate neighbourhood of the openings made on the ore, are generally massive, though also in places schistose. They are here frequently more or less completely silicified and blotched by little seggregations of quartz. On the slopes of the summit situated about a mile to the westward from the houses at the mine, some blackish argillite-like beds occur, and on this summit one of the distinctly amygdaloidal rocks previously alluded to was found. Lithologically this rock is a diabase-porphyrite.

The rocks are generally highly inclined or vertical and their strike is nearly parallel to that of the schistose lamination, so that it is difficult to determine whether the schistose zones have differed originally in composition, or whether they merely represent lines along which the rocks have yielded to crushing. The general run of the metalliferous veins is also here nearly, though probably not exactly, parallel to the strike of the rocks.

The greater part of the work accomplished, has been carried out on the "Silver King" claim, for an opportunity to examine the openings on which and other facilities I was indebted to Mr. J. Macdonald and Mr. Hall.

The lode or ore-body, has been traced more or less continuously through the "Silver King" and "Kootanie Bonanza" claims, with a general direction nearly east-and-west magnetic. While, however, the general continuity of the ore-bearing zone has thus been proved, it appeared to me probable, on comparing the positions of the various openings, that its run is not throughout perfectly straight. On the "Silver King" claim, houses have been built and two drifts have been run in at different levels on the lode. From the end of the upper drift, the ore had been followed down by a winze to a depth of thirty feet at the time of my visit. This is stated since to have been continued to fifty feet, at which depth it is reported to be in a large body of rich ore.

The best opportunity of examining into the character of the deposit occurs in these workings. The lode is found to possess no distinct walls, but to occur as a zone of variable, and sometimes apparently of indefinite width, of shattered and mineralized rock, throughout which veins of pure and richly argentiferous ore occur in a

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* According to Dr. A. C. Lawson, this rock consists of a ground-mass of felspar and quartz, throughout which is scattered secondary muscovite, calcite and chlorite and an opaque indeterminable mineral, and in which are imbedded numerous idiomorphic, porphyritic crystals of much decomposed orthoclase felspar.

somewhat irregular manner. Where gangue appears it is principally quartz, but there is on the whole a rather notable absence of gangue or crystallized vein-material, the ore apparently filling irregular crevices and running in shoots and spurs into the rock so as to form here and there considerable masses. The metalliferous minerals comprise bornite and tetrahedrite, with some iron- and copper-pyrites but only occasional traces of galena. The two first-mentioned minerals, when nearly pure, contain the largest percentage of silver, while the pyrites is comparatively poor. In surface exposures the material of the lode is almost completely oxidised, producing a brown or blackish gossany material with some green and blue carbonates of copper. Mining claims Toad Mt. continued.

The excavations so far made are of a very irregular character, the ore having been followed wherever it appeared, and in some cases a considerable quantity of barren rock has been dealt with in pursuing this method of work, which can be justified only because of the great richness of the ore and the want of sufficient capital for more systematic operations. All the circumstances appeared to me to warrant the expenditure of a large sum of money, if necessary, in order to define and open out this remarkable deposit in a proper manner, and till work of this kind has been done it will be impossible to ensure any large or continuous out-put of ore. The richer portions of the ore are at present selected by cobbing and hand-picking, and packed in sacks for shipment; but a considerable proportion of the whole is thrown to one side, pending the erection of machinery for fine concentration. According to the Report of the Minister of Mines of British Columbia for 1889, the cost of conveying the rich ore on pack-mules from the mine to Nelson, was $10 per ton, and from Nelson to Butte, Montana (a distance of 700 miles), including the charge for smelting, cost a further sum of about $47.

The character of the ore obtained is shown by the following analyses by Messrs. Johnson and Matthy, London, for which I am indebted to Mr. R. D. Atkins, who collected the three specimens referred to.—

	1.	2.	3.
Copper	47·000	24·900	40·100
Silver	2·360	·232	1·292
Iron	7·300	12·200	1·800
Zinc	1 300	2·400	5·700
Manganese	1·200	5·100	·400
Antimony	1·400	3·400	15·600
Cobalt and Nickel	traces.	traces.	traces.
Lead	·100	traces.	1·700
Arsenic	3·100	2·100	4·500
Carbonic Acid	nil.	6·000	nil.
Lime	nil.	5·200	nil.

Mining claims Toad Mt. continued.

	1.	2.	3.
Magnesia	.700	traces.	nil.
Alumina	nil.	.200	nil.
Sulphur	22.900	22.000	27.200
Phosphorous	nil.	traces.	nil.
Siliceous insoluble matter	9.200	8.800	1.000
Traces of gold, oxygen, water and loss	3.440	7.468	.708

To the ton of 2240 lbs., specimen No. 1 contains 771 ounces of silver. No. 2, 75 ounces 16 dwt. No. 3, 422 ounces. Traces of gold were found in all, and in two shipments made to smelter, of which details have been obtained, the value of the gold recovered per ton of 2000 lbs., amounted to $2.16 and $1.44 respectively.

The ore where exposed on the "Kootanie Bonanza," to the east of the "Silver King," and at a height of about 200 feet above the level of the lower drift on that claim, is similar in appearance to that of the "Silver King," but more or less superficially decomposed. What is known as the "Grizzly" claim, lies parellel to the "Kootanie Bonanza," adjoining it to the north. This is not a part of the Hall Brothers' property. An opening made to a small depth in one place, again shows similar ore in a shattered zone of country-rock. The "American Flag" claim was not visited.

A small opening made at the side of the main trail a short distance below the houses on the "Silver King" and at the west end of that claim, deserves some notice. This, according to Mr. Macdonald, is precisely on the line of the main lode, and is considered to represent its continuation at a lower level. The lode is here much more regular in character than where it has been worked, being enclosed by schistose rocks, the strike of which it follows. It is from three to four feet in width, and contains a considerable proportion of galena, approaching in character and appearance the deposits found on the "Iroquois" and "Dandy" claims, subsequently noticed. On the assumption that this actually represents the continuation of the "Silver King" lode, it is evident that that deposit must change in its character to the westward or in depth, and it seems probable that such change occurs together with that in the nature of the country-rock, the hard, massive, irregularly shattered rocks found in the drifts appearing to yield the richest ore. The shipments from the "Silver King" during the past season are reported to have aggregated sixty tons, averaging about 300 ounces of silver to the ton.

Dandy Claim.—Height above lake (at entrance to drift) 3980 feet, or about 300 feet below the houses at the "Silver King." This claim lies to the west of the "Silver King" claim, adjoining it, and there can be little doubt that it is located on the continuation of the same lode, which has been exposed at various places throughout the length of the claim. Comparatively little work beyond this tracing of the lode, had been done at the time of my visit. The lode runs nearly east-and-west magnetic, showing, where a drift had been begun, a dip at an angle of about 80° to the southward and a width of three feet. The ore consists principally of galena, with copper-pyrites, and occasionally some blende. It shows besides occasional stringers of tetrahedrite, which are reported to yield very high assays. The gangue consists of quartz, which is present in larger quantities than in the "Silver King" ore. The wall-rocks are composed of green slates or schistose diabases, the strike of which the vein follows exactly. It holds its width well where exposed and appears to be fairly regular in direction and character. No ore rich enough to ship under present circumstances has yet been obtained from this property, which nevertheless promises well, and appears capable of yielding, with fine concentration, a large proportion of rich ore.

Mining claims Toad Mt. continued.

Iroquois Claim.—Height above lake (at entrance to drift) 4190 feet. This claim lies to the south of the run of the "Silver King" lode, and is supposed to cover a distinct deposit. The vein here runs about S. 80° E. and has been traced by trenching at intervals through the whole length of the claim, or for a distance of about 1500 feet. The country-rock is a grey, rusty or green-grey schist, probably a diabase-schist, but so much decomposed in some places that it is difficult to characterize it. A drift about sixty feet in length had been run in along the lode at the time of my visit. The lode is practically vertical, with a width in some places of twelve feet of ore or mineralized rock. It is stated to be not less than six feet in width in any place where it has been exposed. The ore somewhat resembles that of the "Silver King," but contains more galena, and is more diffused through the gangue and the country-rock where exposed in the working. It also contains copper- and iron-pyrites, together with some tetrahedrite, the last-mentioned mineral being the richest in silver. Crystalline quartz, which often occurs in nearly pure masses of some size, is much more abundant than in the "Silver King" workings. This is another very promising deposit, but like the "Dandy," yields no ore rich enough for present shipment.

The group of claims to which the above description refers, including those of the Hall Brothers, are contiguous, and are comprised in a comparatively small area on and near the sources of Give-out Creek. Here, the discoveries and work already accomplished are such as to ensure a large output of rich, or rich and medium grade, silver ores, and the combination of the interests thus included within a length of less than a mile from east to west, would appear to justify the imme-

Mining Claims Toad Mt. continued.

diate initiation of some more efficient system of transport to the shore of the lake than that afforded by the present trail. While a waggon road with moderate grades might, I believe, be constructed from Nelson, the cost would be great, and the late date at which snow lies at the considerable altitude of these claims, as compared with that at which it entirely disappears from the lower levels, would be a drawback. The transport of ore down the steep grades of the upper part of the mountain might be arranged for, however, by a tramway to a point lower in the valley of Give-out Creek, or an aërial wire-tramway might without difficulty be constructed. Some such means of conveying the ores, together with the capital necessary for the systematic opening up of the deposits and the introduction of machinery for the fine concentration of the second quality of ore, are the most pressing needs of this locality. No very important further developments need be expected till some such facilities are available, except indeed, in the case of the richer portions of the "Silver King" lode, which may continue for some time to yield sufficient high-grade ore to pay for its working on the present comparatively ineffective system.

Cottonwood Mine.—Height above lake 2835 feet. This is situated at the extreme east end of Toad Mountain, on the summit of a spur which lies between the source of Cottonwood-Smith Creek and a small western feeder of that stream. A good trail has been constructed from Nelson to this property, which consists of three claims placed end to end on the length of the deposit, and a fourth claim lying alongside. The deposit consists essentially of a belt of pyritized schists holding gold. The rocks of the stratified series seen a short distance to the north of the deposit, and near their junction with the granite, are diabases and diabase-schists of the usual kind, and include diabase-porphyrite precisely like that previously described. In the immediate vicinity of the metalliferous belt, the rocks are chiefly schistose diabase, and the belt itself consists of similar rocks, which here and there include lenticular areas of massive diabase, together with some almost nacreous pale-grey and whitish schists. In what I have spoken of as the metalliferous belt, all these rocks are more or less completely, though irregularly, silicified, and charged with granular iron-pyrites, with here and there a little copper-pyrites and specks of galena. These pyritized schists are further, seamed in all directions by little veins and stringers of quartz, holding the same minerals but chiefly iron-pyrites. The entire superficial portion of this metalliferous belt of rock has been more or less completely oxidized to a depth varying from a couple of feet to ten, twenty, or more feet. The decomposition of the rock is usually so complete that it may be removed easily with the pick and shovel. Some portions of the little quartz veins traversing the rocks, present in the decomposed mass an almost scoriaceous appearance, due to the removal of the iron-pyrites, and occasionally the whole of the iron-oxide produced in this process, has subsequently been leached out, leaving porous masses of white quartz. The iron-oxide thus removed has elsewhere been deposited in fissures and hollows in the form of bog-iron ore.

Mining claims, Toad Mt. continued.

The metalliferous belt is said to be continuously traceable throughout the length of the three claims above alluded to, and in the vicinity of the present workings must have a width of at least 300 feet. The average dip of the schists at this place is about S. 12° E. $<$ 80°, and this is probably followed by the metalliferous zone.

The assay value of the metalliferous material appears to vary considerably, and I am not in possession of such information as to be able to state what might be taken as a fair average. For the purpose of working the superficially decomposed portions of the deposit, two Huntington mills with a capacity of 12½ tons, have been erected, and the necessary houses, ore-shoots, etc., constructed. But a small quantity of the material has, however, as yet been milled. Should the results prove satisfactory, the quantity of pyritized material which may eventually be treated by concentration and chlorination appears to be practically unlimited, and in consequence of the facility with which it may be handled and worked, a comparatively small average yield in gold would be sufficient to justify work on a large scale.

Labeau Mines.

Umatilla and Uncle Sam Claims.—Height above lake (at cabin) 1280 feet. These claims are situated on the east side of Cottonwood-Smith Creek, about two miles and a half from Nelson. Together with a third claim called the "Apex," these are generally known as the "Labeau Mines." They occur in an outlier of the diabase series, the extent of which to the eastward was not ascertained. The vein opened on the two first-mentioned claims, is stated to be continuously traceable for a considerable distance and to average about two feet in width. Where I saw this vein, at a point at which a small shaft has been sunk on it, it runs N. 20° W., and is nearly vertical or dipping at an angle of about 80° to the eastward. The eastern or hanging-wall is here formed by a dyke of grey granite, five or more feet in width. The foot-wall is not well defined, the ore blending irregularly with the diabase rock on that side. The vein covered by the "Apex" claim is stated to run nearly east-and-west.

The character of the ore obtained from this group of claims differs considerably from that elsewhere seen in the district. The quartz gangue is hard and vitreous, and more or less charged with green chloritic minerals. The metalliferous constituents are fine-grained, and consist chiefly of galena, and an intimate mixture of galena and blende. Tetrahedrite, or some such richly argentiferous mineral probably also occurs in small quantity, irregularly disseminated.

Mining claims, Toad Mt., continued.

Tough Nut Mine.—This is situated on the northern slope of Toad Mountain, at the head of Sandy Creek, and about two miles in a northwestward direction from the "Silver King." The vein here opened appears well defined. It runs S. 70° E., and is nearly vertical; the width of the ore-bearing part of the vein being, where seen, about four feet and a half. The vein has been exposed at intervals throughout the length of the claim of 1500 feet, and is seen on the summit of the ridge to the eastward on an adjoining claim known as the "Evening Tide." The ore contains galena with iron- and copper-pyrites, zinc-blende and tetrahedrite, the last named mineral being as usual the richest in silver. Crystalline quartz is moderately abundant, but a considerable part of the gangue is made up of dolomite and shattered and mineralized rock-matter. The adjacent country-rock consists of green schists of the usual character. The vein is well situated for working by means of drifts, as the hillside up which it runs is very steep, and over 900 feet in height. The work done at the time of my visit, besides surface stripping, included a drift about one hundred feet in length on the vein, and a shaft thirty feet deep at a distance of 440 feet from the mouth of the drift, and about 160 feet higher on the hill.

Several other claims have been taken up in this vicinity, but with the exception of the "Tough Nut," little or nothing has been done toward their development.

Eagle Creek.

Poorman Mine.—This is one of several claims belonging to the Eagle Creek Gold Mining Company, but on this only has any considerable work of development been accomplished. These claims, with several others in different hands, are situated about four miles west of Nelson, and the point at which most work has been done is about half a mile south of the main trail from Nelson to Sproat's Landing, on the east side of Eagle Creek. The deposits of this locality differ from all those previously described in being situated beyond the area of the stratified rocks, the country-rock here being a dark grey, mica-syenite of granitic appearance, and referable to the granites of the second period of irruption, as already noted. This, as already mentioned, is an interesting point, as showing that the granitoid rocks may under certain circumstances also prove to be metalliferous.

The lode opened up on the "Poorman" claim, runs about S. 60° E., with a northerly dip at an angle of 50° to 60°. It averages about eighteen inches in width, and seems regular and fairly constant in this respect. The gangue consists of glassy or milky quartz, and contains copper- and iron-pyrites distributed throughout in stringers and small bunches. The gold is contained in these sulphurets, and the average value in gold per ton of the ore is stated at $30. At the date of my visit an adit had been run in to the vein, intersecting it at a depth of about ninety-five feet from the outcrop, and since that time further work has been done, and a ten-stamp mill, with concentrators and other machinery, has been placed on the ground ready for erection in the spring.

Other Metalliferous Deposits.

Though scarcely recognized as belonging to the Toad Mountain region proper, the deposits on Eagle Creek are really on the northern slope of the mountain-mass thus named. A few outlying localities in this vicinity and elsewhere in the district, in which minerals of economic value are known to occur, may now be alluded to.

Copper Queen.—This name is applied to a discovery situated on the north side of the Kootanie River, about a mile above the mouth of Forty-nine Creek. I was unable to visit this claim, which is described as an irregular deposit of great size. Specimens received from it, however, show the ore to consist chiefly of massive copper-pyrites. Though reported to contain a considerable proportion of silver, specimens of this ore subjected to examination in the laboratory of the Survey proved to contain only 1·4 ounce of silver to the ton, with traces of gold. **Copper ore**

Iron Ore near the Lower Fall.—About half a mile below the lower fall of the Kootanie River, on the north bank, and near the water's edge, is a remarkable occurrence of magnetic iron-ore. The ore is found in large loose masses weighing several tons, but owing to the want of good exposures its actual relations to the rocks adjacent could not be ascertained. The place of its occurrence is near, if not on, the line of junction of the granites with the, here, highly altered rocks of the stratified series. It appears to be associated with a dyke about forty feet in width of green-grey augite-porphyrite of somewhat peculiar appearance, which crumbles down easily under the action of the weather.* It seems probable that the iron-ore when *in situ* may form large irregular masses along the borders of this dyke. **Iron ore**

* In this intrusive mass, according to Dr. A. C. Lawson, the predominant mineral is pyroxene, in idiomorphic porphyritic crystals, or occasionally in polysynthetic masses. The pyroxene is partially altered to hornblende and there are besides some hornblende crystals which may not have been so derived. Felspar is present, but in subordinate amount. Biotite, magnetite and chlorite are sparingly found as accessory minerals, and there is a little quartz which is probably secondary in origin.

The ore is finely granular in texture and generally free from rock-matter or other impurities, but in some places contains siliceous kernels, with epidote and brown garnet. A fragment of the ore comprising one of these kernels and rusty in appearance, was examined for gold and silver, but proved to contain neither.

North-east Arm On the north-east arm of Upper Arrow Lake, referred to on page 36 B, ten mining claims have been taken up, according to the Report of the Minister of Mines for British Columbia. Good specimens of argentiferous galena ores have been brought from these claims, which, however, were not visited by me, and on which little work has yet been done.

Quartz Veins Specimens from a quartz vein traversing, the argillite-schists a short distance north of the mouth of Koos-ka-nax Creek, on Upper Arrow Lake, proved, on assay in the laboratory of the Survey, to contain neither gold nor silver.

Some specimens of a peculiar vitreous quartz traversing the gneissic and mica-schist series at the north-west corner of Kootanie Lake, though showing a little galena, also proved to contain neither gold nor silver on assay.

The occurrence of tourmaline with some peculiarities in the appearance of the granites, already referred to (p. 39 B) as being characteristic in the vicinity of Fry River on Kootanie Lake, led me to collect some of the heavier materials by washing the gravel of the river in a gold-pan, for the purpose of ascertaining whether any trace of tin could be found, but this also proved to be quite barren on analysis.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON AN EXPLORATION

IN THE

YUKON AND MACKENZIE BASINS, N.W.T.

BY

R. G. McCONNELL, B.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

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NOTE.—The bearings throughout this report are given with reference to the true meridian.

The invertebrate fossils have been determined by Mr. J. F. Whiteaves (for description of new species see Contributions to Canadian Palæontology, vol. 1, part iii), the fossil plants by Sir William Dawson, and the recent plants by Professor Macoun.

The name Pelly-Yukon, as a compromise between the old name and the new, is used in this report to designate the continuation of the Yukon River above Fort Yukon to the junction of the Lewes and Pelly.

A. R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Deputy Head and Director Geological Survey Department.

SIR,—I beg to present herewith a report on an exploration in the Mackenzie and Yukon country, carried out during the seasons of 1887-88, in connection with the Yukon exploring expedition. Only one season's work was at first contemplated, and no provision was made before starting for wintering in the north and continuing the work for a second summer, and for the means of doing so I am indebted to the kindness of the Hudson's Bay Company. Mr. Camsell, Chief Factor of the Mackenzie River District, afforded me every assistance in his power, and my thanks are also due to Mr. Reid, of Fort Providence, with whom I passed the winter; to Mr. Hodgson, of Fort Macpherson, and to all the officers of the company with whom I came in contact. I have also to thank the Rt. Rev. Bishop Bompas, the Ven. Archdeacon McDonald and the Rev. Mr. Canahan, of the Church Missionary Society, for ready assistance and advice.

It may be mentioned here that the late date at which this report is issued is due to a delay in the drafting of the accompanying index and route maps, caused by the pressure of other work.

I have the honor to be,

Sir,

Your obedient servant,

R. G. MCCONNELL.

GEOLOGICAL SURVEY OFFICE, May 9th, 1891.

REPORT

ON AN EXPLORATION

IN THE

YUKON AND MACKENZIE BASINS, N.W.T.,

BY

R. G. McCONNELL, B.A.

Introduction and Summary of Proceedings.

The work on which the following report is based, was carried out under the direction of Dr. G. M. Dawson in connection with the Yukon Exploring Expedition,* and occupied parts of the seasons of 1887-88. I separated from the main party on the 25th June, 1887, at the junction of the Dease and Liard Rivers, with instructions to descend the Liard and make a geological examination of the valley, and with discretionary orders, when this was accomplished, either to winter in the country and continue the exploration the following summer, or to make my way out by Slave River and the Athabasca and return to Ottawa the same season. Both of these plans proved feasible, but as I was able to make satisfactory arrangements with the Hudson's Bay Company to stay at Fort Providence, one of their posts on the Mackenzie, I decided to adopt the first mentioned. **Separate from main party.**

I arrived at Fort Simpson on the 5th of August, and as there was still time to carry on considerable work before the setting in of winter, I took passage on board the Hudson Bay Company's steamer *Wrigley* for Fort Smith, on Slave River, and embarking there in a bark canoe with a couple of Indians the remainder of the season was spent on Slave River, Salt River, and Hay River, and in coasting around part of the western end of Great Slave Lake. About the 1st of October I returned to Fort Providence and went into winter quarters. **Reach Fort Simpson.**

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* Annual Report Geological Survey of Canada, Vol. iii.

Work during winter.

Exploratory work was necessarily suspended during the greater part of the winter, but rough traverses were made at intervals to Lake Bis-tshô, Fort Rae, and other places in the vicinity of Fort Providence, and while staying at the post meteorological observations were recorded twice a day.

Leave Fort Providence.

I left Fort Providence on the 1st of May, 1888, travelling on the ice with dogs, and reached Fort Simpson, at the mouth of the Liard, on the 6th, where I remained until the river became sufficiently free from ice to allow travelling by boat. The river broke up on the 13th of May, but continued full of floating drift ice all the month. On the 28th of May, having had a boat built at Fort Simpson in the meantime, I left that post, accompanied by two Indians and spent about a month descending and examining the valley of the Mackenzie as far as the mouth of the Peel, and in ascending the latter river to Fort McPherson. Here a delay of a few days, caused by the non-arrival at the expected time of the Mackenzie River boat, on which I depended for some supplies, enabled me to make a short exploratory trip up Rat River to the mountains. On the 12th of July, the Mackenzie boat not having then arrived, and it being uncertain how much longer it would be delayed, I decided to risk obtaining supplies at Rampart House on the Porcupine, rather than waste any more of the short summer season, and started across the Rocky Mountains by what is called the Peel River Portage. Lapierre House, on the western side of the mountains, was reached on the 15th, and having meanwhile had my boat taken across the mountains by some Indians (who followed a route to the north of mine), I immediately started down the Porcupine, accompanied by an ex-employé of the Hudson's Bay Company named Skee, whom I engaged to go to the coast with me and who proved to be a capable voyageur. We made the descent of the Porcupine in safety and reached the site of old Fort Yukon, at the mouth, on the 24th. From this point the coast and outside communication can be reached either by descending the Yukon to St. Michael's, or ascending it to the head of the Lewes, about 850 miles, and crossing the Coast Range by the Chilkoot Pass. The former is by far the easier route, as the lower part of the Yukon presents no obstacle to navigation, but as it lay altogether beyond Canadian territory it was decided, if possible, to try and ascend the stream. A second boatman, in the person of a Loucheux Indian, was engaged. No boat was available except the one in which we had descended the Porcupine and which was thoroughly unsuitable for up-stream navigation, but in this, by the greatest exertion, we managed to breast slowly the impetuous current of the river and arrived at Forty Mile Creek after a laborious trip of fifteen days. At

Trip up Rat River.

Descend the Po cupine.

this place, which is the headquarters of the miners on the Yukon, a suitable boat was built and the ascent of the upper part of the river was made with less difficulty. We left Forty Mile Creek on the 14th of August and arrived at Chilkoot Pass on the 15th of September, Juneau on the 21st, and Victoria on the 1st of October. Ascend the Yukon.

The total distance travelled from the time I left the coast at Fort Wrangell until I reached it again at the head of Lynn Canal was about 4,000 miles, 3,000 miles by water and 1,000 on foot, and the time occupied in actual work was about seven months. Distance travelled.

Among the more important geographical results of the exploration may be mentioned the traverses of the Liard from Dease River to the Mackenzie, of the lower part of Hay River, of the Rocky Mountains by the Peel River Portage, and of Bell River and the Porcupine, from Lapierre House to Fort Yukon. A sketch traverse of the Mackenzie, from Fort Simpson to the mouth of Peel River, was also made, but as this portion was afterwards measured with the micrometer by Mr. Ogilvie, I have adopted his survey in the accompanying map, but have used my own notes to sketch in the topography of the adjoining country. Another result of the exploration of some interest to the geographer is the discovery of a great break in the continuity of the Rocky Mountains in about lat. 60° N. The range here is suddenly jogged eastward for a couple of degrees and is then continued northward along nearly the same bearing as before. Geographical results.

The geological examination of the routes traversed was necessarily conducted in a somewhat hasty manner and can make little pretension to completeness. Detailed observations are obviously out of the reach of a traveller hurrying along at the rate of twenty to thirty miles a day through a country more or less complicated, and especially when in addition to the ordinary surveying and geological work the duties of pilot and head boatman also fall to his share. Fortunately, in the present case, the effects of haste were compensated to some extent by a familiarity with most of the terranes met with, acquired by several years experience among similar rocks to the south. Also, at the more important points and at the contacts of the different formations short halts were called and more extended examinations made. In this manner it proved possible to obtain at least a general knowledge of the geology of the routes traversed, and to outline approximately the limits of the greater geological divisions. Character of work.

Such notes as were collected on the fauna and flora of the country travelled through, and which seem worthy of publication, are, in order to avoid repetition, incorporated in the general description, along with the topographical and geological details. This course, though leading to some confusion, can hardly be avoided in an account of a hasty general exploration, such as the one treated of. The meteorological notes are given in the form of an appendix at the end.

Principal Physical Features.

Extent of region.

The region travelled through and partially examined embraces the extreme north-western portion of the Dominion of Canada, and has a length from north to south of 650 miles, a width from east to west of 350 miles, and an approximate superficial area of 227,000 square miles. The whole of this great district lies on the arctic slope of the continent, and is included in the drainage basins of the Mackenzie and the Yukon. It is traversed, in a direction a little north of west, throughout its whole length by the Rocky Mountain chain, which constitutes the main water parting of the district.

Rocky Mountains.

The Rocky Mountains enter the district on the south between long. 126° W. and 126° 30′ W., as an assemblage of nearly parallel limestone ridges, striking in a north-westerly direction, and rising to altitudes of 3,000 to 4,000 feet, but diminish rapidly both in height and width before reaching the Liard, in lat. 59° 30′ N., and appear to die away in this latitude shortly after crossing this stream. Two degrees farther east ranges of limestone mountains rise suddenly from the plains up to heights of 3,000 to 4,000 feet, and, striking in a northerly direction, extend without any interruption, so far as known, to lat. 67° 30′ N. and beyond.

South-western part of district.

In the south-western part of the district, the country lying between the Cassiar Mountains and the Rocky Mountains, and drained by the Liard and its tributaries, may be described as an irregular, forested plain, relieved at intervals by short disconnected ranges of rounded hills, which appear to become more numerous as the Rocky Mountains are approached. Its surface irregularities and rounded lines of relief are evidently the result of long-continued denudation. This plain slopes gently to the south-east, and has an average elevation of about 2,000 feet above the sea, while the hills and ridges resting on it rise 1,000 to 1,500 feet higher. The northern extension of the plain is unknown. To the south it is closed by ranges of mountains.

Foot-hills.

In the south-eastern part of the district the Rocky Mountains are bordered by a foot-hill belt about thirty miles wide, which is characterized, here as elsewhere, by long, nearly parallel ridges, often crested with tilted sandstone beds, but also contains some high peaks little inferior in elevation to those of the central range. Of these Mount Prudence, which is situated a few miles south of the Devil's Portage on the Liard, forms the most conspicuous example, and was estimated to have a height of nearly 4,000 feet above the river. The foot-hill belt is fringed in the latitude of the Liard by a high plateau built of flat-lying Cretaceous beds, through which the river has cut a great gorge, which in some places is fully 1,000 feet deep. The surface of this plateau has been carved by the drainage system into a series of irregular flat-topped elevations.

Region east of mountains.

East of the fringe of high plateaus the plains in the neighborhood of the Liard slope uniformly eastwards towards the Mackenzie, while farther to the south-east, along the Lake Bis-tchô trail, they descend to the same level by a series of steps and escarpments. East of the Mackenzie a flat plain stretches eastwards for thirty miles to the base of a steep escarpment called the Horn Mountains. This was not examined, but is reported to be merely the westerly face of a higher plateau running parallel with the Mackenzie. It corresponds in a general way to those west of the river, but faces in the opposite direction. The whole of the country bordering the Mackenzie in this latitude, on both the lower and higher levels, so far as examined, is thickly mantled with drift. The surface is usually more or less undulating, and is diversified by innumerable shallow lakes of all sizes, while a large proportion is underlaid by muskegs and marshes, covered with sphagnum or bog-moss, which remain frozen throughout the year. The higher lands and ridges separating the lakes and marshes are usually rather densely forested, chiefly with white spruce (*Picea alba*), the Banksian pine (*Pinus Banksiana*) and the aspen (*Populus tremuloides*).

The Mackenzie.

The eastern part of the district examined is traversed throughout by the Mackenzie. This great stream is described in some detail in a subsequent part of this report, and need only be referred to here. It ranks among the first dozen rivers of the world, and in length and size of basin is, on the North American continent, second only to the Mississippi. The volume of water carried by the Mackenzie is not known exactly, but such rough measurements and estimates as I was able to make showed it to have, at a medium stage, an approximate discharge of the water, of 500,000 square feet per second. It issues from Great Slave Lake with a width of several miles, but soon contracts to about a mile, and then maintains this as an average width all the way to the sea, the host of streams which enter it at various parts of its course being apparently incapable of increasing its size to any appreciable extent. The current of the Mackenzie at a high or medium state of the water is remarkably uniform throughout its whole length, but in low water its course is interrupted by several small rapids. It has an average fall of about six inches to the mile.

Tributaries.

The principal tributaries of the Mackenzie, north of Great Slave Lake, are the Liard, which originates west of the Rocky Mountains, and breaks through that range on its way to join the parent stream, Bear River, the outlet of Great Bear Lake, and Peel River, which drains the eastern slopes of the northern portion of the Rocky Mountains.

Plains bordering the Mackenzie.

The plains bordering the Mackenzie above the Liard have already been referred to. Below the mouth of the Liard the Mackenzie rapidly approaches the Rocky Mountains, and in lat. 62° 15′ N. impinges against them and is then deflected more to the north parallel to their course. Thirty miles farther down a high ridge appears on the eastern bank of the river, and this, followed for a short distance, soon developes into a high mountain range crested with bare limestone peaks and ridges exactly similar to those flanking the valley on the west. This point may be considered as the northern limit of the great central plain of the continent. The mountains here rise suddenly from the plains to heights of 3,000 to 4,000 feet, without any fringing belts of foothills and plateaus such as accompany them elsewhere.

North of the point at which the Mackenzie enters the mountains it is flanked on both sides by lofty and almost continuous ranges of limestone mountains to near the Sans Sault Rapid, in lat. 65° 40′ N. The lowlands between the two ranges through which the river flows have a width of from twenty to sixty miles. They are broken by low plateaus and by a number of short ranges such as Bear Rock, Roche Carcajou, and the Rock by the River Side, but contain no elevations exceeding 2,000 feet in height.

Mountains disappear.

North of lat. 65° 40′ N. the ranges east of the Mackenzie lose their importance and gradually disappear, while those on the western side recede beyond the range of vision, and the river flows through a dreary plain, covered to a large extent by lakes and frozen marshes, which extends northwards to the Arctic Coast. The coniferous forest, varied in places by aspen-covered tracts, still continues, but the trees present a stunted appearance, and except in sheltered localities seldom exceed six to eight inches in diameter. Isolated groves and individual trees were, however, noticed even far within the Arctic circle, which equal in size those found in the upper reaches of the river.

Mountains at Peel River Portage.

North of lat. 67° N. the Mackenzie bends suddenly westward and at the mouth of Peel River again approaches the Rocky Mountains, but the range here presents few familiar features. It may be described, where crossed in lat. 67° 20 N., as a huge ridge, sixty miles wide and 2,500 feet high, surmounted by two longitudinal ranges of mountains rising to heights of from 1,000 to 2,500 feet above the summit of the ridge. The forests extend only a short distance up the slopes and the greater part of the surface is either bare or covered with mosses and coarse grasses.

West of the Rocky Mountains in the north-western part of the district, a rugged mountainous region, clothed on the lower levels with a monotonous coniferous forest, stretches westwards to the Alaskan boundary. This region is drained into the Yukon by the Porcupine and its tributaries, and has an elevation above the sea of from 1,000 to 1,500 ft. It contains numerous short ranges of mountains and hills, but these appear to be entirely independent of one another, and trend in different directions. Country west of mountains.

The tract of country in the western part of the district lying between the Pelly-Yukon and the Rocky Mountains, south of the Porcupine, is almost unknown. It is drained principally by the Stewart and its tributaries, and is reported to be hilly and mountainous throughout. One range of high limestone mountains skirts the Pelly-Yukon on the east some distance above the boundary striking a little east of south, while a second range, according to the miners, follows up the north bank of the Stewart. On most maps a range of mountains is shown crossing the Pelly-Yukon below the mouth of the Stewart and continuing on into Alaska. The country bordering the river here is higher than usual as shown by the increased depth of the valley, but no definite range was noticed.

Navigable Waters.

The Mackenzie River and its continuation Slave River are navigable from Fort Smith at the foot of the Slave River rapids to the Arctic ocean, a distance of over 1,300 miles. A small steamer built by the Hudson's Bay Company at Fort Smith, in the winter of 1886-8, now makes annual trips from that post down Slave River and the Mackenzie as far as the mouth of Peel River, which enters the latter at the head of its delta, and thence thirty miles up Peel River to Fort Macpherson. The navigable season for the whole route barely averages three months as Great Slave Lake is seldom free from ice much before the 1st of July, and in September the rapids at the head of the Ramparts become impassible, while at low water the wide channel at the outlet of Great Slave Lake does not exceed four to six feet in depth. Long stretches of the river are, however, navigable for nearly five months. Navigation of the Mackenzie.

An account of the breaking up of the ice on the Mackenzie and Liard is given in another place (see page 87 D). The Liard opens at Fort Liard about the 25th April, and is usually clear as far as its mouth before the 10th May. The impact of the moving Liard ice breaks up the sheet covering the Mackenzie, and clears in the course of a month a passage to the sea. Above the mouth of the Liard the ice on the Mackenzie usually remains firm until near the 20th of May. On Great Slave Lake the opening of navigation varies from the 18th June to the 5th July.

In the autumn of 1887 drift ice was floating past Fort Providence on the 21st of October, and on the 16th of November the river was frozen across. Great Slave Lake is usually frozen for some distance from the shores before the end of October.

It follows from these dates that the Mackenzie, disregarding the obstructions in low water from rapids, cannot be considered as navigable much before the 10th of June nor later than the 20th of October. On Great Slave Lake the navigable season lasts from about the 1st of July to the end of October.

Navigation of the Liard.

The navigation of the Liard, the principal tributary of the Mackenzie, is interrupted about twenty miles above its mouth by a series of strong riffles. These might possibly be overcome by the use of the line, but the steamer *Wrigley* has not yet attempted to stem them. Above the riffles the Liard is easily navigable as far as Fort Liard and thence on up the west branch as far as Hell Gate. Above Hell Gate its navigation, owing to the numerous rapids and cañons, is exceedingly difficult and dangerous even with small boats. The Nelson or East Branch of the Liard is reported to be navigable by small steamers for a hundred miles or more above its mouth.

Of the other tributaries of the Mackenzie, Peel River is the only one which can be considered as navigable. This is ascended annually as stated above by the steamer *Wrigley* as far as Fort Macpherson, a distance of about thirty miles, and if necessary could be followed much farther, but the exact distance is not known.

Navigation of Rat River and the Porcupine.

On the west side of the Rocky Mountains, Rat River and the Porcupine could easily be navigated for three or four months of the year, by small steamers, from Lapierre House down to the junction of the latter with the Yukon. Above the mouth of the Porcupine the Yukon, beyond a stiff current of from four to five miles an hour, presents no obstacle to navigation as far as Rink Rapids, a distance of over five hundred miles, and below the mouth of the Porcupine it is navigable to the sea. Stewart River, the principal tributary of the Yukon on the east in the district examined, is reported to be navigable for a distance of nearly two hundred miles above its mouth, but has not yet been ascended by the steamers plying on the Yukon.

The navigable waters of the Mackenzie are separated from those on the Yukon in lat. 67° 20 N. by a distance of about sixty miles only. A cart trail was staked out some years ago by the Hudson's Bay Company across the interval separating these rivers with the intention of supplying the Mackenzie River district with goods by way of the Yukon, but the project fell through and the road was never built.

GEOLOGICAL SUMMARY.

CRYSTALLINE SCHISTS.

The region examined lies to the west of the great Archæan axis of the continent, and the rocks of this system were only seen at two points east of the Rocky Mountains. At the foot of the rapids on Slave River they consist of coarse grained granitoid gneisses indistinctly foliated, and at Fort Rae of a medium grained biotite granite-gneiss. At both these places the gneisses evidently belong to the Laurentian, or oldest division of the Archæan. Archæan rocks.

In the Rocky Mountains themselves no pre-Cambrian rocks were observed.

West of the Rocky Mountains crystalline schists are largely developed along the valley of the Pelly-Yukon. They were first met with, in ascending the river, near the International Boundary, and were then traced southwards by numerous exposures as far as Fort Selkirk, at the junction of the Lewes and Pelly, and they continue on up the Lewes about thirty miles farther. The belt of crystalline rocks has a width of something over a hundred miles and strikes in a south-easterly direction from the International Boundary, or lon. 141° W. diagonally across the Pelly-Yukon and up the Pelly to near its head, and then continues on across the Frances River.* The extension of the belt beyond the Frances River is not known. It does not reach the Liard, however, as no crystalline schists were noticed on that stream. South of the latitude of the Liard the crystalline rocks, like the Rocky Mountains themselves, do not continue southwards along their old strikes, but along parallel strikes a couple of degrees farther west. The break in the continuity of the Rocky Mountains, which is referred to on another page, has its counterpart in a break in the continuity of the belt of crystalline rocks which usually accompanies them on the west. Crystalline schists along the Yukon.

The dips of the crystalline rocks along the Pelly-Yukon are usually westerly and at high angles. Dip of rocks.

Along the eastern edge of the crystalline belt the rocks are characterized by a general greenish colour and consist largely of altered volcanic Character of crystalline rocks.

* Annual Report Geol. Survey, 1887-88, part B.

rocks. The most important variety is a sheared and altered greenish quartzose schist. With this are associated greenish chlorite bearing schists, lustrous mica-schists, diabases and serpentines. The schists are interbedded with occasional bands of slates and crystalline limestones, and are broken through in many places by igneous intrusions.

The green schists are underlain in ascending the river by a great thickness of well foliated mica-gneisses alternating with mica and hornblende schists, which are distinctly Archæan in appearance and lithological characters. They bear a strong general resemblance to the Archæan rocks, recently described by Dr. Dawson from the western part of the Selkirks. Granite intrusions occur in the gneissic area, but less frequently than in the green schist belt.—(See pp. 143, 144).

CAMBRO-SILURIAN.

Cambro-Silurian rocks.

The greater part of the unfossiliferous dolomites, limestones and calc-schists found along the Liard, west of the Rocky Mountains, are identical in lithological characters with the Castle Mountain group of the Bow River section, and are probably of Cambro-Silurian or later Cambrian age. Similar rocks also form the base of the geological section in the Nahanni Butte, and in the mountains near the bend of the Mackenzie, seventy miles below Fort Simpson. The Cambrian slates and quartzites which underlie the limestones and dolomites of the Castle Mountain group along the Bow River are not brought to the surface, so far as observed, in the mountains along the Liard and Mackenzie.

No rocks holding Silurian fossils were found in any part of the district.

DEVONIAN.

Distribution of the Devonian.

Devonian rocks were not definitely recognized west of the Rocky Mountains. East of the mountains they have a wide distribution and underlie the greater part of the country bordering the Mackenzie, all the way from Great Slave Lake to below old Fort Good Hope, a distance measured in a straight line of over 700 miles. They were found all around the western arm of Great Slave Lake and were traced up Hay River to the falls and up the Liard to the "Long Reach." South of the Liard and extending as far south as Peace River, the Devonian outcrops at the surface in a broad band, averaging fully 150 miles in width, striking in a north-westerly and south-easterly direction, parallel to the western margin of the Archæan axis. On the southwest it is generally overlain by the Cretaceous, and on the north-east overlaps all the older Palæozoic formations and comes directly in contact with the Archæan. In all this region the beds are practically undisturbed and are seldom affected by dips exceeding a few feet to the mile.

North of the Liard the Devonian has become involved in the foldings of the Rocky Mountains, but in the plain followed by the river between the ranges, the beds, except in a few places, such as Rock Island opposite Fort Wrigley, Rock by the River Side, and Bear and Carcajou Mountains, are horizontal or nearly so, and rocks older than the Devonian are seldom brought to the surface.

For some miles above the mouth of Bear River the Devonian, which forms the top of the Palæozoic system in the district, is overlain unconformably by the Cretaceous, and Cretaceous outliers of limited extent recur at intervals all the way to the Upper Ramparts. Below the Ramparts Devonian rocks are traceable by numerous exposures as far as old Fort Good Hope, where they disappear beneath the Cretaceous.

Divisions of the Devonian.

Throughout the Mackenzie district the Devonian is generally divisible lithologically into an upper and lower limestone, separated by a varying thickness of shales and shaly limestones, but in some cases limestones occur throughout. The upper division has an approximate thickness of 300 feet and consists of a compact yellowish weathering limestone occasionally almost wholly composed of corals, interstratified with some dolomitic beds. This limestone is well exposed at the falls on Hay River and also at the Ramparts on the Mackenzie. In both these places it is underlain by several hundred feet of greenish and bluish shales, alternating with thin limestone beds. At the " Grand View " on the Mackenzie the shales are hard and fissile, and are blackened and in places saturated with petroleum. At the Rock by the River Side, and at other places where the beds are tilted and older rocks exposed, the middle division is underlain by 2,000 feet or more of greyish limestones and dolomites interbedded occasionally with some quartzites. No fossils were collected from the lower part of this series, and rocks older than the Devonian may possibly be represented in it.

Fossils.

Representative collections of fossils, showing a mixture of Hamilton and Chemung forms, were obtained from the upper part of the shales on Hay River, at a point about forty miles above its mouth, and from the same horizon at the Ramparts on the Mackenzie. The lithological characters and the stratigraphical relations of the limestones at these two points, notwithstanding the fact that they are separated by a distance of over 570 miles, are almost identical. The fossil faunas also, at the two points, show similar close relations, the principal differences being the presence of *Rhynchonella cuboides* and *Spirifera disjuncta* at Hay River, and of *Stringocephalus Burtini* at the Ramparts. This might seem to indicate that the beds at the Ramparts are slightly older than those at Hay River, but Mr. Whiteaves thinks that both are referable to the Cuboides Zone. A number of smaller collections of fossils were obtained at various points along the Mackenzie, and a complete list as determined or described by Mr. Whiteaves is given below.

SPONGIÆ.

Astræospongia Hamiltonensis, Meek and Worthen. Hay River.

ANTHOZOA.

Aulopora serpens, Schlotheim. Hay River.

ZOANTHARIA.

Streptelasma rectum, Hall. Mackenzie River. ten miles below Bear River.

Cyathophyllum arcticum, Meek. Rampart, Mackenzie River.

Cyathophyllum Richardsoni, Meek. Ramparts, Mackenzie River.

Campophyllum ellipticum. Hay River.

Campophyllum cæspitosum, Goldfuss. Hay River.

Heliophyllum parvulum, Whiteaves. Hay River.

Phillipsastræa Hennahi, Lonsdale. Hay River.

Phillipsastræa Verrillii, Meek (Sp.). Hay River

Cystiphyllum Americanum var. *arcticum*, Meek. Ramparts, Mackenzie River.

Pachypora cervicornis, DeBlainville. Hay River; and Ramparts Mackenzie River.

Alveolites vallorum, Meek. Hay River; and Ramparts, Mackenzie River.

CRINOIDEA.

Arachnocrinus Canadensis, Whiteaves. Hay River.

VERMES.

Spirorbis omphalodes, Goldfuss. Hay River; and Ramparts, Mackenzie River.

Spirorbis Arkonensis, Nicholson. Hay River.

Polyzoa.

Hederella Canadensis, Nicholson. Hay River and Ramparts, Mackenzie River.

Proboscina laxa, Whiteaves. Hay River.

Stomatopora moniliformis, Whiteaves. Hay River.

Ascodictyon stellatum, Nicholson. Hay River.

Paleschara quadrangularis, Nicholson (Sp.). Hay River; and Ramparts, Mackenzie River.

Ceramopora Huronensis, Nicholson. Hay River.

Brachiopoda.

Crania Hamiltoniæ, Hall. Hay River.

Productella subaculeata, var. *cataracta,* Hall and Whitfield. Rock by river side, Mackenzie River.

Productella spinulicosta, Hall. Hay River; and "Grand View," Mackenzie River.

Productella lachrymosa, var. *lima,* Hall. Ramparts, Mackenzie River.

Orthis striatula, Schlotheim. Hay River; and Ramparts, Mackenzie River.

Strophodonta demissa, Conrad. Hay River.

Spirifera disjuncta, Sowerby. Hay River.

Spirifera disjuncta var. *occidentalis,* Whiteaves. Hay River.

Spirifera cyrtinæformis, Hall and Whitfield. Hay River.

Spirifera (Martinia) glabra, var. *Franklini,* Meek. Hay River; and Ramparts, Mackenzie River.

Spirifera (M.) *meristoides,* Meek. Ramparts, Mackenzie River.

Cyrtina Hamiltonensis, Hall. Ramparts, Mackenzie River.

Atrypa reticularis, Linnæus. Hay River; the Ramparts and "Grand View," Mackenzie River.

Atrypa reticularis, var. *aspera.* Hay River; the Ramparts, and "Grand View," Mackenzie River.

Rhynchonella pugnus, Martin. Ramparts, Mackenzie River.

Rhynchonella cuboides, Sowerby. Hay River.

Rhynchonella castanea, Meek. Ramparts, Mackenzie River.

Eatonia variabilis, Whiteaves. Hay River.

Pentamerus galeatus, Dalman. Ramparts, Mackenzie River.

Stringocephalus Burtini, Defrance. Ramparts, Mackenzie River.

Cryptonella Calvini, Hall and Whitfield. Ramparts, Mackenzie River.

Newberria (Rensselaeria) lævis, Meek (Sp.). Ramparts, Mackenzie River.

Pelecypoda.

Paracyclas elliptica, Hall. Ramparts, and ten miles below Bear River, Mackenzie River.

Schizodus Chemungensis, Conrad. Hay River.

Gasteropoda.

Euomphalus (Straparollus) inops, Hall. Ramparts, Mackenzie River.

Euomphalus (Straparollus) flexistriatus, Whiteaves. Ramparts, Mackenzie River.

Euomphalus Maskusi, Whiteaves. Hay River.

Cephalopoda.

Orthoceras (two species). Hay River.

Goniatites. Hay River.

Crustacea.

Ostracoda.

Primitia scitula, Jones. Hay River.

Aparchites mitis, Jones. Hay River.

Isochilina bellula, Jones. Hay River.

Trilobita.

Proetus Haldemani, Hall. Ramparts, and Grand View, Mackenzie River.

The limestones which rise from beneath the Cretaceous on the Liard a few miles below Fort Liard hold fossils characteristic of transition beds between the Devonian and the Carboniferous. The following species were collected there from one exposure :—

Streptorhynchus, like *S. umbraculum*.

Spirifera, two ribbed species.

Spirifera (Martinia) setigera, Hall.

Athyris subquadrata, Hall.

Proetus peroccidens, Hall and Whitfield.

Similar transition beds occur all along the Rocky Mountains, south to the International Boundary, but have not been detected heretofore east of the Cretaceous basin of the plains.

Trias.

Beds holding Triassic fossils occur along the Liard in the eastern foot-hills of the Rocky Mountains. They consist of dark shales, usually rather coarsely laminated, and passing into calcareous shales interstratified with sandstones and shaly and massive limestones. The latter are moderately crystalline, are dark in colour, and are usually very impure. They are harder than the shales, and at Hell Gate narrow the valley into a cañon. The beds undulate, usually in easy folds, along the valley, and are exposed in numerous disconnected sections, but it was found impossible in hurrying through to make even an approximate estimate of their thickness. Triassic fossils were found at the Rapids of the Drowned, at Hell Gate and at one intermediate point. It is probable, however, that a considerable proportion of the barren shales east and west of these points are also of Triassic age. All the fossils collected have been examined by Mr. Whiteaves, and the following list of species, nine of which are described by him in Vol. I, pt. 2, of the "Contributions to Canadian Palæontology," is furnished by him:— Character of Triassic beds.

Spiriferina borealis.
Terebratula Liardensis.
Monotis ovalis.
Halobia (Daonella) Lommelli, Wissman.
Halobia occidentalis.
Nautilus Liardensis.
Popanoceras McConnelli.
Trachyceras Canadense.
Trigonodus ? productus.
Margarita Triassica.

Triassic beds were not detected along the eastern edge of the Liard Cretaceous basin. They are also absent from the valley of the Mackenzie, as the Cretaceous rocks were found there in a number of places resting directly on the Devonian.

Cretaceous.

Fossiliferous Cretaceous beds were not recognized in descending the Liard until the plateau belt which borders the eastern foot-hills was reached. Below Fort Halkett, west of the mountains, a band of soft dark shales crosses the river, which may be in part Cretaceous, but no fossils were found in it. The eastern foot-hills are built of a great series of alternating shales and sandstones, with some limestones, all folded closely together, which resemble those found in the foot-hills farther Cretaceous of the foot-hills.

south, and, like them, probably consist largely of Cretaceous rocks, but it was found impossible on a hasty trip along one line to separate these from the Triassic, or from the shales which cap the Palæozoic system, owing to the lithological similarity which prevails throughout. East of the foot-hills the convolutions gradually cease and the section becomes more legible. The beds here consist of soft, finely laminated shales, interstratified with a few beds of sandstone and ironstone. They have a minimum thickness of 1,500 feet. The shales yielded some fossils among which were several specimens of *Placenticeras Perezianum*, one of the characteristic fossils of series C. of the Queen Charlotte Islands. With this were species of *Camptonectes* and *Inocerami*. Near the eastern edge of the plateau belt the shales are overlain by massive beds of rather soft sandstones and conglomerates, the thickness of which was not ascertained. The conglomerates are affected by a gentle easterly dip, and descend to the level of the river in the course of a few miles. From the point at which they disappear to the eastern edge of the Cretaceous basin, the rocks consist of dark fissile shales, crumbly sandy shales and sandstones, but the exposures along the valley are infrequent, and the succession soon becomes obscure.

Character and age of beds.

Age of Cretaceous.

The Cretaceous section along the Liard thus shows two great shale and sandstone series separated by a heavy band of sandstones and conglomerates. The lower shales, from the imperfect fossil evidence at hand, and also from their lithological character, may be referred tentatively to the horizon of the Queen Charlotte Islands or Kootanie formation, the upper shales to that of the Benton, while the intervening conglomeritic band probably represents the Dakota. The lithological succession of the Cretaceous beds here is almost identical with that which obtains in other parts of the Cordilleran belt north of the International Boundary and on the Queen Charlotte Islands,* and shows that similar conditions of deposition prevailed at the same time over this whole area.

The Cretaceous rocks cross the Liard with a width of over a hundred miles, and north of the river enter a bay in the mountains, the extent of which to the north-westward is not known; southwards they are connected with the great Cretaceous basin of the plains.

Junction of Cretaceous with Devonian.

Fifteen miles below Fort Liard the Devonian limestones rise to the surface, but the junction between them and the overlying Mezozoic rocks is concealed, and I was unable to ascertain whether the older beds continue to the eastern edge of the basin or are here overlapped by the Upper Cretaceous. It is probable, however, that the latter is the case.

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

The plains bordering the lower part of the Liard and the upper part of the Mackenzie rest on Devonian limestones and shales, and Cretaceous rocks were not detected in descending the latter stream until the Dahadinni River in lat. 64° N. was reached. They consist here of a couple of hundred feet of dark grey shales and sandstones. They are exposed along the valley for ten or twelve miles, and are then concealed by the boulder-clay, but probably continue under the latter as far as the Tertiary basin at the mouth of Bear River, a distance of fifty miles. The Cretaceous beds here occupy a depression between two high ranges of limestone mountains and cannot have a greater width than ten or fifteen miles. They have been separated from the Cretaceous beds which form the western shores of Great Bear Lake by the elevation of the Mount Clark range.

Cretaceous along the Mackenzie.

Forty miles below Bear River the Cretaceous beds reappear on the banks of the Mackenzie, and with the exception of one break of a couple of miles where they have been removed by denudation, underlie the valley all the way to the Ramparts, a distance of ninety miles. The fossils obtained both from this area and from the one above Bear River consist of fragments of Ammonites and Inocerami, too imperfect for specific determination.

A hundred and twenty miles below the Ramparts, the Mackenzie enters a third Cretaceous area, and the largest one on the river. Cretaceous beds appear in the banks a short distance below old Fort Good Hope and extend down the Mackenzie to the head of its delta, and westwards across the Rocky Mountains and down the Porcupine to about long. 139° W. They consist on the Mackenzie of coarse shales interstratified with some sandstones and fine grained conglomerates; in the mountains of several thousand feet of barren sandstones and quartzites underlain by dark shales, and on the Porcupine of the same two series underlain by a great thickness of alternating shales, sandstones and conglomerates, holding *Aucella Mosquensis* var. *concentrica*. The intermediate dark shales are probably of Benton age, while the lower division so far as the fossil evidence goes, represents the Queen Charlotte Island formation and the Dakota (see p. 139).

Cretaceous shales holding *Aucella* and passing upwards into fine grained conglomerates, occur on the Yukon for many miles above and below the mouth of the Tatonduc (see p. 139), and were traced by Ogilvie up the latter stream for some distance. They have been greatly disturbed and are folded up in broad bands with the underlying Palæozoic limestones.

Cretaceous rocks on the Yukon.

It is highly probable that the various Cretaceous areas scattered along the Liard, Mackenzie, Porcupine and Pelly-Yukon, were originally connected and have been separated by denudation. This is shown by the structure of the region, by the fossil evidence so far as it goes, and by the lithological and stratigraphical resemblances which prevail throughout.

TERTIARY.

Distribution of Tertiary.

Tertiary beds occur at the mouth of Bear River and occupy a basin of about thirty to forty miles in length and twenty to thirty in breadth. They rest unconformably on the underlying Cretaceous shales and Devonian limestones. They are lacustral in origin and consist largely of discordantly bedded sand, sandy clays, clays and gravels. Beds of purely argillaceous material usually somewhat plastic in character are also present, and seams of lignite and carbonaceous shales not infrequently constitute a considerable proportion of the section. A more detailed description will be found on page 96. The beds have an anticlinal attitude on the whole, but are usually nearly horizontal. They have a minimum thickness of 600 feet. Remains of plants are abundant in some of the beds, but no animal fossils either vertebrate or invertebrate have so far been obtained. The following list includes all the species collected by various travellers up to date:—

Character of Tertiary.

Pteris Sitkensis, HEER.
Smilax Franklini.
Glyptostrobus Ungeri, HEER.
Sequoia Langsdorffii, BRONGT.
Taxodium distichum.
Taxites Olriki, HEER.
Populus arctica, HEER.
" *Richardsonii*, HEER.
" " var. *latior.*
" *Hookeri*, HEER.
Salix Raeana, HEER.
Betula macrophylla, GPT.
Corylus McQuarrii, FORBES.
Quercus Olafseni, HEER.
Platanus aceroides, HEER.
Juglans acuminata, BRONGT.
Viburnum Nordenskioldii, HEER.
Pterospermites spectabilis, HEER.
" *dentatus*, HEER.
Tilia Malmgreni, HEER.
Phyllites aceroides, HEER.

Hedera MacClurei, Heer.
Magnolia Nordenskioldii, Heer.
Callistemophyllum latum, Dawson.
Carpolithes seminulum, Heer.
Carpolithes.
Leguminosites (?) *borealis*, Dawson.
Antholithes amissus, Heer.
Pyritized and ferruginous wood of *Sequoia* and other genera.

This list is in the main the same as that published by Sir William Dawson in the Transactions of the Royal Society of Canada (Vol. VII, Sec. IV, Page 69), but it also includes some additional species collected by the writer, and since described or determined by Sir William. On the evidence of the plants enumerated above, Sir William refers the beds to the Laramie (see p. 99). This reference is not supported by the stratigraphical evidence, but is not contradicted by it. The beds occupy a separate basin and differ from the Laramie in resting unconformably on the terranes below. In this respect and also in their lithological character they are more closely allied to the Miocene lacustral deposits of the southern plains.

Age of Tertiary.

West of the mountains soft incoherent beds resembling those at the mouth of Bear River and probably of about the same age, are exposed along the Porcupine River in the vicinity of the Old Crow Mountains. They were first seen about half a mile above Fishing River and were traced as far as the head of the Ramparts, a distance in a direct line of forty-two miles. Opposite the Old Crow Mountains and at another point farther up the river they are interrupted by uplifts of the underlying Cretaceous shales. Like the Bear River beds they rest unconformably on the rocks beneath. They consist essentially of light coloured sands, sandy clays, clays and conglomerates, with occasional nodular beds of ironstone, and in one section held a small lignite seam. No fossils of any kind were obtained from them. They are horizontal, or nearly so, and have a minimum thickness of 300 feet. Similar beds were noticed in the interval between the Upper and Lower Ramparts, and also occur for a short distance along the river below the Lower Ramparts.

Tertiary west of mountains.

The Tertiary beds occupy basins in the older rock, and evidence an elevation of the land at the end of the Cretaceous period followed by prolonged denudation, and a subsequent depression, accompanied by the formation of the lakes in which they were laid down.

[1] Superficial Deposits and Glacial Action.

Details of the character of the various superficial deposits met with will be found in the descriptive part of the report, and it will only be necessary here to summarize the general results.

Glacial deposits on the Liard.

On the Liard River, below the mouth of the Dease, stratified sands, gravels and clays of glacial age are constantly met with, and in one or two places are underlain by sandy clays, which were doubtfully referred to the boulder clay period. The distribution of the latter is, however, very limited in the section cut by the river west of the mountains, and the gravels and sands were repeatedly observed to rest directly on the underlying older rocks. Below Portage Brûlée terraces rising in steps up to a height of several hundred feet are extensively developed, and border the river all the way to the mountains. While passing through the mountains and eastern foot-hills ordinary river valley deposits were noted. Eastern erratics were first noticed on leaving the broken plateau belt which flanks the foot-hills on the east in this latitude, and were then traced all the way to the Mackenzie. The highest point at which they were found was on the flanks of a mountain situated opposite Fort Liard, approximately in lat. 60° N., long. 123° W., where they reach an elevation of 1,500 feet above the surface of the surrounding country, or about 2,300 feet above the sea. The erratics extend much farther west than the boulder-clay, and are probably water-borne. Eastwards from the foot-hill region stratified sands and gravels rest on the Cretaceous rocks, and are exposed in numerous sections until a point about twenty miles below Fort Liard is reached. Below this the river winds for many miles through one of those filled up depressions in the boulder-clay which are so frequently met with on the area of the great plains. In this stretch stratified sands and silts only are seen. Forty miles from the mouth of the river, measuring in a straight line, the Devonian rocks rise from beneath their lacustral covering, and are soon afterwards overlain by unmistakeable boulder-clays of the ordinary type. Boulder-clays are then almost continuously exposed on to the mouth of the river.

First appearance of boulder-clay.

Alluvial beds on Slave River.

Slave River, below Fort Smith, winds through an alluvial plain all the way to Great Slave Lake, and sections of sands, clays and gravels of later age than the boulder-clay are exposed at the elbows of all the bends. The width of this plain is considerable, as Salt River, a tributary of Slave River, serpentines through it in a westerly direction for fifteen miles, and it probably extends nearly as far to the east. It is underlain partly by loam and partly by sandy soils, and contains a number of treeless areas.

[1] Republished in part from Bull. Geol. Soc. Am., vol. i, p. 540.

Terrace on Great Slave Lake.

Some notes on Great Slave Lake are given on pages 67-71. The low terraces which surround this lake are interesting, as they afford evidence either of a damming up of the whole eastern end of the lake by ice, or, what is more probable, judging by the much greater heights at which they were found by Back at the eastern end of the lake than those which obtain around the western part, of significant changes in elevation. The elevation of the region bordering the Mackenzie where it issues from the lake is inconsiderable, and a rise in the level of the latter sufficient to bring it up to the higher terraces would, under present conditions be impossible, as the outlet would immediately be enlarged to a width equal to that of the lake itself. The Archæan portion of Great Slave Lake is evidently pre-glacial in its origin, as its peculiar cruciform shape, its great depth, viewed in connection with the comparatively low elevation of the surrounding country, and the precipitous shore cliffs which occur so frequently around it, are all features which can scarcely be attributed in their entirety to glacial work. It is possible, however, that the western part, which is much shallower and has low shelving shores, may have been excavated in part or altogether by a glacier forcing its way out of a previously formed basin to the east.

Hay River.

Hay River, which empties into Great Slave Lake near its western end and drains the country to the south-west, has evidently had a history somewhat similar to that of Niagara, but it has not yet been thoroughly explored. It was ascended as far as the Alexandra Falls, and a description of the latter and the accompanying gorge will be found on page 73.

Morainic ridge.

About ninety miles south-west of the west end of Great Slave Lake, a north-easterly facing escarpment, marking a permanent rise in the general elevation of the country was crossed, while on a winter trip from Fort Providence to Lake Bis-tchô, the front and summit of which were covered with a medley of steep-sided, interlacing hills and ridges, similar in appearance to those found on the Grand Côteau de Missouri of the plains, and evidently like them of morainic origin. The depth of the snow, however, prevented a satisfactory examination. No other morainic belts or areas were noticed in this part of the district, and the surface, as a rule, is rather uniform, but swells occasionally into wide ridges of little height running in a north-north-westerly direction. The shallow depressions between the ridges are covered largely with mossy muskegs and lakes.

Proceeding down the Mackenzie from Great Slave Lake, alluvial clays form the banks for some miles, aud then a boulder-clay makes its appearance scarcely distinguishable in character from the same forma-

Boulder-clay on the Mackenzie.

tion as developed in Eastern Canada, 3,000 miles distant. It occurs here as a light-yellowish, compact, arenaceous clay, filled with rounded Archæan boulders, and, as elsewhere, showing little or no signs of stratification, and is traceable, with some variations in character, as far as the Lower Ramparts, or to the head of the deltoid portion of the river; and this notwithstanding the fact that less than a hundred miles below the mouth of the Liard the Mackenzie enters the flanking ranges of the Rocky Mountains, and for the next three or four hundred miles its valley is partially guarded on the east by ranges of mountains, some of which exceed 4,000 feet in height. The thickness of the boulder-clay is extremely irregular. In some of the pre-glacial depressions sections exceeding 250 feet in thickness were frequently noticed, while a few miles away the older rocks rise to the surface, and the boulder-clay blanket either thins out or completely disappears.

Dark boulder-clay.

For some fifty miles above Bear River the boulder-clay is much darker in colour than is usually the case, and is apparently mostly derived from the dark shales of the Cretaceous and Devonian, which floor the valley. It is almost destitute of boulders, is very plastic, and is broken down by land-slips into ruinous-looking banks similar to those produced on the Saskatchewan and other rivers of the plains by the sliding of the Pierre shales. The scarcity of boulders in this reach is probably connected with the fact that the mountains east of the river are here higher and more continuous than in other parts of the valley, and afforded a more complete protection against the eastern ice invasion. North of Bear River the boulder-clays revert to their normal character.

Stratified beds overlying and underlying boulder-clays.

The boulder-clay throughout the greater part of the valley is overlain by heavy deposits of stratified sands, clays, and gravels, probably lacustial in their origin, and is underlain by a gravel terrane somewhat similar to and occupying the same relative position as the Saskatchewan gravels of the plains of Alberta and Assiniboia, but differing in containing a much greater proportion of Laurentian pebbles. These beds have a thickness in some cases of fully 150 feet, and contain well-rounded pebbles ranging in size up to eight or ten inches in diameter. They are intimately connected with the boulder-clay, and in one place were observed to alternate with it, and they seem to show that the boulder-clay period in this region was preceded as well as followed by what may be termed a lacustrine epoch, during which the surface depressions were filled with extensive lakes.

Direction of ice flow.

The few facts observed in regard to the direction of ice flow in the Mackenzie valley support the theory of Dr. Dawson as to its northerly movement. In the western part of Great Slave Lake the direction of the ice current, as stated on page 76, was due west. Five degrees farther north well marked glacial striæ, striking 15° north of west, were observed crossing the summit of Roche Carcajou. This rock, which must have been completely submerged, rises to a height of 1,000 feet above the surface of the river. Important evidence on the same point is also afforded by the fact that the boulder-clay near the Lower Ramparts of the Mackenzie is in approximately the same latitude as the northern boundary of the Archæan area to the east, and the gneissic boulders which it contains must have travelled either straight west or north-west in order to reach their present situation. These facts allow the inference that the ice from the Archæan gathering grounds to the east poured westwards through the gaps and passes in the eastern flanking ranges of the Rocky Mountains, until it reached the barrier formed by the main axial range, and unable to pass this, was deflected to the north-west, in a stream approximating 1,500 feet in depth, down the valley of the Mackenzie and thence out to sea.

In crossing the mountains by the Peel River Portage few glacial features were noticed. A couple of terraces, the higher of which has an elevation of about 550 feet above the sea, flank the range on the east, and a sub-angular gneissic erratic was found at a height of 1,500 feet, but this was probably water-borne. On the western side of the mountains a terrace, with fragments of a higher one resting on it in places, was crossed at an elevation of about 1,500 feet above the sea. Proceeding down Rat River to the Porcupine, and down the latter through the ramparts, sands, gravels and silts are found resting on the underlying rocks, but no boulder-clay, perched boulders or other evidence of glaciation were anywhere seen. Along the upper part of the Ramparts river gravels, often very coarse in character, were noticed at various points up to elevations of 400 or 500 feet above the surface of the river. Some miles below the Ramparts the banks of the valley diverge on either side, and enclose a great plain through which the Porcupine serpentines all the way to the Yukon, a distance measured in a straight line of about seventy-five miles. This plain has a width in its widest part of fully ninety miles. Sections are cut through it in different directions both by the Porcupine and Pelly-Yukon, and show it to be underlain throughout by stratified sands and silts, often showing false bedding and with occasional layers of gravel. The latter appeared to become finer-grained and of less relative importance towards the centre of the area. The size of the plain, its uniformity and the character of the beds which underlie it suggest a delta origin, and correlate it with the lowlands at present in course of formation at the mouth of Slave River in Great Slave Lake. It is probable that a lake basin

Terraces.

Great plain

or great dilatation in the channels of the Porcupine and Yukon once existed here and has been obliterated by the deposition of the detritus brought down by the two streams, or, as suggested by Russell,* the facts may be explained by a damming back of the Yukon by recent orographic movements.

Terrace opposite boundary.

The Yukon, above its junction with the Porcupine, winds through the alluvial or lacustral plain which has just been described for a distance of seventy miles. Above this the valley becomes more contracted, and is floored with the older rocks or the ordinary river wash. Opposite the International Boundary a terrace was noticed by Russell at a height of 734 feet above the level of the river. Above the boundary fragments of similar high terraces, usually somewhat indistinct, occur at several points, and rolled gravels were found at varying heights opposite all our camps. Thirty miles below the mouth of the Pelly rolled gravels, evidently derived from broken down terraces, were found in some abundance up to a height of 800 feet. From the Stewart River upwards, terraces of a more recent date, ranging up to a hundred feet in height, border the river at intervals and increase in elevation as we ascend, but no boulder-clay or other evidences of glaciation were seen until a point about seven miles below the Rink Rapid was reached. Above this signs of glacier action, as previously pointed out by Dawson, are unmistakeable. The plateau bordering the Pelly-Yukon was not examined, but, judging simply from the records of the Ice age which the valley itself affords, it would appear that the glacier which undoubtedly filled the upper part of the valley of the Lewes and moved northwards did not descend much below lat. 62° 24′ N. Below this the deposits indicate a flooded valley, but nothing else.

Limits of glacier.

A feature of some interest in connection with glacial phenomena, and which may have some bearing on the non-glaciated condition of part of Alaska and the adjacent portion of the North-West Territory of Canada, is the fact that glaciers are unknown in the Rocky Mountains north of the headwaters of the Athabasca, or about lat. 54° N. North of this occasional patches of snow survive the summer in sheltered nooks, but even these decrease in frequency with increasing latitude, and on the Peel River portage, in lat. 67° 20′ N., the snow had entirely disappeared before the middle of July. Also, in descending the Porcupine and ascending the Yukon, no snow was seen until far up the Lewes, and no glaciers until the head waters of this stream were reached. It follows from this that climatic changes which would extend the present glaciers of the Bow and Saskatchewan far down

Absence of glaciers in mountains.

* Bull. Geol. Soc. Am., Vol. I, p. 114.

their valleys might have little or no effect in imposing glacial conditions on this more northern region.

Economic Synopsis.

Gold.—As a full account of the discovery of gold and the progress and present condition of gold mining in the Upper Liard, Cassiar and Yukon districts is given by Dr. Dawson in the Annual Report of the Survey, 1887-88, Part B., pp. 78-86 and 178-183, it will be unnecessary to go into the subject in detail here. "Colours" of gold occur in the bars of the Liard all the way to its mouth, but no deposits of economic value have been found below the Devil's Portage. A number of bars were worked, between the Devil's Portage and the mouth of Dease River, for several years after the discovery of gold on the Liard by Messrs. McCulloch and Thibert in the year 1872, but these are now all abandoned and the records of them lost. At the present time no miners are employed on the Liard below the mouth of Dease River. Gold on the Liard.

Gold in paying quantities has not been found on either the Mackenzie or the Porcupine, and the rock formations bordering these rivers do not appear to be gold-bearing.

On the Pelly-Yukon above the Boundary, and as far as the mouth of the Pelly, the limit of my examination, gold in varying quantities is of almost universal occurrence, but up to the present time active operations have been confined almost entirely to two of the tributaries. Of these Forty Mile Creek enters the Pelly-Yukon from the west, about forty miles above the boundary and has its course mostly in Alaska, while Stewart River comes in from the east and flows through Canadian territory all the way. Gold was discovered on the Stewart in 1885, and in that and the following year the estimated yield of the various bars amounted to over $100,000, but in 1887 it was almost deserted owing to the discovery of coarse gold on Forty Mile Creek, and the consequent "stampede" of the miners to that stream. The gold on the Stewart is reported to be "fine," and the bars are often exhausted under present conditions in a single season's work, but as they are abandoned when the yield falls much below $10 a day per man, it is highly probable that work on many of them will be resumed when improved methods of mining are introduced, and the present exhorbitant prices for labour and provisions are reduced. Extensive gravel benches of a more or less auriferous character border the Stewart in many places, and promise remunerative returns if worked on a large scale. Gold on the Yukon. Stewart River.

Forty Mile Creek proved a veritable bonanza to most of the miners who reached it early in 1887, but in 1888 the returns, owing to the Forty Mile Creek.

continued high water, were disappointing. In the former year the yield has been estimated all the way from $75,000 to $150,000 and was probably in the neighbourhood of $100,000. In 1888 the yield in conquence of the enforced idleness of the miners, declined to less than $20,000, most of which was obtained from the upper or Alaskan part of the stream. The number of miners employed on the stream during the two seasons varied from about 100 to 350. The gold on Forty Mile Creek is coarser than that obtained from the Stewart, but the auriferous bars are usually of little depth and are soon skimmed over. Some attention was paid during the season of 1888 to prospecting the gulches and gravel terraces bordering the stream, but these have not been worked as yet to any notable extent.

Quartz veins.

The country rocks bordering the Pelly-Yukon, all the way from the boundary to White River and beyond, consist of schists broken through by eruptive granites and diorites, geological conditions peculiarly favorable to the existence of metalliferous deposits. (See p. 140.) They are traversed in many places along the river by promising quartz veins and ledges, but these have been very little prospected as yet, the miners contenting themselves up to the present with the development of the more easily worked placer deposits.

Argentiferous galena.

SILVER.—A small lode of argentiferous galena crosses Forty Mile Creek a couple of miles above its mouth. A specimen of this brought back by Mr. Ogilvie and analyzed by Mr. Hoffmann yielded over 38 oz. of silver to the ton.

Copper Pyrites.

COPPER.—Copper pyrites, in small quantities, was noticed at several points between Forty Mile Creek and Fort Reliance. It does not occur in veins, but appears to impregnate individual layers of the schist itself. Traces of copper were also observed in the Castle Mountain dolomites at the base of the Nahanni Butte section.

Asbestus.

FIBROUS SERPENTINE.—Some of the serpentines in the vicinity of Forty Mile Creek occasionally assume a fibrous structure and pass into a picrolite or coarse asbestus. A small specimen of good serpentine asbestus has also been brought from the Stewart River, (see Annual Report Geol. Survey, 1887–88, p. 27 B).

Gypsum.

GYPSUM.—Gypsum occurs in large quantities in the Devonian rocks of Bear Mountain at the mouth of Bear River (see p. 102).

Salt springs.

SALT.—Several salt springs drain into Salt River, near Fort Smith, about twenty-five miles above its mouth. Some of the springs have basins ten to twelve feet in diameter, which are encrusted with crystalline salt of excellent quality (see p. 65). Salt is also reported to occur on the head-waters of a small stream which enters the Mackenzie about fifty miles above Fort Norman.

SULPHUR.—Mineral springs of large volume occur at Sulphur Point, on the south shore of Great Slave Lake, and also at the tar springs, north of Point Brûlée on the north shore. In both cases small quantities of sulphur are deposited in the basins of the springs and along the channels of the streamlets which drain them. Sulphur spring.

COAL.—Small seams of impure lignite were found on the Liard, a few miles above the Little Cañon, and large blocks of drift lignite occur on the same stream at the mouth of Coal River. On the Mackenzie the Tertiary beds at the mouth of Bear River hold several seams of lignite, ranging in thickness from two to four feet, and one seam which was concealed at the time of my visit, is reported by Richardson to be nine feet thick. The lignite here is of inferior quality, and has been burnt in many places for some distance from the surface by fires which have been in existence since the river was first discovered. West of the mountains a small seam of lignite was observed on the Porcupine, a few miles above the mouth of Old Crow River, and seams of coal are reported to occur in a small stream which enters the Pelly-Yukon from the east below Forty Mile Creek. The latter is probably of Cretaceous age. Lignite.

PETROLEUM.—The Devonian rocks throughout the Mackenzie valley are nearly everywhere more or less petroliferous and over large areas afford promising indications of the presence of oil in workable quantities. The rocks in several places around the western arm of Great Slave Lake, are highly charged with bituminous matter, and on the north shore tar exudes from the surface and forms springs and pools at several points (see p. 77). The tar from these springs is used by fur traders and others in the country for pitching boats and canoes, and they report that a pool when exhausted quickly renews itself. In descending the Mackenzie bituminous limestones were noticed at the "Rock by the River Side," at Bear Rock, at the Ramparts, and at numerous other places. Near Fort Good Hope several tar springs exist, and it is from these that the Hudson's Bay Company now obtain their principal supply of pitch. The springs are situated at some distance from the river and were not examined. Still farther down, in the vicinity of old Fort Good Hope, the river is bordered for several miles by evenly bedded dark shales of Devonian age which are completely saturated with oil. The shales here have been reddened in many places by the burning of the oil which they contain (see p. 111). Oil bearing beds.

The possible oil country along the Mackenzie valley is thus seen to be almost co-extensive with that of the valley itself. Its remoteness from the present centres of population, and its situation north of the still unworked Athabasca and Peace River oil field will probably delay its development for some years to come, but this is only a question of time. The oil fields of Pennsylvania and at Baku already show signs of exhaustion, and as they decline the oil field of northern Canada will have a corresponding rise in value.

Climate and Agriculture.

Climatic statistics.

In the region in the vicinity of Great Slave Lake and down the valley of the Mackenzie for two or three hundred miles, spring weather generally sets in about the last week in April or the first week in May, and by the 15th of May the snow has usually disappeared and vegetation has begun. The summer temperature, as a rule, is moderate, the thermometer rarely rising much above 70° F. in the shade, or sinking below freezing point. The warm weather lasts about four months only, and by the middle of September is practically over.

Frozen soil.

Around Great Slave Lake the soil seldom thaws out to a greater depth than eight feet, and in many of the muskegs and marshes ice remains throughout the year at a depth of about two feet. In descending the Mackenzie the frozen soil gradually approaches the surface. At Fort Norman at the end of summer it lies at a depth of about six feet, at Fort Good Hope at about four feet, and at the mouth of Peel River at about two feet. The thickness of the frozen stratum was not ascertained.

Character of winter.

Winter sets in about the middle of October and lasts for fully six months. In the autumn of 1887 the first snow fell at Fort Providence on the 1st of October, on the 21st of October ice was drifting in the river, and on the 16th of November the Mackenzie was frozen across. The winters are characterized by their steady cold weather. In 1887-88 the thermometer did not rise above freezing point between the 4th of November and the 20th of April, and from the 1st of December to the 1st of March was usually 20° or more below zero. The coldest dip of the season occurred on the 13th of February, when the thermometer marked 48° below zero. The winter winds are seldom very strong, and are generally from the N.N.W. or N.E. The precipitation is light, but no accurate records of it have been kept. In the season of 1887-88 the snow accumulated on the ground to a depth of about three feet. This represents the total snowfall as no thaw occurred between the 29th of October and the 1st of May.

Agricultural capabilities.

The agricultural capabilities of a region in which the snow lies on the ground for nearly seven months in the year, and in which the soil never thaws out to a greater depth than six or eight feet, are necessarily limited, but that crops of various kinds will mature even under these unfavorable circumstances has been proved by the experience of over a quarter of a century. At all the posts of the Hudson's Bay Company, along the Mackenzie and its tributaries, with the exception of Fort Macpherson, small plots of land are annually cultivated and large quantities of potatoes, turnips, beets and other vegetables are grown for use in the district; while at Fort Liard and Fort Providence, the two most southerly posts in the district, both wheat and barley, have been tried with success (see p.p. 54D and 78D). There is, however, little reason to hope that the Mackenzie River district as a whole, or even the southern part of it, except in limited areas, will ever be able to support a purely agricultural community, or that its products will ever be able to compete in the open markets of the world with the produce of more favoured regions. Its agricultural development will depend on a local market being obtained. When the time comes, as come it must, when the undoubted mineral resources of the region are drawn upon, the food required by the mining population, or the greater part of it at least, can be supplied locally.

Amount of arable land.

The amount of arable land is small compared to the total area, and is mostly confined to the vicinity of the larger streams. Away from the rivers frozen marshes and muskegs, and shallow lakes cover the greater part of the surface. The alluvial lands along Slave River, the upper part of Mackenzie River, and the country bordering the Liard for some distance above and below Fort Liard and west of the mountains, are the best parts of the district. The lower part of the Mackenzie valley and the country along the Porcupine and the Pelly-Yukon below Fort Selkirk afford little prospect of ever becoming of agricultural value.

DESCRIPTION OF ROUTES.

LIARD RIVER.

Mouth of Dease River to the Devil's Portage.

General description of river.

The Liard River is one of the three principal tributaries of the Mackenzie, the other two being the Athabasca and the Peace. It has its sources west of the Rocky Mountains, one of its branches reaching to within one hundred and fifty miles of the sea, and drains the eastern part of the broken country lying between that range and the coast mountains. Its branches spread through four degrees of latitude, from 58° N. to 62° N., and interlock with those of the Yukon, Stikine, Skeena, and Peace Rivers. In its upper part it divides at intervals into four nearly equal streams, the Mud or Black River, Dease River, Francis River, and the branch which retains the common name. Of these the latter and Black River are still practically unknown. Dease River and Francis River were examined by Dr. Dawson in 1887, and the following account treats of the main river from its junction with the Dease to its mouth, a distance of about 470 miles. Rising in the elevated country west of the Rocky Mountains, the Liard falls rapidly towards the east, the difference in elevation between the mouth of the Dease and the Mackenzie amounting to nearly 1,650 feet, and is characterized nearly every where by impetuous currents, by dangerous rapids and narrow whirlpool-filled cañons. The descent of the river is greatest and its rapids most numerous, while passing through, and for some distance on either side of the Rocky Mountains. After leaving the foot hills it is nearly free from interruptions until near its junction with the Mackenzie, where a series of strong riffles occurs.

Liard River used as a trade route by H. B. Co.

The Liard River was used for a number of years by the H. B. Co., as a trading route to the Yukon, and a line of posts extending from Fort Simpson on the Mackenzie, to Fort Selkirk at the junction of the Lewes and Pelly was established by them, but the expenses incurred in overcoming the great length of difficult navigation made the trade unprofitable, and most of the posts have been long since abandoned. At the present time a trading post exists at the mouth of the Dease, but it is supplied from the Pacific by way of the Stikine and Dease River. The Liard has also been used to some extent by prospectors and miners, the discoverers of the Cassiar Gold fields, Messrs McCullough and Thibert having ascended it from Fort Simpson to the mouth of the Dease in 1871-72.

Early notices of river.

Information in regard to the Liard previous to the present exploration was exceedingly limited, as notwithstanding the use which had been made of it by both fur traders and miners, no survey of the river had ever been made, and its course as laid down on existing maps was found naturally to be extremely incorrect, in some places being fully one hundred miles out of position. The best sketch of the river I could obtain was one drawn for me from memory by Mr. Thibert who had ascended the river eighteen years before. The published descriptions also were of the vaguest hearsay character. Sir J. Richardson gives a few notes in regard to the lower part in his "Journal of a Boat Voyage through Rupert's Land," and L'Abbé E. Petitot writes of it in the following manner:—

[1] "*Je n'ai remonté la rivière des Liards que de quelques milles, mais tous les voyageurs qui y ont navigué s'accordent à faire une description effrayante de ses montagnes à pic, de ses gouffres et des tourbillons que la vélocité d'un*

[1] Bulletin de la Société de Géographie, Paris, 1875.

courant resserré entre des rochers, détermine dans ses eaux. Pour descendre cette rivière vertigineuse avec sécurité les timoniers métis se lient sur le pont de leur barque, afin de n'être pas lancés dans les flots blanchissants. Pour retrouver un tel spectacle il faudrait affronter les périls de Charybde ou les girations intermittentes de Maëlstrom."

Character of survey.

The present survey is only intended as a provisional one, and was made by estimating the rate according to measurements made at intervals along the shore and taking the bearings with a prismatic compass. Observations for latitude were also taken whenever practicable, and serve as a useful check on the traverse.

Begin descent of river.

We left the mouth of Dease River on the 26th June, in a small wooden boat which was built by ourselves on Dease Lake. The party consisted besides myself of two white men, Louis Trépanier and John McLeod. Besides these, I also engaged a couple of Indians to accompany us as far as the Devil's Portage, but they deserted at the first difficulty which presented itself. The natives along this part of the Liard are very inferior canoemen, and are afraid to venture on the river except in its smoothest portions. They seldom ascend the river with canoes, as they prefer carrying their outfit along the shore to tracking a boat against the rapid current, and in descending use small spruce bark canoes which they can build in a couple of hours and abandon without much loss. They belong to the Kas-ka branch of the great Tinnéh family, and are commonly referred to as the Grand Lake Indians.

Indians along river.

Width of river and valley.

The Liard River below the mouth of the Dease has a general width of from two hundred and fifty to four hundred yards, but widens out in places to over half a mile, and a current of four miles and a half an hour. It separates in places into a number of channels enclosing low alluvial islands usually well wooded. Its valley is from two to three miles wide, and is shallow with rolling banks sloping easily up to the general level. The country is everywhere well wooded, but the trees are usually small, seldom exceeding a foot in diameter. The principal varieties observed were the black pine (*Pinus Murrayana*), the White spruce, (*Picea alba*), and the smooth and rough barked poplars, (*Populus tremuloides* and *balsamifera.*) Besides these, groves of larch were occasionally seen, and some varieties of willow and alder. Twelve miles below the mouth of the Dease the Liard receives a large tributary from the north. This stream is over a hundred yards wide, and is called the Highland River, after a prospector who ascended it for some distance. On the older maps it is named the McPherson River. In the direction from which it comes are some low hills at a distance of four to five miles, behind which appear snowy mountains. From the mouth of Dease River the Liard runs in a general E. S. E. direction for eigh-

Bordering forests.

Highland River.

teen miles, and then making a sharp bend to the north, runs for about the same distance in a direction nearly at right angles to its former course. Below the bend the river for twelve miles is wide and filled with islands, after which it gradually decreases in width, and this, with the steeper slopes of the valley and the increasing strength of the current, which occasionally breaking into small riffles now hurries along at the rate of seven miles an hour, all afford signs of our approach to the Little Cañon, of the dangerous character of which we had been previously warned, and which soon comes into view.

Little Cañon.

The Little Cañon is about half a mile long, and in its narrowest place about two hundred feet wide. It is easily navigable in low water, but is dangerous for small boats during flood, as the channel is very crooked, and the current striking with great violence against the right hand bank is thrown forcibly back, with the production of a number of breakers running nearly lengthwise with the direction of the channel, and large enough to swamp any ordinary river-boat which is drawn among them. A number of Chinamen were drowned at this point some years ago. This cañon can be run with safety by entering it nearly in the middle of the stream, which is as close to the left hand bank as the lines of reefs and isolated rocks running out from that side will allow, and once past these making all haste to the left so as to clear the breakers below. In high water the rapid can be avoided by making a portage of about half a mile along the right bank.

Rocks between Dease and Little Cañon.

Rock exposures are infrequent in the valley of the Liard between the mouth of the Dease and the Little Cañon, but those observed will be described in order. Three miles below the mouth of the Dease is a small exposure of somewhat soft dark shales associated with friable sandstones and conglomerates. A second exposure of the same beds was observed about a mile farther down the river, where they dip N. 60° W. $<$ 20°, beyond which they disappear. These rocks are unfossiliferous, but from their lithological characters, and the fact that they overlie unconformably the hard quartzites, slates, and limestones, of the neighborhood were referred to the Tertiary. At the mouth of Highland River, on a small island is an exposure of hard whitish sandstone, passing into quartzite. This rock weathers yellow, and dips N. 50° E. $<$ 50°. Six miles farther down, at a bend which the river makes to the north, is a cut bank showing unconsolidated sands, sandy clays and gravels, and holding some small beds of impure lignite. Below this, with the exception of rolled river gravels, no further exposures were seen until near the Little Cañon, when black shales appear in a couple of places.

The rocks in the Little Cañon consist of dark and sometimes cleaved shales, holding large flattened ironstone nodules, hard sandstones and quartzites, and some beds of fine grained hard siliceous conglomerate. They are closely folded together and strike N. 35° W. No fossils were found in any of these beds, nor any definite evidence of their age obtained beyond the fact that the shales have a close lithological resemblance, both in appearance and composition, with those on Dease River, from which Dr. Dawson obtained graptolites of Utica-Trenton age. Rocks in Little Cañon.

Below the Little Cañon the river widens out to over half a mile, and the steep, rocky banks are replaced by easier slopes of gravel and sand. These continue for three miles, after which shales and sandstones reappear in the bank, and their confining influence is immediately seen in the rapid contraction of the stream and the formation of a second narrows. These sudden dilatations and contractions constitute one of the most characteristic features of the Liard, and are an indication of the heterogeneity of the formations through which it cuts. Through the defile just mentioned the stream rushes with great velocity, but with an even current until near its foot, where it is forced between two points of rock scarcely a hundred feet apart, which project into the stream from either bank and determine the formation of two rapidly gyrating and dangerous looking whirlpools. These can be avoided, if necessary, by making a portage of a few feet across one of the points. In ordinary stages of the water, however, they can be run without difficulty. Character of river below Little Cañon.

At this point the shales, sandstones and conglomerates which have been exposed at intervals all the way from the mouth of the Dease, are replaced by shaly limestone and soon afterwards by more massive varieties of the same rock. Shales, sandstones, etc., replaced by limestones.

Beyond the narrows, the river at once resumes its ordinary dimensions, and rushing rapidly around a short bend enters one of the most picturesque portions of the valley of the Liard. The river here averages about three hundred yards in width, and glides along with a strong even current of about five miles an hour. It is narrowly confined by sloping banks, which follow closely all the bendings of the stream, without any intervening flats, or, except at low water, any disfiguring bars and beaches. The valley is everywhere densely wooded with evergreens, aspens, birch and alder, the changing greens of which are agreeably relieved at intervals by grey limestone cliffs, which rise steeply from the water's edge, and ruffle the surface of the otherwise glassy stream. Picturesque valley.

Eight miles below the entrance to this portion of the river is situated Porcupine Bar, once the scene of active mining operations, but now worked out and abandoned. Opposite to it is a range of low hills, at the base of which I camped somewhat early on the afternoon of the 28th, for the purpose of ascending them and so obtaining a view of the surrounding country. Porcupine Bar.

These hills extend in an irregular manner for some miles along the left bank of the river, but appear to have no definite strike. They have the rounded outlines, which characterize all glaciated districts, but no striae were anywhere observed. They are composed of limestone and have an altitude of 1,500 feet above the river, or one thousand feet above the general plateau level. From their base stretches in all directions, an irregular rolling plateau, broken here and there by ranges of low hills and dotted with innumerable small lakes and marshes. To the south the horizon is broken by the serrated crests and jagged summits of the Cassiar range, one prominent peak bearing S 20° W. In a direction N. 25° W., at a distance of twelve to fifteen miles are some low hills still covered with streaks of snow, while a range of partially snow-clad hills were also seen at S. 26° E. The plateau is everywhere densely wooded, the principal trees observed being the white spruce, the black pine, the larch, the rough and smooth barked poplars, the birch, and species of alder and willow. Of these the spruce, which obtains here a diameter of fifteen to twenty inches, is by far the most abundant and valuable.

Appearance of country.

Character of limestone.

The limestone of which the hills are formed is usually greyish in colour and rather compact, but passes in many places into a whitish highly crystalline variety without distinct bedding. It has a general strike of N. 15° W. It is destitute of determinable fossils, but holds fragments of crinoid stems, and traces of brachiopods and trilobites.

River below Porcupine Bar.

From Porcupine Bar the river runs S.S.E. for some miles, and then bending more to the south, preserves a general southerly direction for ten or twelve miles, when it is closed in by a nameless cañon. In this reach it presents much the same features as those noted above, but its valley is somewhat wider, and is now bottomed by long narrow well wooded flats. Also the bed of the river becomes considerably enlarged in places and divides around a number of alluvial islands. The banks of the valley have an average height of five hundred feet and show frequent exposures of whitish coarsely crystalline, greyish, fine grained limestone, striking a few degrees west of north and dipping at all angles. Four miles and a half below Porcupine Bar, is Bed-rock Bar, now like the former deserted. Eight miles farther down is another adandoned miner's camp now represented by a single log hut. Passing this, the river bends more to the north and divides around a rocky island, on either side of which is a short riffle, then runs with an even current of about four miles an hour to the cañon mentioned above.

This cañon is scarcely a hundred yards in length, and is bounded by precipitous limestone cliffs about one hundred and fifty feet apart. It presents no obstacle to navigation. Immediately below the cañon the river dilates for some distance into a large island-filled basin, beyond which it contracts again to its ordinary width of three or four hundred yards, and runs with a swift even current in an easterly direction for five miles, when its course is interrupted by the Cranberry Rapids.

Character of limestone.

The limestones seen along this part of the river are often coarsely crystalline and cut up by white calcspar veins. Other varieties show wavy lines projecting from weathered surfaces due to alternating magnesian and calcareous layers, and closely resemble in this respect the limestones of the Castle Mountain group as developed along the Bow River Pass. In some places the limestone becomes shaly and impure, and is altered into an imperfectly developed schist.

Limestones replaced by clastic rocks.

Two miles above Cranberry Rapids the limestones are replaced by shales, sandstones and conglomerates, and a change is immediately noticeable in the character of the stream. The declivity is greatly increased and for the next fifty miles rapids are of constant occurrence.

Rapids at Cranberry Portage.

The rough water at Cranberry Portage has a total length of a mile and a half, but there is a reach of comparatively undisturbed water about half way down. The upper part of the rapid is exceedingly wild, as the bed of the river is filled with huge angular masses of rocks against which the current breaks with frightful violence. No part of the channel is clear and a glance at the forbidding array of foaming breakers and whirling eddies, showed at once the utter hopelessness of any attempt to run it with our small heavily laden boat. We passed it by portaging our outfit about half a mile along the right bank, and then dropping the empty boat with a rope, and at the worst places dragging it across points of rock. The lower part of the rapid is not so rough, and we managed to work our boat through without unloading.

Rocks at Cranberry Portage.

The rocks at the Cranberry Rapids consist of shales, sandstones and conglomerates closely resembling those observed at the Little Cañon and evidently of the same age. The shales are dark, finely laminated, and occasionally show well marked cleavage lines. They are interstratified in places with the sandstones,and often enclose flattened ironstone concretions, a number of which were broken, in a resultless search for fossils. The sandstones, lighter colored than the shales, are hard and often pass into quartzites. The conglomerates are very fine grained and consist principally of white well rounded quartz pebbles imbedded in a siliceous matrix. The shales and accompanying beds are broken through and altered to some extent by a series of dykes. They have a general easterly strike and lie at all angles from horizontal to vertical. On the opposite side of the river an exposure of soft shales and conglomerates resting unconformably on the beds just described, and evidently of Tertiary age, was observed, but was not closely examined, owing to the impossibility of getting across to it.

Below the rapids the river hurries on with a smoother surface, but with scarcely diminished velocity, its strength being shown by the way it foams around the occasional rocky obstructions in its course. It is bordered for some distance by large eddies between which and the downward current are long lines of dangerous looking whirlpools. Farther down is a long but easily navigable riffle, beyond which, with the exception of an occasional rock, the channel remains comparatively clear until the stream variously known as Black, Mud, or Turnagain River is reached.

Mud River.

This stream, although one of the principal affluents of the Liard, is at present almost unknown. It originates near the Findlay branch of the Peace River and joins the Liard after a course of about two hundred and fifty miles. At its mouth it is over one hundred and twenty yards wide. Eighty miles above its mouth is situated a small trading post, built some years ago by Mr. Rufus Sylvester, but now in the possession of the Hudson's Bay Co. This post is connected with the central post at the mouth of McDame Creek on Dease River by a pack trail about seventy miles long.

Mountain Portage Rapids

From Mud River the Liard bends more to the north, and still running with great rapidity and breaking into occasional riffles, reaches, in a couple of miles, the Mountain Portage Rapids, one of the worst rapids met with on the trip. The river here falls over a band of shales irregularly hardened by a system of dykes and worn into a succession of ridges and hollows, and the roughened surface thus produced throws the hurrying waters into an indescribable turmoil. We landed at the head of the rapids on the right bank and were forced to spend a day in making a difficult portage of about half a mile with both boat and outfit. I afterwards learned from W. Lépine, an old Hudson Bay voyageur, that we might have avoided this portage if we had landed on the left hand side, as what we supposed was the mainland was really an island, behind which a small channel existed which can be run with comparative safety.

Rabbit River.

Half a mile below Mountain Portage, Rabbit River comes in from the south. This stream is about two hundred feet wide and brings in a large volume of clear water. At its mouth is a large auriferous bar, which has evidently been worked by placer miners to a considerable extent. I was, however, unable to obtain any information in regard to it. Below Rabbit River the channel is clear for a couple of miles and then dancing white-caps on ahead indicate the presence of another rapid. In the next mile the river alternately narrows in and expands three times, and falls over short but strong riffles at each constriction, all of which can easily be avoided, if necessary, by making portages a few yards in length. The behaviour of the water in the dilated basins between the narrows is somewhat peculiar, as it seems, viewed from the bank, to be running in all directions and to be split into a network of cross currents. At the lower narrows three ugly looking whirlpools are formed by the rapidly contracting stream endeavouring to crowd its way through its narrowed channel, while the water sucked down by the whirlpools is thrown up a little farther down in huge boils and with a sound resembling the rumbling of distant thunder. The whirlpools occur near the left side and can be passed in safety by keeping to the right bank. Whirlpools.

From Cranberry Portage to Whirlpool Cañon, the point now reached in the description of the river, numerous exposures of the same shale sandstone and conglomerate series previously described are everywhere present, and to the heterogeneity of this formation are mostly due the numerous rapids which occur on this portion of the river, the harder bands narrowing in and damming back the stream, while the softer and more easily eroded parts have acquired a more uniform slope. The shales and associated beds are everywhere greatly disturbed and usually dip at high angles. They have a general southeasterly strike. At Whirlpool Cañon the shales disappear and are replaced by a shaly variety of limestone. Rocks between Cranberry Portage and Whirlpool Cañon. Shales replaced by limestone.

From Whirlpool Cañon the river flows swiftly around a sharp bend, at the extremity of which it receives Coal River, and after a clear course of less than four miles, plunges over the rapids at Portage Brûlé.

Coal River is a small, clear stream about a hundred feet wide, and is interesting on account of the quantity of lignite which it brings down. At the time of our visit a bar at its mouth was thickly strewn with large angular and apparently little-travelled blocks of this mineral. The fresh appearance of the lignite induced me to spend part of a day, while the men were packing across Portage Brûlé, in exploring for the bed from which it originated, but a walk of several miles up the stream failed to reveal its presence *in situ*, although an abundance of drift fragments was everywhere noticed. The lignite is of inferior quality. It is soft and shows a well-marked woody structure. The banks of Coal River, as far as my examination extended, are low, and consist of uncemented sands, clays and gravel, like those holding the lignite beds above the Little Cañon. This formation is of irregular thickness, but of wide distribution, as it was observed filling depressions in the older rocks all the way from the mouth of the Dease to the passage of the Rockies. Coal River. Lignite at mouth of Coal River.

Portage Brûlé is nearly two miles long, and leads across a nearly level, well wooded flat, which, at the upper end of the portage, is only elevated a few feet above the surface of the river, but at the lower end Portage Brûlé.

is terminated by a sharp descent of over two hundred feet. A good track was cut across this portage when mining was being prosecuted on the Liard, and a windlass built at the east end for the purpose of hoisting boats up the steep bank, both of which are still in good condition. It was at the lower end of this portage, in the year 1836, that a party of Hudson Bay voyageurs, bound on a trading expedition to the Stikine, after carrying their packs up the hill, were seized with a panic caused by the supposed approach of a band of hostile Indians, and, abandoning their outfit, fled for safety down the river. In the succeeding year Mr. Robert Campbell found the goods in the same position in which they had been left.

Rapids at Portage Brûlé.

The rapids at Portage Brûlé do not look so formidable as those at the Mountain Portage, and if I had examined them before making the portage I would have been strongly tempted to try and run them with the empty boat They are about two miles long, and are caused by numerous limestone blocks and small islands obstructing the channel. At the lower end the river is narrowly confined by high vertical cliffs.

Rocks between Whirlpool Cañon and Portage Brûlé.

The rocks observed along the river from Whirlpool Cañon to the lower end of Portage Brûlé consist altogether of different varieties of limestone. This occurs in some places in massive beds, ranging in texture from compact to moderately crystalline. In other places it becomes very impure and shaly, and often passes into imperfectly developed calc-schists. No fossils were obtained from it, but it has a close lithological resemblance to the limestone, occuring above Cranberry Rapids, and to the Castle Mountains group of the Bow River section, and is probably of Cambro-Silurian age.

River below Portage Brûlé.

After freeing ourselves from the rapids at Portage Brûlé, no farther obstacles to navigation were encountered until the Devil's Portage was reached. The river is wide and filled with low islands and bars, some of which are auriferous. McCullough's Bar, on which gold in paying quantities was first discovered on the Liard, occurs in this vicinity, but I was unable to identify it. The river valley is now lined with rows of terraces rising up to a height of several hundred feet, and clothed in unwooded portions by as luxuriant a growth of grasses and vetches as I have ever seen in any part of the country. Behind the terraces is a gently undulating region, occasionally swelling into elevations of from 1,200 to 1,500 feet in height, and everywhere densely forested, chiefly with white spruce. To the eastward the elevations increase in height and frequency until they merge into the range of the Rocky Mountains, the dim outline of which can now be seen along the eastern horizon.

Terraces along river.

Agricultural prospects.

This part of the country judging from the luxuriance of the vegetation and the character of the soil, seems well adapted for agricultural purposes, but the complete absence of climatic statistics render any positive statements in this connection premature. On the present trip at the Little Cañon, large snow banks were observed in sheltered places along the banks of the river as late as the 28th of June. It must be borne in mind, however, that the spring of 1887 in this part of the country was an exceptionaly late one.

Ten miles below Portage Brûlé, Smith River comes in from the north. This is a small stream about one hundred feet wide, and appears to orignate in a north-westerly spur from the Rocky Mountains, visible in the distance. At its mouth was situated Fort Halkett, a Hudson's Bay trading post which has been abandoned since 1865. I found no traces of the post. **Fort Halkett.**

Near the mouth of Smith River, a number of exposures of dark shales were observed. These shales are much softer than those seen farther up the river, and are probably of Mezozoic age. They were traced down the river for several miles, and are then replaced by limestones. No fossils were found in them. **Shales at mouth of Smith River.**

From Fort Halkett the mountains appear quite close and the river runs swiftly in an E. S. E. direction straight towards a narrow gap which now appears in their ranks. Before entering this we pass, on the right-hand side, the mouth of Rivière des Vents. This river comes from a large lake a few miles south of Fort Halkett, from which the fish supply of the post was obtained. It cuts off from the main range a steep sided, massive looking mountain, which I named Mt. Reid in honour of Mr. Reid, the Hudson's Bay officer at present in charge of Fort Providence and an old traveller in these regions. From Rivière des Vents we approached the gap cautiously, on the lookout for the Devil's portage and rapids, which were reported to exist in its neighbourhood, but, much to our surprise, passed through without hindrance, and in a few minutes found ourselves among the rolling foothills on the eastern side of the range. The mountains here are narrowed to a single range, and even this. a few miles north of the river, is so reduced in height that it can scarcely be distinguished from the ordinary ridges of the district. To the south the range is much wider and the river seems to skirt the northern extremity of what may be considered the main division of the Rocky Mountain system. **River below Fort Halkett.**

The Rocky Mountains, regarded as forming the eastern mountain system of the Cordillera, are consequently interrupted in this part of their length. The range of which the northern extremity is here found has a length of over 1,000 miles. It extends uninterruptedly southward to the International Boundary, and is still further continued into Montana to about lat. 46°. The width of this persistent **Rocky Mountains.**

mountain range probably averages throughout about fifty miles; and its main physical and geological features are almost identical in all parts of its length. Where the particular line of crumpling and upheaval of the earth's crust to which this range is due dies away at the Liard, another similar line begins, nearly in the same latitude, but about eighty miles farther to the east. The mountain range produced by thie new line of disturbance extends northward nearly parallel to the general course of the Mackenzie to the Arctic Ocean.

South of the Liard the bare limestone ridges are ranged in parallel lines, and are surmounted by sharp zigzag knife-edges, or jagged serrated crests. The ridges have a general strike of N. 30° W. The spur of the mountains which crosses the river consists of a greyish and moderately compact limestone. The beds are at first almost horizontal, but are soon thrown into almost vertical attitudes, and have the appearance of a sharp anticlinal. Several of the exposures were examined unsuccessfully for fossils, and the only specimens collected here consist of some fragments of corals which were found loose at the mouth of Rivière des Vents, and resemble those occurring in the Intermediate limestone of the Bow River section. The limestones are exposed along the river for six miles, and are then covered with dark shales similar to those from which Triassic fossils were afterwards obtained. It is noteworthy that in the Liard section dark shales of Mesozoic age are found resting on both flanks of the mountains, and are not confined to the eastern slope, as is the case farther south.

Rocks in mountains.

Limestones replaced by shales.

Rounded hills east of mountains.

East of the passage of the Rockies the mountains gradually recede from the river towards the south, and are replaced by high rounded and well wooded hills and ridges built of dark shales, numerous exposures of which occur all along the banks of the river. The shales undulate at all angles, and do not appear to have any predominating dip in towards the mountains such as characterizes them in other localities. They are interstratified in places with beds of quartzite, and are, so far as I could learn, completely unfossiliferous.

River smooth.

Since leaving Portage Brûlé the river has remained wonderfully smooth, and we had the pleasure of passing one night away from the roar of a rapid, and without the usual prospect of having the next morning either to run a rapid or make a portage. The river has here an average width of four hundred yards, and a steady current of about four miles and a half an hour. It is bordered in places by long gravel and sand beaches, and encloses occasionally wooded islands. Ten miles east of the gap, Trout River joins the Liard from the south. This is a

Trout River.

swift, clear mountain stream about a hundred and fifty feet wide, which seems to cut back into and drain the central ranges. Below Trout River the Liard bends abruptly to the north for some distance, and then, turning to the east continues on with an ever increasing current between banks which gradually become steeper and higher, until they develop into a wide cañon. We had been on the lookout for the Devil's Rapids ever since leaving the Rivière des Vents, and as the threatening appearance of river and valley indicated that we were approaching them at last, we dropped down cautiously along the right bank, watching carefully all the time for signs of the old portage. We failed to discover any, but landed at what seemed to be the last break in the almost vertical cliffs, with which the river was now bordered, and just at the head of a long easy riffle. Looking down the river ominous streaks of white could be seen in a couple of places, stretching from bank to bank, while the familiar roar of clashing water was plainly audible. On landing we found, after a short search, traces of the old portage track, and the next few days were spent in carrying our outfit across.

Threatening appearance of river.

The river at this point makes a great bend to the north-east, all around which is a succession of rapids and cañons. At the elbow of the bend a large fall is reported. At the lower end of the bend, the river is reduced to a mere thread, as it is scarcely a hundred and fifty feet wide, and as fully a third of this is occupied by shore eddies, its bed must be eroded to an enormous depth. Immediately below the contracted part is a large eddy, and the river expands at once to over half a mile in width.

Fall reported.

The Devil's Portage to Hell Gate.

The portage across the bend proved, greatly to our satisfaction, to be less than four miles in length instead of twelve, as we had been informed and expected. It is however very difficult, as it passes over a ridge fully a thousand feet high, on both sides of which the slopes are exceedingly steep. The old portage track was easily followed among the heavy timber for some distance after leaving the upper end, but going east it became gradually overgrown with brushwood, and at last disappeared and we were obliged to cut out a new one for ourselves. This track was cleared out by Mssrs McCullough and Thibert, in 1871 for the purpose of hauling their boat across, and it speaks somewhat favorably for the activity of forest growth in this region, that it should now be covered with shrubs and small trees several inches in diameter.

Devil's Portage.

Abundance of moose.

In crossing the portage we started several moose, and it may be mentioned here that the country we have been passing through and as far on as Hell Gate, is probably the best moose country in North America. Everywhere we landed, fresh tracks in abundance were observed. We killed one at the mouth of Rivière des Vents, and another farther down near Crow River, and could have shot a number of others if we had so desired. At the "Rapids of the Drowned" we scared three into the river, but these unfortunately attempted to swim the rapids and were drowned. They were found afterwards some distance below lodged in a drift pile. Their abundance is due to the fact that the country is practically uninhabited. After leaving the Little Cañon we saw no Indians nor any traces of them, such as old camps, abandoned canoes, old cuttings, &c., anywhere along the river. The country in question forms a kind of neutral ground between the Indians trading east and west of the mountains, and is also difficult of access on account of the danger in navigating the river. The absence of Indians and the consequent immunity from hunting enjoyed by the moose, since the abandonment of old Fort Halkett, has resulted in a great natural increase in their numbers. Besides, as they are persistently hunted in the adjoining country on either side of the mountains, by the bands of Indians trading at Fort Liard, and at the mouth of Dease river respectively, many of them must escape into this district as into "a city of refuge." The beaver are also abundant, and like the moose, appear to have thriven in the absence of their hereditary enemies. Grizzly bears were reported to be especially common on the Devil's Portage, but we did not meet with any.

Rig up canvas boat.

We spent altogether six days on the Devil's Portage crossing our outfit and framing a boat. We found that it would be impossible to cut out a track and haul our heavy wooden boat up the steep hills on the portage without wasting more time than we could well spare, and decided, somewhat reluctantly, to abandon it. To meet such an emergency I had provided myself, before leaving Ottawa, with a roll of stout canvas sewn up in the shape of a boat, and this we at once proceeded to put into shape. It was stretched on a stout plank hewn out of a small pine tree. Spruce poles, to which the canvas was firmly sewn, were used as gunwales, and willow withes for ribs, while slips to lay between the ribs and the canvas were easily cut. We painted the canvas with half a gallon of oil, which had been brought for the purpose, but this did not prevent it from leaking badly, and we were obliged to give it a second coat, made up of everything oleaginous which we still possessed. This mixture consisted of sperm candles, gun oil and bacon grease, stirred up with spruce gum, and proved effective in keeping out the water. Our new boat was not well adapted for running heavy rapids, especially where sudden turns had to be made to avoid rocks, but was quite serviceable in ordinary water and on easy riffles, and was, besides, light and easily portaged.

Below the Devil's Portage for thirty or forty miles the river flows through what is called the Geand Cañon, but is more correctly a succession of short cañons, with expanded basins between filled with eddying currents. In low water the whole of this reach can be easily run in almost any kind of a boat, but in the season of high floods such as it was when we passed through, the water forcing its way through the throat-like contractions is thrown into a commotion too violent for any but the staunchest boats to stand. The cañon is reported to have been run in two hours, which would be at the rate of about eighteen miles an hour, an astonishing velocity, but the time was probably underestimated. It took us several days to get through, but we were obliged to make a number of short portages and one of over three miles in length. Grand Cañon.

We launched our canvas boat and commenced the descent of the Grand Cañon on the 16th July. I had previously explored the river for some distance and knew that we had nothing serious to encounter for several miles. The river is at first wide and encloses a number of islands. As we proceed the bordering banks close in, become higher and steeper, while the current runs with increasing impetuosity until, rounding a bend, it breaks into foam against a barrier of rocks which intercepts its course. We passed this by a small portage and then continued our headlong course down the river, but were soon stopped again by a succession of bad riffles. In the next couple of miles we ran through a number of wild places, the canvas boat riding the waves gallantly, but were forced to make one or two short portages and then entered a deep, gloomy defile, walled in by black vertical cliffs. The river here is, however, less boisterous and flows with a steadier current. Part way down the cañon a couple of small islets with steep, rocky banks divide the stream into several channels. These were soon left behind, and then hurrying through a second narrow pass we came out on a wider portion of the river. In the next twelve miles the river is generally wide and shallow and filled with gravel bars. The current is still swift, running at the rate of seven miles an hour, but the navigation is easy. Descent of Grand Cañon.

At the end of this reach it bends to the north, and striking violently against some sombre cliffs which line the left hand bank, is deflected again to the east with the formation of what are known as the "Rapids of the Drowned." Here, one of the most dangerous spots on the river Rapids of the Drowned.

is formed by the water plunging with its whole force, over a ledge of rock which curves outwards and downwards from the left hand bank, into a boiling *chaudière* behind.

Name of rapid. The name of the rapid originated from the drowning at this point of a Hudson Bay clerk named Brown, and a boat load of voyageurs. As the story goes, Brown, disregarding the advice of his steersman, insisted on running close to the northern bank, and the canoe plunging into the hole mentioned above was drawn under.

We passed the rapid by letting our boat down cautiously with a rope to the *chaudière*, and then making a short portage. With a proper boat, however, no difficulty would be experienced in crossing the river above the rapid, and running down close to the right bank.

Below the "Rapid of the Drowned" is a long riffle, down which we ran at an exciting pace, and then the river is closed in by a hard sandstone bank, through a narrow gap in which it forces with difficulty a stormy passage. An examination of this convinced me of the impossibility of running it at the present high stage of the water with a boat such as we possessed, and also disclosed the unwelcome fact that a number of similar obstructions existed ahead. In the next four miles the river is closely cañoned in, five times, and falls over a number of riffles. Only some of these are dangerous, but we were forced to portage around the whole reach, owing to the steepness of the banks and the impossibility of getting down to the bottom of the valley, except at a few points. Three miles of rapid current followed, and then we reached Hell Gate, so named because it is the entrance from below, to the wild portion of the river we have been descending. At this point there is an abandoned channel on the left hand side, which is navigable in high water, and affords an easy passage through.

Hell Gate.

Rocks between Devil's Portage and Hell Gate. From the Devil's Portage to Hell Gate the rocks noticed on the banks of the river consist mainly of shales, with bands of sandstone at intervals, and occasionally some limestone. Exposures of the latter occur at the east end of the Devil's Portage, where they are brought up by an anticlinal from below the shales. They are here greyish in colour, are moderately crystalline, and hold fragments of crinoids and other fossils, and evidently belong to the upper part of the Palæozoic series of the mountains. This series was not observed farther east. The shales are usually rather hard and weather into high bold cliffs, which often border the river on either side for miles without a break. They are dark in colour, and as a rule are rather coarsely laminated, but vary greatly in this respect and also in their texture. The shales undulate at all angles, and are continuously exposed all the way down the cañon. They are interstratified with a hard greyish and yellowish sandstone, and a dark compact limestone. The sandstone occurs in bands, which form constrictions where they cross the river, and in the adjoining country rise into high hills and ridges. The limestones associated with the shales are usually impure and occur as a rule in thin shaly beds, but heavily bedded varieties were also observed at Hell Gate and at other places.

No fossils were obtained in descending the cañon until the "Rapids of the Drowned" were reached, where the following species, since described or determined by Mr. Whiteaves and referred by him to the Trias, were obtained.* Triassic fossils.

Spiriferina borealis, Whiteaves.
Terebratula Liardensis, "
Monotis ovalis, "
Halobia (Daonella) Lommelli, Wissman.
Halobia occidentalis, Whiteaves.
Nautilus Liardensis, "
Popanoceras McConnelli, "
Trachyceras Canadense, "

Some miles farther down at the lower end of the last cañon before coming to Hell Gate, a second fossil locality was discovered which yielded the following species.

Terebratula Liardensis, Whiteaves.
Trigonodus ? productus, "
Margarita Triassica, "
Popanoceras McConnelli, "

At Hell Gate three miles below the last, specimens were obtained of—

Trachyceras Canadense, Whiteaves.
Terebratula Liardensis, "

The localities from which Triassic fossils were obtained, extend along the river for ten miles, but it is highly probable that the rocks of this age have a much wider distribution than this and include the greater part of the barren shales above the "Rapids of the Drowned," as well as those below Hell Gate. It will require, however, more time than could be spared on a rapid reconnaisance, to separate precisely the shales which cap the Palæozoic from those of the Trias,

* Contributions to Canadian Palæontology, Vol. I, Part II, pages 127-149.

and the latter from the Cretaceous. The three terranes are closely allied lithologically and will have to be defined largely from fossil evidence.

Hell Gate to Fort Liard.

River below Hell Gate.

Escaping from Hell Gate cañon, the river dilates as usual and is bordered by large eddies. Below these, it runs swiftly around a large island, and then enters a cañon-like reach of the river about a mile long. The stream here is narrowed down to about a hundred and fifty yards in width, and flows easily between vertical banks three hundred feet high. This cañon proved to be the last on the river, and from this point on the river has an uninterrupted flow, and presents no obstacles to navigation until near its mouth. Five miles below the cañon the undulations in the shales and associated sandstones and limestones cease, and at the same time the ridgy and hilly foot-hill district we have been passing through is replaced by a region of high irregular plateaus.

Foot-hills.

The foot-hills along the Liard have a width of 38 miles, and are characterized by a much greater irregularity in altitude than is usually the case. South of the Devil's Portage, Mount Prudence, a steep-sided, reddish looking mountain, rises abruptly from a surrounding of round topped hills to an estimated height of over 4,000 feet. Going east from Mount Prudence, lower elevations prevail until near the "Rapids of the Drowned" where the ridges again commence to increase in elevation, and in a few miles culminate in peaks over 4,000 feet high. Still going east they gradually diminish in importance and at last die away and are replaced by flat-topped plateaus. This region with the exception of the higher peaks, is everywhere densely forested, chiefly with the white spruce, the banksian pine and the aspen.

River east of foot-hills.

After leaving the foot-hill country the river runs in a general direction of N. 30° E. for thirty miles. In this reach it has a steady current of about four miles and a half an hour, and varies in width from five hundred yards to over a mile. In the wider portions the river is usually divided into several channels by islands and bars. The valley is narrow and trough-like, with steep sides rising up in places to a height of fully a thousand feet. The bottoms are usually small, and are here chiefly wooded by members of the poplar family. Some important tributaries are received by the Liard in this portion of its course, among which is Crow River, which joins it from the north after entering the plateau country, and Toad River, which comes in from the south through a deep gloomy valley four miles farther down. Two miles below Toad River, on the opposite side, is situated Toad

River post, which was abandoned when the post on the Nelson was established. The buildings are still standing.

Geology of plateau belt.

The geology of the plateau belt is exceedingly simple. The banks of the valley are usually scarped, and show everywhere extensive sections of flat-lying shales. These shales are dark in colour, are soft and finely laminated, and are interstratified with small beds of sandstone and ironstone, and layers of ironstone nodules. They are of Cretaceous age, but their mode of junction with the Triassic shales of the foothills was not clearly ascertained. Some fossils were collected from this formation about four miles below Toad River, among which are specimens of *Placenticeras Perezianum*, a species of *Camptonectes*, and fragments of an *Inoceramus*. Towards the eastern part of the plateau belt the shales along the river are overlain by massive beds of soft sandstone and conglomerate, which form a steep escarpment running parallel with the river.

Enter lower country.

At the end of the northerly reach just described, the river, here over a mile wide and filled with islands, bends suddenly at right angles to its former course, and after passing through a narrow gap, enters a much lower country. The steep scarped banks of the plateau district disappear, and are replaced by gently inclined hillsides covered with forest, while the river spreads out and flows for some miles in a multitude of channels through a bewildering maze of islands.

The eastern edge of the plateau district faces eastward with a steep slope, and has a height of over a thousand feet. It runs nearly due north and south and forms an important feature in the general topography of the country. Where it crosses the river it shows exposures of soft conglomerates dipping lightly in an easterly direction. East of this escarpment Beaver River joins the Liard from the north. This is reported to be a fair sized stream and to be navigable for canoes for a long distance. It empties into the Liard behind a group of islands and we passed it without seeing it. Near its mouth we saw Indians for the first time since leaving the mouth of the Dease. They belonged to Ft. Liard, and were on their way up the Beaver to hunt. We endeavored to buy some meat from them, but found that they were totally unacquainted with the use of money, and as we were not supplied with trading goods, or, in fact, with anything except what we wore, it was found impossible to strike a bargain.

Beaver River.

Meet Indians for first time.

East of the Beaver the Liard runs in a south-easterly direction for a few miles and makes a couple of sharp bends before joining the Nelson. In the first of these bends we met a crew of Hudson Bay voyageurs in charge of W. Lépine, who were endeavouring to make their way up the river to the mouth of the Dease. Lépine had been employed on

Meet crew of H. B. voyageurs.

the river as a guide, in the old days when goods were taken by this route to the Yukon, and was well acquainted with it. He brought news of a scarcity of provisions in the Mackenzie River District, and this decided me to send my two men back up the river with him, and to depend on the services of natives for canoemen in the future. Lépine had become disheartened by the continued high water and the difficulties of upstream navigation, and when we met him talked of returning, but we induced him to persevere. A small spruce bark canoe which an Indian and his wife built in an afternoon, in addition to the large birch canoe which he already possessed, furnished sufficient accommodation for his increased party, and on the 28th July, after a day's delay, he proceeded up the river. I afterwards learned that with the exception of one upset, caused by the unskilfulness of Trépanier, one of my men, the journey was successfully accomplished and Dease River reached in safety.

Send men back up river.

After separating from Lépine I continued down the river to Fort Liard in the canvas boat, at first in company with an Indian, but for the greater part of the distance entirely alone. After starting we rounded a large bend and then continued in a northerly direction to the mouth of the Nelson, or east branch of the Liard.

Nelson River.

Nothing has been published concerning the Nelson, but it is reported to be a somewhat sluggish river of about one hundred and fifty or two hundred yards in width. A hundred miles above its mouth is situated Ft. Nelson, a Hudson Bay trading post. Above the Fort the river divides into two branches, one of which, named Buffalo River, turns west to the mountains, while the other continues on and interlocks with tributaries of Hay River.

*In 1872-73 a party of miners crossed from Peace River to the Liard by way of the Nelson on a prospecting trip. They descended Peace River to Half-Way River, so called because it is half way between Rocky Mountain Portage and Fort St. John, and ascended the latter partly in canoes and partly on the ice for a hundred miles. They then made a portage of twenty-five miles, and reached the Nelson, down which they sledded for sixty miles, and then built boats and came the rest of the way by water. They only mention one portage of half a mile, but describe the river as flowing for a long distance above Fort Nelson, between lofty banks of sandstone and shale. *Colours* of gold were obtained on the Liard at the mouth of the Nelson.

Fort Nelson.

At Fort Nelson some farming is annually done, and potatoes and

* Extracted from letter by Fred. W. Harte.

other vegetables are grown without difficulty. The surrounding country is everywhere well forested, and is reported to produce a better grade of timber than any other part of the Mackenzie District.

Below the Nelson the Liard has a general northerly direction for thirty miles, and then, bending more to the east, follows a N.E. course as far as Fort Liard, fifteen miles farther down, where I arrived on July 29th. In this reach it has undulating shore lines, but is generally wide and filled with sandbars and wooded islands. It is bordered in many places with wide alluvial flats, covered with tall, straight cottonwood, and large spruce, and canoe birch. Its valley is wide and shallow and lined with gently sloping, spruce-clad banks. On some of the flats the Indians have built houses, and fenced in small plots for farming purposes, for which the greater part of this section of the district seems well adapted. We passed one small Indian farm about thirteen miles below the mouth of the Nelson, and another one at the mouth of Fishing Creek, a few miles above Fort Liard, while others were noticed in the lower part of the river.

Liard below the Nelson.

Indian farms.

The two principal tributaries of the Liard between the Nelson and Fort Liard are Rivière la Biche and Black River. The former enters it from the N.W., about twenty miles below the Nelson, and the latter from the S.E. at Fort Liard. Black River is the outlet of Lake Bis-tchô, a large lake situated about 120 miles S.S.W. of Fort Providence, and is reported to be navigable with difficulty throughout its entire course in high water. It will afford, with the Nelson and Hay rivers, a ready means of entering and exploring the vast block of unknown country lying between the Liard and Peace River, the Mackenzie and the Rocky Mountains.

Tributaries of Liard.

Since leaving the plateau district the rock exposures observed along the river have been few and small, and consist of dark shales, alternating with sandy shales and sandstone, all of Cretaceous age. Twelve miles below the Nelson an exposure of sandy shales and sandstone yielded, an *Ostrea* like *Ostrea subtrigonalis*, and at the mouth of Black River, near Fort Liard, in a hard, crumbly shale, specimens of an *Inoceramus* were obtained, while the surface of the shale in some places is covered with well marked impressions of gigantic palm leaves, probably belonging to the genus *Sabal*, which occurs in Vancouver Island in rocks of a similar age.

Rocks east of plateau district.

The quaternary deposits in this part of the river are represented by stratified sands and gravels, immediately overlying the shales, and by gneissic erratics, which are distributed everywhere over the surface of the country, and in some places, as at the mouth of Black River, are present in great profusion. The western limit of the eastern drift

Quaternary deposits.

Eastern drift. along the Liard, judging from the river section, appears to be nearly coincident with the eastern edge of the plateau district, although gnessic fragments were found in the mountains opposite Fort Liard at a somewhat higher elevation.

Rocky Mountains. Thirty miles below the Nelson, the Liard approaches and for the next seventy-five miles hugs closely, a chain of mountains which may be considered as a northern division of the Rocky Mountain system, and as the complement of the chain around the northern end of which the Liard passes west of the Devils Portage. The mountains are not fringed with a belt of foot-hills, such as usually accompany them in other places, but rise abruptly from an almost level plain, and attain at once their full height of about 4,000 feet. The folds and fracture to which the mountains are due also seem to die away with startling rapidity. The Liard for fifteen miles above Black River, cuts at a distance of two to five miles directly across the strike of the ranges, and yet the beds along its valley wherever seen are practically undisturbed. While waiting at Fort Liard I climbed one of the ranges to a height of 3,000 feet, but obtained little geological informatiom. The rocks were only exposed in a few places, and where seen consisted of westerly dipping unfossiliferous chert and cherty limestone. Gneissic fragments apparently belonging to the eastern drift were found up to a height of over 1,500 feet. I obtained, however, an extensive view from the summit, over the plains to the eastward. The country in that direction rises gradually from the river in easy undulations, and appears to culminate at a distance of twenty-five or thirty miles in a low plateau through which Black River has cut a wide gap. A dense forest relieved in places by gleaming lakes and light green marshes stretches to the horizon. To the north and north-west the eye is met by a succession of bare topped and nearly parallel limestone ridges striking about N. 20° W., and reaching elevations of from 4,000 to 5,000 feet.

Absence of foot-hills.

Climb range.

View from top of mountain.

Fort Liard is at present the only fort on the Liard below the mouth of the Dease, and is resorted to for trading purposes by about two hundred Indians, most of whom are known as Nahanni or Mountain Indians. Under this term are included a number of tribal divisions of the Tinneh family, but the names of these I was unable to obtain. They are reported to be fast dying off. The fort is situated on a fertile flat, part of which has been cultivated for years with unfailing success. Wheat and barley are grown here year after year, while potatoes, cabbages, turnips and other vegetables are raised without the least difficulty. At the time of my visit, 1st August, all the crops were well advanced and in good condition; the barley was just turning colour, and the potatoes were almost large enough to eat. There is no reason, either

Agricultural resources.

climatic or otherwise, why the whole country bordering the Liard, from Beaver River to near its mouth, should not, when needed, support an agricultural community.

Fort Liard to Fort Simpson.

I was delayed several days at Fort Liard before I could engage an Indian to accompany me down the river, but having at last succeeded, and also having exchanged my canvas boat for a bark canoe, I resumed my journey on the 5th August.

From Fort Liard the river has a north-easterly course for five miles, and then bending to the N.N.W., runs for over twenty miles nearly parallel to the easternmost range of the mountains, after which, while still preserving the same general direction, it makes a couple of great bends to the east before joining the Nahanni River at the foot of the Nahanni Butte. It has in this reach a general width of four to five hundred yards, and a current of about four miles and a half an hour. Islands and bars are of constant occurrence, and divide the river in many places into numerous channels. The valley depression for some distance below the fort is insignificant in size, and farther down disappears altogether, and the river undulates through a low, level plain, elevated only a few feet above its surface. As in the upper part of the river, the trees observed consisted of white spruce, aspen and cottonwood, with some banksian pine and canoe birch, and an undergrowth of willows and alders. River below Fort Liard.

Four miles below Fort Liard is a cut bank showing Quaternary sands and gravels, while three miles farther down the same sands are underlain by sandy shales and sandstone, evidently belonging to the Black River *Inocerami* bearing series of shales and sandstone. This was the last Cretaceous exposure noticed in descending the river. In the next nine miles no rocks were observed, and then a small section of limestone shows that we have passed over the junction between the Cretaceous, and the Devono-Carboniferous. The concealment of the beds along this part of the river made it impossible to decide from the Liard section alone whether the Triassic beds which underlie the Cretaceous on the western side of the Cretaceous basin, underlie them also on the eastern side, or are overlapped by them. It is probable, however, that the latter is the case. A second outcrop of limestone occurs eight miles below the one just noted. The beds are here inclined at a low angle, and are fossiliferous. From the specimens collected, Mr. Whiteaves has identified the following forms: A *Streptorhynchus* of the type of *S. umbraculum*; two ribbed species of *Spirifera*, one of which Rocks below Ft. Liard.

is very like *S. centronota*, Winchell; a smooth *Spirifera* of the *Martinia* section, probably identical with *S. setigera*, Hall, but closely related to *S. fimbriata*, Conrad; *Athyris subquadrata*, Hall; a new species of *Platyceras;* and *Proetus peroccidens*, Hall & Whitfield. The general *facies* of this fauna seems to indicate a horizon intermediate between the Devonian and Carboniferous, and probably equivalent to the Waverly group. Continuing down the river stratified sands were observed at the elbows of most of the bends, but the limestone is not again exposed until the Nahanni Butte is reached.

Nahanni Butte.

The Nahanni Butte, called also Mount McPherson, after the gentleman who first ascended it, stands at the confluence of the Nahanni River with the Liard, and has been carved out of the twisted end of the easternmost range of the Rockies. It is easily reached from the river, and on this account I determined to spend part of a day in climbing it. I took up a small aneroid barometer, which gave the height as 3965 feet. From the summit much the same character of country was displayed as that previously seen from the ridge opposite Fort Liard. To the S. and S.E. a wooded plain dotted with lakes and marshes, and, with the exception of three small buttes which formed a miniature mountain range almost at our feet, without conspicuous elevations, stretches as far as the eye can see, while in an opposite direction the prospect showed range after range of bare and rugged limestone peaks, among which the Nahanni River pursued a tortuous course until lost in the distance. The ranges here, while preserving a general parallelism, are more than usually irregular in this respect, and in some cases follow a very zigzag course. The general strike is nearly due north and the general dip of the beds westerly. A group of high peaks, which bore almost west, were observed to be partly covered with snow, and were estimated to rise to an elevation of between five and six thousand feet.

View from summit of Nahanni Butte.

Nahanni Butte section.

In the Nahanni Butte three rock series are clearly defined. In the lower part is a great thickness, probably a couple of thousand feet, of coarse grained magnesian limestones. These limestones are heavily bedded and often show the striped and cavernous appearance so characteristic of the more massive varieties of the Castle Mountain group, to which they undoubtedly belong. Copper stains were noted in a number of places, but no specimens indicating deposits of economic value were obtained. The limestones are overlain by several hundred feet of black, finely fissile shales, which occupy the same relative position as the Graptolitic shales of the Kicking Horse Pass, but are not fossiliferous. Above the shales and forming the top of the mountain comes a series of light yellowish and greyish magnesian and ordinary limestones. These limestones yielded some imperfect and scarcely determinable fossils, among which is a coral which shows the external characters of the Carboniferous genus *Stylaxis*, but the internal structure has not been preserved. A specimen of limestone from this series collected by Mr. McPherson and shown to Sir J. Richardson, is described by the latter as being similar to that which outcrops in the "Rock by the River's Side" on the Mackenzie. This would place it in the Devonian. A salt spring, with a basin fifteen feet in diameter, is reported by Sir J. Richardson on the authority of Mr. McPherson, as existing on the top of the mountain, but this I did not succeed in finding. A neighbouring mountain, however, showed a white patch on its steep side which is plainly due to the deposits of a mineral spring of some kind, and may be the one referred to. Salt Spring.

River below Nahanni Butte.

From the Nahanni Butte and River the Liard bends more to the east, and for the next sixty or seventy miles follows a general east north-easterly course. In the first section, extending to the "Grand Reach," a distance of twenty-five miles, it is wide and somewhat tortuous and encloses several large islands. The valley is insignificant in size, and where cut into at the bends of the river, shows small sections of stratified sands only. The general features of the country here and for some distance above the Nahanni River, seem to show that the river along this part of its course flows through a lake basin which formerly existed at the foot of the mountains, but is now silted up. It is worth noting that the Mackenzie passes for some distance through the same style of depressed alluvial country when approaching the northerly extension of the same range sixty miles below Ft. Simpson, and it is just possible that the depression follows the base of the chain throughout.

Long Reach.

The Long Reach is a beautiful stretch of gently flowing water of something over fifteen miles in length, and has an average width of fully a thousand yards. It is nearly straight, and a view down it discloses a long vista of smooth, glassy water which extends to the horizon, and is bordered by a succession of low wooded points which stretch out one behind the other until they fade away in the distance. Its valley is shallow and rises from the water's edge. At the lower end of this reach there is a decided rise in the general elevation of the country, which is at once made evident by the increased depth of the valley, while at the same time the river becomes narrower and its current swifter. The sand bars are replaced by shingle beaches, and for the first time the banks show sections of undoubted boulder clay. A few miles farther down, the river, now enclosed on both sides by low cut banks, makes a short bend to the east, at the elbow of which is an island with steep shale banks. In the next twenty-five miles the river

First appearance of boulder-clay.

is bordered by steep scarped banks from two to four hundred feet in height, and has the appearance of a wide cañon. The current in this reach is everywhere exceedingly swift, and for nearly ten miles breaks over a succession of strong riffles. These are easily run in a small boat by keeping close to the right bank, but will form rather a serious obstacle to the navigation of the river by steamboats. It is possible, however, that steamers may be taken up by lining, and once above them, the river affords easy navigation up the main branch as far as Hell Gate and up the Nelson, except at low water, as far as the forks.

Rock sections in valley.

The banks of the valley all along this reach are bare and afford continuous sections of shales, limestones and calcareous sandstones lying in a nearly horizontal position. The shales are greenish in colour, are soft and alternate above with the limestones, which form the top of the section. The limestones are greyish, or light yellowish in colour, are moderately crystalline, and are often impure and pass into a species of calcareous sandstone. In this condition they often show ripple marks, worm burrows, and other evidences of a littoral origin. Fossils were found in a number of places, but are usually in a poor state of preservation, and the only forms which Mr. Whiteaves has identified so far are *Atrypa reticularis*, and two species of *Orthis*.

Devonian uplift.

The Devonian uplift which crosses the Liard here extends far to the southward, and is doubtless the cause of the falls and heavy rapids which occur along the same line, on Trout River, Beaver River, Hay River, Buffalo River, and in fact on all the streams coming from the west and emptying into the Mackenzie or Great Slave Lake. It is possible, also, that the Vermilion Falls on Peace River may be due to the same cause. The Devonian in all this region has an upper division of hard limestone and a lower one of soft shales, an arrangement peculiarly favourable for the production of falls.

After passing the rapids the river continues to run with great velocity for some miles and then the current gradually moderates, and at the same time the valley loses its cañon character, and for some miles cut banks are only occasionally seen. Approaching the

Mouth of Liard.

Mackenzie the Liard turns away to the north, and gradually enlarging itself, pours its tribute into the former, through an embouchure of over a mile in width.

In the lower part of the river the Devonian shales and limestones disappear beneath a covering of boulder clay and other glacial deposits, sections of which appear all along. They crop out again on the right bank of the Mackenzie, opposite the mouth of the Liard, but at this point they are not fossiliferous.

Slave River.

I finished the traverse of the Liard and reached Fort Simpson on the 9th August. This post is situated on an island at the junction of the Liard and the Mackenzie, and is the headquarters of the Mackenzie district. I was fortunate enough to catch here, after a delay of a few days, the Hudson Bay Co.'s steamer Wrigley, which was on its way up from Peel River, and proceeded on it to Fort Smith, on Slave River. On the way up arrangements were made with Mr. Cummings and Mr. Reid, of the Hudson's Bay Co., subject to the approval of Mr. Camsell the chief factor of the district, who was absent, to winter with Mr. Reid at Fort Providence, and I was thus left at liberty to continue work as long as the season permitted. After arriving at Fort Smith I made a trip across the portage, and then embarking in a bark canoe with a couple of Indians, started down Slave River. This river has been used by the fur traders for over a century, and the Mackenzie for nearly as long, and as both have been visited by numerous celebrated travellers, to whose narratives I will be obliged to make frequent references, it will be necessary here, before proceeding with a description of the river, to give a brief account of the progress of exploration.

Fort Simpson.

Make arrangements to winter at Ft. Providence.

Start down Slave River.

The honour of discovering Great Slave Lake and River belongs to that persevering traveller, Samuel Hearne, who reached them on his return from his third and successful journey to the mouth of the Coppermine. Hearne arrived at Great Slave Lake on the 24th of December, 1771, and crossing it in a leisurely manner, reached Slave River on the 16th January, 1772. He continued up the River until the 27th, and then after having travelled upwards of forty miles, he "left it at that part where it begins to trend due south," and struck off to the eastward. Hearne calls the lake Athapuscow Lake, and describes it as being one hundred and twenty leagues long from east to west, and twenty wide from north to south. He was particularly pleased at the change from the "jumble of rocks and hills," which cover the country north of the lake, to the "fine level country in which there was not a hill to be seen or a stone to be found," which he met on the southern side. It is interesting to note that at the time of his visit this region swarmed with buffalo.

History of exploration.

Hearne's journey.

Hearne was followed, in 1789, by Sir Alexander Mackenzie, but the fur traders had before this extended their operations as far as Slave Lake, as Mackenzie states that Messrs. Grant and Leroux had erected houses at the mouth of Slave River in 1785.* Mackenzie left Fort Chipewyan on June 3rd, and reached Slave Lake on the 9th, but was

Mackenzie's voyage.

* Page 8 Mackenzie's Voyage through North America.

delayed on the lake by ice and did not succeed in entering the mouth of the river into which the lake emptied until the 29th. He then followed the river, since called after himself, until it debouched into the polar sea. The object of Mackenzie's voyage was to further the interests of the fur trade by discovering a passage to the Pacific, an object which he afterwards attained by crossing the mountains by the Peace River Pass.

Franklin's first voyage.

In 1820 Captain, afterwards Sir John Franklin, descended Slave River, and crossing Slave Lake to Fort Providence, which was then situated on a northern arm of the lake, started on his memorable voyage down the Coppermine to the shores of the Arctic Sea. He was accompanied by Dr. Richardson and Mr. Back, both of whom were subsequently knighted as rewards for their success in arctic exploration.

Franklin's second voyage.

In 1825 Franklin, again associated with Dr. Richardson and Lieutenant Back, descended Slave River and the Mackenzie to the sea, and in the succeeding summer explored all the Arctic coast between Return Reef and the mouth of the Coppermine.

Back's expedition.

In 1833 Captain Back was placed in charge of an expedition which was sent out to search for Sir John Ross. On this occasion he wintered at the east end of Great Slave Lake, and in 1834 explored Great Fish or Back's River from its source in Sussex Lake to the sea. Back was followed, in 1837, by Thomas Simpson, probably one of the most energetic of the many famous travellers who have worked along the confines of the frozen ocean.

Simpson's exploration.

Simpson (Dease and Simpson expedition) was sent by the Hudson's Bay Co. to explore the coast between Point Barrow and Return Reef, and between Point Turnagain and the mouth of Great Slave River. This difficult service was successfully accomplished in three seasons.

Richardson's exploration.

In 1848 Sir John Richardson again descended the Mackenzie, this time in search of his former chief, and for the second time navigated the sterile coast stretching from the Mackenzie to the Coppermine. He was assisted in this expedition by Dr. Rae. Richardson in his various journeys, spent altogether about seven years in the north, and has given us by far the best and most trustworthy account of the ethnology, natural history and geology of the boreal regions.

Pullen ascends Mackenzie:

Richardson was followed by Captain Pullen, who ascended the Mackenzie in 1849-51, after traversing the coast between Icy Cape and the mouth of the Mackenzie, previously delineated by Beechy, Elson, Simpson and Franklin.

Other explorers

In addition to the explorers named, M. L'Abbé Petitot, a Roman Catholic missionary, spent a number of years travelling in the region adjoining the Mackenzie, and has published a map and a series of papers describing the geology and ethnology of the district.* Major Kennicott also passed a couple of years on the Mackenzie collecting natural history specimens for the Smithsonian Institute. He also made a collection of fossils, which formed the basis of an interesting paper published by F. B. Meek in the proceedings of the *Chicago Academy of Sciences,* 1868, on the geology and palæontology of the valley of the Mackenzie. Professor Meek also refers to fossils collected by Messrs. R. W. McFarlane and B. D. Ross, of the Hudson's Bay Co., and by the Rev. Mr. Kirby, of the Church Missionary Society.

The geological notes of the various Arctic travellers above mentioned have been collected together by Dr. G. M. Dawson, and published as part R. of the Annual Report of the Geological Survey for 1886.

Slave River flows from Athabasca Lake to Great Slave Lake, and performs the important function of uniting the waters of the Peace and Athabasca rivers with the Mackenzie. It runs a little west of north, and has a total length of about 290 miles. For about a hundred miles below Lake Athabasca it is easily navigable, but its course is then interrupted by a series of short rapids, which have altogether a length of fourteen miles, and form the only break in the navigation of the waters of the Mackenzie between Fort McMurray on the Athabasca and the Arctic ocean, a distance of about 1,630 miles. A cart trail has been cut out by the Hudson's Bay Co. around these rapids, and a number of horses and oxen are employed during the season in transporting the freight brought down by the Athabasca steamer across the portage to Fort Smith, where it is placed on board the Mackenzie River steamboat and distributed among the various posts down the river. **Slave River.**

The rapids are caused by a gneissic spur from the Laurentian district to the east, which crosses the river here, and must extend a considerable distance in a westerly direction. At the lower end of the rapids an exposure in the bed of the river was found to consist of coarse grained hornblendic granitoid gneiss. These rocks have an imperfect foliation, chiefly marked by a roughly linear arrangement of the hornblende granules. They are polished and striated by the action of the river ice. Another exposure at the south end of the portage showed light colored and well foliated gneisses striking in a westerly direction. **Gneiss at rapids.**

The country in the vicinity of the rapids is mostly level, and is covered with white spruce, banksian pine, the rough and smooth barked poplars and various species of willow and alder. The Mackenzie River steamer was built here in the winter of 1887 and the timber used in construction was all obtained from the surrounding forest. The soil

* See Bulletin de la Société de Géographie, Paris 1875.

Soil and agriculture.

is often sandy, but good crops of potatoes and other garden vegetables are grown at Fort Smith, and also by the Indians on the east side of the river. A ridge of high hills is shown in most maps crossing Slave River at the rapids and running in an easterly direction, but these have no existence in reality.

Slave River below the rapids is extremely uninteresting geologically, as the older rocks are nearly everywhere concealed under a heavy alluvial covering. The deposit of post glacial stratified sands is so continuous, and spreads so far on both sides of the river as to lead to the supposition that it was laid down in an ancient arm of Slave Lake, which extended to the south along the line of junction of the Laurentian and Palæozoic, and corresponded in a general way to the arm of this lake, which now stretches to the north along the same geological line. The banks of the river, which at first are about one hundred feet high, and in places are broken up into terraces, become lower as we descend the river. Seven miles below Fort Smith, on the

Bell's Rock.

left hand bank, is Bell's Rock, a square, massive looking cliff, composed of light yellowish brecciated limestone. The bedding of this rock is indistinct, and it yielded no fossils or other evidence of age. It enjoys the distinction of being the only exposure observed between the rapids and Slave Lake. A couple of miles below Bell's Rock we passed on the right the fishery at Pointe de Gravois, and a few miles farther on reached the mouth of Salt River, which comes in from the

Character of Slave River.

left. Slave River in the distance traversed has an average width of nearly half a mile, and is characterized by numerous sandy beaches and bars and by occasional wooded islands. It has a current in low water of two miles and a half an hour.

At the mouth of Salt River is a house belonging to one of the numerous Beaulieu family, the members of which have been so frequently noticed by arctic explorers. I found the present representative of the name living in a lodge with his numerous progeny, and supporting himself by catching Inconnu (*Stenodus Mackenzii*). This fish, as pointed out by Richardson, finds its southern limit at the foot of Slave River Rapids, which are too violent for it to ascend, and below which, consequently they collect at certain seasons in great numbers. Beaulieu, in addition to his fishing, claims the proprietorship of the salt springs on Salt River, but his laudable attempt to derive a revenue from this source has been foiled by the discovery by Mr. Scott Simpson, of the Hudson's Bay Company, of other salt deposits farther up the river.

Ascent of Salt River.

I ascended Salt River on August 26th as far as the springs. This stream is about thirty or forty yards in width, and winds in an exasperating manner through a flat wooded plain. Its water is distinctly brackish and unfit for use even at its mouth, and increases in salinity as it is ascended. It has scarcely any valley, and its low banks, where uncovered, afford sections of the same clays and sands as seen on Slave River, and evidence the wide distribution of this alluvial deposit. Near the springs the river forks, and while one branch turns off to the south the other pursues a winding way through the salt plains. These plains are four or five miles in width, and are bounded to the west and north by swelling ridges covered with spruce and aspens, the leaves of which at this date, 26th August, were already turning yellow. The plains are well grassed, and in former days were the favourite feeding grounds of the buffalo, and even at the present time stray survivors of this fast disappearing animal are occasionally killed here, although we were not so fortunate as to see any. The springs have been visited and described by both Back and Richardson. They are situated near the base of the ridge mentioned above, are three or four in number, and are surrounded for some hundreds of yards by a salt-sprinkled and desolate looking clay flat, through which numerous briny streamlets make their way to the river. The springs are enclosed by small evaporating basins, the largest of which is about fifteen feet in diameter, and is crusted with a remarkably pure deposit of sodic chloride. The salt obtained here is of excellent quality, and has been used in the Mackenzie River district for many years.

Salt River plains.

Salt springs.

The ridge behind the springs is composed of light yellowish limestone, and holds, according to Richardson, several beds of greyish compact gypsum. Some brachiopods were collected here, but are too imperfect for identification.

We descended Salt River on the 27th August, and resumed our course down Slave River. This stream presents few features of interest. Its average width is about half a mile, but it frequently spreads out around islands to twice this size. Sandy beaches, bars and islands occur all along its course, and are constantly shifting their positions, and being built up and destroyed by the spring freshets. The birth and growth of one of these islands is thus described by Richardson.* "A great quantity of large drift timber is brought down by Peace River; and as the trees retain their roots, which are often loaded with earth and stones, they readily sink, especially when water-soaked, and accumulating in the eddies form shoals, which ultimately augment into islands. A thicket of small willows covers the new formed island as soon as it appears above water, and these fibrous roots serve to bind the whole together."

Descend Salt River.

Genesis of an island.

* First journey of Franklin, page 518.

Such an island by diverting the course of the stream may produce currents, which will result in its own destruction, or, as often happens, it will travel slowly down stream; the slow erosion at its head being counterbalanced by the accretions received in the eddy at its lower end. Beds of drift timber in varying stages of decomposition alternate with the clays and sands in many of the islands, and in some cases constitute a considerable proportion of the whole material.

Slave River below Salt River.

Below Salt River, Slave River runs in a south-westerly course for fifteen miles, and then makes a great bend to the west called Le Grand Détour. This bend is nearly fifteen miles around, but can be avoided by a short portage of a few hundred paces across its narrow neck. Twelve miles below Le Grand Détour is Pointe Brûlée, the extremity of a blunt easterly bend, and some thirty miles farther down is Point Ennuyeux, around which we have to paddle nearly ten miles in order to advance half a mile on our course. On both sides of the river are level plains, which extend without any evident elevation as far as the eye can reach, and support extensive forests of white spruce and banksian pine mingled with larch and rough and smooth barked poplar. The spruce frequently attains a diameter of eighteen inches, and affords excellent timber. A few miles west of Slave River, on Little Buffalo River, wide grassy plains, destitute of trees, and resembling in appearance the great prairies to the south, are stated to exist. This style of country finds its northern limit here, as it was not observed anywhere north of Great Slave Lake.

Wooded plains.

After rounding Point Ennuyeux we passed on the right a point covered with massive boulders and limestone fragments, and then entered a small *chenal* behind Big Island, a narrow spruce-covered island about six miles long. From Big Island the river runs in a north-westerly direction for thirty miles to Rivière à Jean, one of its outlets into Slave Lake. From this point the western channel, after rounding Point Seul, follows an easterly course to the lake, which it enters by a number of channels separated by low marshy islands, formed from the sediment brought down by the river.

Slave River brings down an enormous amount of sediment every year, and has pushed its delta far out into the lake, on the western part of which it threatens to inflict a similar fate to that which has already overtaken the southern arm.

From the mouth of Slave River we turned to the west, and passing through a narrow channel, inside of a couple of islands, reached and crossed a shallow bay, about a mile wide, and then turning to the south between Mission Island and the mainland came suddenly in sight of Fort Resolution, where we arrived on August 31st.

Great Slave Lake and Surrounding Country.

Great Slave Lake, so far as known, has a superficial area, including islands, of about 10,400 square miles, and ranks fifth among the great lakes of the continent.* No complete survey of its shores, however, has yet been made, and our knowledge of its geography is still confined to the disconnected explorations of Hearne, Mackenzie, Franklin, Back and Petitot. These give the lake a total length from east to west of about 288 miles. Its width is variable, and in one place exceeds sixty miles. It is situated along the western margin of the Archæan axis, and had originally the form of a great cross with one arm penetrating the crystalline schists, while two others stretched north and south along the junction of these with the newer sedimentaries, and the fourth extended itself over the flat-lying Devonian to the west. The southern arm, as stated before, has been silted up by Slave River.

Great Slave Lake.

Size of Great Slave Lake.

The eastern or archæan portion of the lake has an irregular outline, and is dotted with rocky islands. It is reported to be much deeper than the western part, and its water is exceedingly clear and limpid. The eastern part of this arm is divided, according to Back, by Rabbit Point (Gah-houn-tchella) and Owl Island (Peth-the-nueh) into two deep bays, of which the northern is called McLeod's Bay and the southern Christie's Bay. The latter is still very imperfectly known, and principally from Indian report. It is stated by Petitot to receive five streams † "*les rivières du Rocher, des Seins, du Loup, de la Terre-Blanche et de la Poudrerie,*" none of which are of any considerable size. North of Christie's Bay is Owl Island, which is stated by Back to be fifty-four geographical miles in length, and is described as being an ccumulation of trap mountains,‡ "and to exhibit long lines of mural precipices resting one upon another, and capped by even and round eminences, thinly clad with meagre pines." This island increases gradually in height towards the east.

Eastern portion of lake.

North of Owl Island is a narrow sheet of water filled with bold and picturesque islands, and terminating to the east in McLeod's Bay. Into this bay Hoar Frost River precipitates itself over a precipice sixty feet in height, and the Ah-hel-dessa, the outlet of Artillery Lake, in a quieter manner.

The country north and east of the eastern part of this lake is described by Back as covered with bare roundbacked hills and ridges which

* It is exceeded in size by Superior (31,500), Huron (23,800), Michigan (22,300), and Great Bear (11,400).

† Bulletin de la Société de Géographie, Paris, 1875, page 143.

‡ Fitton's Appendix to Back's Journal, page 545.

rise gradually from the water's edge to a height of ten to twelve hundred feet, and are separated by sparsely-wooded and moss-covered valleys. This part of the lake approaches within twenty miles of the "Barren Lands," as the pines are said by Back to disappear along Artillery Lake in Lat. 63° 15′ N..

West of Owl Island the lake contracts, and is filled with an archipelago of small islands, which extend to the eastern edge of the crystalline rocks near the mouth of Slave River.

Northern arm of lake. The northern arm is situated nearly opposite the mouth of Slave River, and is narrow and filled with islands. At its upper end it contracts, and opens out again under the name of Lake Brochet, which communicates in turn by a short river with Marten Lake. Yellow Knife River, at the mouth of which old Fort Providence was situated, and which Franklin ascended on his way to the Coppermine, enters this arm from the east.

Eastern arm of lake. The eastern arm of Great Slave Lake rests on the flat-lying Devonian limestones, and is wider, and presents a greater expanse of water, unbroken by islands, than either of the other divisions. Its southern shore has a gently sinuous outline, and is characterized by low banks and gently shelving beaches, which are often thickly strewn with boulders. The banks as pointed out by Richardson, are often built up of drift timber. The northern shore is more uneven, and is indented with several deep bays. The water of Great Slave Lake between Slave River and the Mackenzie, is never entirely clear, as a portion of the sediment brought down by the former stream is held in suspension and drifts slowly eastward for a hundred miles. The impurity of the water is especially noticeable along the southern shore, and the shallowness of this part of the lake is undoubtedly caused by the partial settlement of the suspended material.

Soil and agriculture. This arm is bordered all around by a flat wooded country, which has been proved to be adapted to the cultivation of barley, and of potatoes and other vegetables. The soil is usually a loam, but in the ridges is often sandy, and in low places passes into a clay. The alluvial lands along Slave River and the grassy plains on Little Buffalo River are the best sections of the district, and deserve the first attention. At Fort Resolution a few acres of land are farmed every year with good results by the Hudson's Bay Company. Mr. Flett, who has charge of this post, informed me that barley is usually sown on the 15th of May, and requires about 110 days to reach maturity. Potatoes are planted about the same date, and are dug about the 15th of September, wheat, according to the same authority, has been tried three times with only one failure. At Hay River, sixty miles west of Fort Resolution, some potatoes are annually grown by the Indians, and even at Fort Rae, which is situated on a bleak island in the northern arm of the lake in Latitude 62° 39′, some gardening has been attempted by the energetic Catholic missionaries who are stationed there. The soil at this place is very stony, and much difficulty was experienced in removing the boulders, and in bringing the ground into a proper state for cultivation. When this was once effected several kinds of vegetables were grown without trouble. Potatoes planted on the 25th May are dug in the middle of September, and yield twenty fold, and the list of garden vegetables raised here includes turnips, onions, cabbages, carrots, radishes, beets and peas. Wheat and barley have not been tried on a large scale, but a few grains were sown at the end of May one season, and became mature, the latter on the 26th August and the former four days later. A less favourable spot for farming purposes, than this rocky island, could scarcely be obtained, and the successful raising of crops here affords a promise that the more fertile lands to the west and south will one day all be utilized.

Ice forms in the bays and along the shores of Great Slave Lake, between the 20th and the last of October, and the whole lake is usually fast by the middle of November. The ice attains a thickness of from six to eight feet. In the spring the disruption of the ice takes place about the 1st of July, but sometimes occurs as early as the 20th of June and as late as the 10th of July. Back states that in a contracted part of the channel between Owl Island and the north shore called Tal-thel-leh, the water is said never to freeze, and his experience proved this to be the case during two winters. A similar occurrence was afterwards noted in the narrows of Lake Bis-tchô. **Ice on lake.**

I remained at Fort Resolution a day, engaged in making preparations, with the assistance of Mr. Flett, for further explorations, and while there examined the shores of the lake in the vicinity of the Fort and along part of Mission Island, but failed to find any rock *in situ*. The shores, however, are plentifully strewn with angular limestone blocks which have evidently not travelled far. These are usually yellowish in colour, but are sometimes dark and bituminous and pass into a calcareous shale. Some of these fragments are fossiliferous, and hold among others the familiar *Atrypa reticularis*, but I expected to find bedded rocks farther on and made no collection. Meek* describes a number of fossils collected near here by Mr. Kennicott, but whether these were obtained from loose fragments or from rock *in situ* is not evident. The collection contained *Favosites polymorpha*, *Atrypa reticularis*, a smooth *Spirifer* (*Martinia*), *Cyrtina Hamiltonensis*, **Fossils.**

* Transactions of the Chicago Academy of Science, 1868, page 68.

a *Chonetes*, a small *Productus*, a *Lingula* and a *Proetus*, all characteristic of the Devonian and belonging probably, as stated by Meek, to a horizon very near to that of the Hamilton group. Richardson obtained fossils here which led him to a similar conclusion. Mingled with the limestone are numerous well rounded gneissic and granitoid boulders and sub-angular traps and conglomerate fragments derived from the Cambrian rocks of Owl and neighbouring islands.

Leave fort. We left the fort on September the 2nd, and made a traverse of three miles across a bay to the mouth of Little Buffalo River, where we were windbound for a few hours. This bay is shallow for a long distance from the shore, and is filled in places with gneissic boulders, on one of which we were driven by the wind, and injured our bark canoe so severely that it was only by dint of energetic bailing that we managed to reach the shore.

Little Buffalo River. Little Buffalo River approaches Slave River a few miles below Point Ennuyeux, and canoes, by ascending it and making a short portage over to Slave River, avoid the long detour around by the mouth of the latter stream. It runs through a flat country throughout. Half a mile west of Little Buffalo River is a ledge composed principally of flat-lying yellowish brecciated limestone precisely similar to that observed in Bell's rock, a few miles below Fort Smith. This rock holds angular fragments, ranging in size up to a couple of inches in diameter, of both ordinary and dolomitic limestones firmly cemented in a compact calcareous matrix. It yielded no determinable fossils.

After repairing our canoe, the wind in the meantime having fallen, we continued our journey, and camped at dusk on a small boulder-lined island, where we were detained the whole of the next day by a strong north-westerly wind. On the 4th we succeeded in getting away again, and after crossing a bay about four miles wide we coasted along the shore, inside the Burnt Islands, to Ile du Mort, where a party of Dog-ribs are said to have been chased and starved to death by their southern neighbours. From Ile du Mort we crossed two shallow bays, and camped in a good harbour at Sulphur Point. **Shores of lake.** The shores of the lake all along are flat and uninteresting, and only one or two small exposures were observed at the various points at which we touched, although loose fragments of limestone and gneissic erratics are seldom absent. Low terraces running parallel with the beach, and other indications of a former higher lake elevation were noticed in places, and appear to encircle the lake, as terraces were afterward found on the northern shore, and Back mentions their occurrence at the east end, near Fort Reliance.

Sulphur Point derives its name from the presence there of several springs which emit a strong odour of sulphuretted hydrogen. The flow from these is small, and the effluent water must carry up large quantities of soluble material, as heavy deposits of calcareus tufa occur all around. The water is clear and almost tasteless, and has a temperature of 57° F.

Sulphur springs.

We left Sulphur Point on the 8th, having been delayed three days by a north-west gale, which are very prevalent on the lake at this season, and reached Hay River the same day. Six miles east of Sulphur Point is Buffalo River, a stream of about fifty yards in width, which originates in a large lake situated, according to report, about fifty miles east of Fort Smith. Heavy rapids occur on it in one place, but it is navigable with York boats to its source. Four miles east of Buffalo River is a blunt headland called Point Presse, and between it and Hay River is a wide, shallow bay with sandy shores, into which a couple of small streams flow.

west ?

west ?

Hay River.

Hay River.

Hay River has never been explored. It is reported to rise near the head waters of the Nelson, or East Branch of the Liard, and to flow in a north-easterly direction for three hundred miles before emptying into Great Slave Lake. Grassy and partly wooded plains extend northwards from Peace River and skirt its southern shores, but do not cross it, and this river may be regarded as practically the northern limit of the prairie country, although small isolated plains occur much farther north in the vicinity of Slave River.

Hay River delta.

Hay River, like Slave River, enters the lake by several channels, and at the extremity of a point formed by the deposition of its own sediment, near its mouth, is an abandoned Hudson's Bay trading post, now occupied by a band of Indians, who assemble there on account of the excellent fishing. For some distance above the post, and while passing through the delta, the river is wide and encloses a line of alluvial islands, but on getting above these it contracts to about one hundred yards in width. Its banks are low and grassy, and the country on both sides is thickly forested. Proceeding up the river the general elevation of the country increases, and the valley becomes higher and wider, and bordering flats make their appearance. The current at the mouth is gentle, but increases in rapidity as we ascend and breaks into riffles on the bars. As we ascend, also, the recent sands and clays of the delta and lower part of the river are replaced by bluish-green soft shales, which rise gradually in the banks until they form bold bluffs along both sides of the valley. These shales are interstratified with ripple-marked and worm-burrowed calcareous sand-

Rocks along Hay River.

stones and yellowish limestone, and resemble exactly the bluish shales at the rapids on the Liard, and hold similar Devonian fossils. Twenty miles above the mouth, the river, which below has been only moderately tortuous, winds around a tedious double bend, at the elbows of which are high sections of the bluish shales. Four miles farther up some heavy beds of yellowish weathering limestone make their appearance. The valley here is about a quarter of a mile wide, and its scarped sides exhibit the shales in magnificent and continuous sections. Still going on we follow the river around an easterly bend at the upper end of which is a rapid, and then pass for some miles along the base of shale cliffs which are highly fossiliferous. The shales are very soft, almost passing into clays, and the fossils weather out in a beautiful state of preservation. The following species were obtained here:—

Fossils.

Astræospongia Hamiltonensis, Meek and Worthen.
Aulopora serpens, Goldfuss.
Campophyllum ellipticum (*Chonophyllum ellipticum*, Hall and Whitfield.)
Cyathophyllum cæspitosum, Goldfuss.
Heliophyllum parvulum, Whiteaves.
Phillipsastræa Hennahi, Lonsdale.
" " *Verrilli*, Meek.
Pachypora cervicornis, De Blainville.
Alveolites vallorum, Meek.
Arachnocrinus Canadensis, Whiteaves.
Spirorbis omphalodes, Goldfuss.
" *Arkonensis*, Nicholson.
Conchicolites (*Ortonia*) *sublævis*, Whiteaves.
Hederella Canadensis, Nicholson.
Proboscina laxa, Whiteaves.
Stomatopora moniliformis, Whiteaves.
Ascodictyon stellatum, Nicholson.
Paleschara quadrangularis, Nicholson.
Ceramopora Huronensis, Nicholson.
Crania Hamiltoniæ, Hall.
Productella spinulicosta, Hall.
Orthis striatula, Schlotheim.
Strophodonta demissa, Conrad.
Spirifera disjuncta, Sowerby.
" " var. *occidentalis*, Whiteaves.
Spirifera cyrtinæformis, Hall and Whitfield.
" *glabra*, var. *Franklini*, Meek.

Atrypa reticularis.
" " var. *aspera.*
Rhynchonella cuboides, Sowerby.
Eatonia variabilis, Whiteaves.
Paracyclas elliptica, Hall.
Schizodus Chemungensis, Conrad.
Euomphalus Maskusi, Whiteaves.
Orthoceras, sp.
Gyroceras (fragment).
Goniatites (fragment) like *G. uniangularis.*
Primitia scitula, Jones.
Isochilina bellula, Jones.
Aparchitis mitis, Jones.

Age of rocks

This assemblage of fossils, according to Mr. Whiteaves, is very suggestive of the "Cuboides Zone" of European writers, and of the Tully limestone of the State of New York, which, according to Prof. H. L. Williams, is its palæontological and stratigraphical equivalent in North America.

Continuing up the river a band of red shales was noticed in one place near the water level, and a few miles farther on, heavy beds of cream-coloured limestone come in from above and produce at once a striking change in the aspect of the valley.

Hay River gorge.

As we advance the valley contracts and becomes a gorge, and its high mural walls buttressed below by an embankment of fallen fragments, appear to almost overhang the stream, while the latter, now reduced in width to a hundred feet, dashes along the boulder-filled channel with bewildering impetuosity. At the lower end of the rapids we left the canoe and scrambled along the beach over high masses of rock to the foot of the portage track. At one point here a graceful effect is produced by a couple of small streams which fling themselves on either hand over the brow of the cliffs bounding the valley and make one clear leap to the floor beneath.

Alexandra Falls.

The Portage track leaves the valley at a point where its walls have been worn into a sloping attitude, and leads for a couple of miles across a level, marshy plain, forested with banksian pine and white spruce, to the Alexandra Falls, so named by Bishop Bompas, in honour of the Princess of Wales. The gorge here suddenly ceases, and the river precipitates itself over the hard limestone band through which the latter is cut, with a sheer descent of about eighty-five feet, as measured by a single reading of the aneroid barometer. These falls present a clear unbroken sheet of falling water, and are exceedingly picturesque in appearance. From their base the river flows along rapidly for about a mile, and then makes a second leap of about fifty feet, below which are three miles of rapids. At the lower falls the cliff is broken down near the centre, and the descent of the water is interrupted by projecting ledges. Above the falls the river loses its valley almost altogether, and has failed to produce more than a feeble impression on the hard limestone beds which floor the surrounding country.

Origin of falls.

The falls here owe their origin to precisely the same cause as that which produces the famous falls at Niagara, viz., the superposition of hard limestone on soft shales, and the consequent undermining and destruction of the former effected by the rapid erosion and removal of the supporting beds. I was surprised to find that the rate of retrocession, dating both falls from the same period, has been almost identical. The Niagara Falls are generally regarded as having receded six miles since they were brought into existence by the elevation of the country at the end of the glacial period, and on Hay River the distance between the point at which the limestone band makes its first appearance and the lower falls, is almost exactly five miles, and between the same point and the upper falls, six miles. The equality of the work done by the two streams is, however, a mere coincidence, as the factors in the two cases are entirely different. The volume of water which falls over the precipice at Niagara is many times greater than that carried by Hay River, while its erosive power is relatively less on account of its somewhat greater purity.

Comparison with Niagara Falls.

Limestone at gorge.

The limestone exposed along the Hay River gorge has a minimum thickness of two hundred feet, inclusive of a band of shales, which separates it into an upper and a lower portion. It appears to have a light dip up stream. It occurs characteristically in thick massive beds which weather to a light yellowish colour. The heavy beds alternate with laminated bands, which occasionally pass into calcareous shales, and with a uniformly grained well stratified cream-coloured limestone, which resembles specimens I have seen from the limestones of Lake Winnipeg. Fossils are less numerous in the limestones than in the underlying shales, and the same forms appear to characterize both series. At the falls I obtained some specimens of *Atrypa reticularis* and of two specimens of a coral, which is probably *Campophyllum ellipticum*, besides some others which are too imperfect for identification.

Fossils.

Limestone escarpment.

The eastern outcrop of the band of limestone which crosses Hay River at the falls, forms an escarpment which follows in an interrupted manner the valley of the Mackenzie in a north-westerly direction as far as the Liard, and is the cause of the falls and heavy rapids which occur on all the streams which enter the Mackenzie from the southwest between these two points. On the Liard the passage from the harder to the softer formations is marked only by a few light riffles and an accelerated current, but there the proportion of shales to limestone is greater than usual, and the formation is more uniform, and besides, that river carries down an immense amount of sediment, and possesses consequently, greater ability to erode a graded channel, than streams like the Hay or Beaver Rivers, which originate in lakes and carry comparatively pure water. On the northeastern side of the river the continuation of the limestone band is probably marked by the steep terrace-like front of the Horn Mountains, but this ridge has never been examined.

We did not ascend Hay River beyond the falls, which are situated about thirty miles in a direct line from its mouth, and on the 14th we returned to the lake. On the way down I sounded the bars, and on a number of them found less than three feet of water. In high water light draught steamers could ascend as far as the foot of the rapids. **Return to lake.**

Slave Lake Continued.

From Hay River point we made a traverse of some twelve miles across a moderately deep bay to Pte. de Roche, a narrow gravel and boulder spit which projects for some distance out into the lake, and affords a good harbour against winds coming from the north or north-east. It is strewn with erratics of various kinds, but principally gneissic, and with angular limestone fragments, but no bedded rocks were observed. Leaving Pte. de Roche we coasted along a shallow and often weedy shore to the Desmarais islands. The country adjacent to the lake is low all along this part, and intersected with marshes, moss-covered muskegs and small lakes, but to the south it rises into a long even ridge called Eagle Mountain. A rock specimen from the mountain which I afterwards obtained, showed it to be composed of a fine-grained yellowish limestone, almost exactly similar to the limestone at Hay River falls. At the Desmarais islands the lake contracts, and the influence of the Mackenzie current becomes apparent. We left the southern shore here and crossed over to the upper end of Big Island, an island of some fifteen miles in length, which is situated at the embouchure of the lake and divides the water issuing from it into two channels. The southern channel is four to five miles in width, but is filled with islands. It carries the main body of the water, and is the one used by the steamer, but is everywhere very shallow, and in low water some difficulty is experienced in navigating it. **Pte. de Roche.** **Country south of lake.** **Big Island.**

Big Island is fringed all around its eastern end with a wide margin of drift timber, closely packed together and covered, wherever the interstices have become filled up by the gradual deposition of sand and the decay of the wood, with a heavy growth of willows. The main shores of the lake, as pointed out by Richardson, show in many cases the same structure.

The northern channel is about a mile wide at its narrowest place, and, except in high water, is not navigable for boats drawing more than three feet of water. On the main land, north of this channel, is situated an abandoned trading post, and near it is the productive Big Island fishery.

Slave Lake fisheries.

The fisheries of Great Slave Lake are of great importance and demand some reference in any account of the lake, however brief. Fish of various kinds can be taken in any part of the lake throughout the year with nets and hooks, but they are especially abundant in some places just before the advent of cold weather. At this season, which usually lasts from the 20th of September to the 10th of October, they leave the deeper parts of the lake, and migrate in vast numbers to certain favored waters, where almost any quantity desired can be obtained. The Big Island fishery supplied Fort Simpson and Fort Providence last year with about 40,000 fish, besides affording constant support to a number of Indians. At the mouth of the Beaver about 20,000 were taken, and the fisheries at the mouth of Hay River, in the bay on front of Fort Rae, and near Fort Resolution, besides other places, yielded corresponding quantities. I estimated the total yield of the lake for the year 1887 at about half a million pounds.

The most abundant and valuable of the fishes of the lake is the widely distributed white fish (*Coregonus clupeiformis*), the superior edible qualities of which are too well known to need description. It is stated by those who have spent some time in the north, to be the only fish on which a person can subsist continuously without becoming satiated with it. The white fish taken at Big Island average nearly three pounds in weight, while those from Fort Rae are much smaller and may belong to a different species. With the white fish are associated the lake trout (*Salvelinus Namaycush*), which often attains a weight of over fifty pounds, but affords too rich a diet for constant use, the inconnu (*Stenodus Mackenzii*), the pike (*Esox lucius*), and the sucker (*Catostomus longirostris*), besides others of less importance. A stray salmon was captured some years ago about forty miles below the outlet of the lake, and is described by Mr. Reid as being identical with the common Yukon salmon, probably *Oncorhynchus Chouicha*, but visitors of this kind are very rare.

On the 19th we left the Big Island fishery and started out to visit the tar springs on the north side of the lake. We first made a long and somewhat risky traverse across a deep bay, and then passed for fifteen miles along a low, swampy shore, lined with driftwood, to Pointe aux Esclaves, a narrow jutting headland of some four or five miles in length, which in windy weather is often portaged by the Indians. On its western side is a small harbour, well protected from winds blowing from any quarter. Beyond Pointe aux Esclaves the shore is bolder and the water becomes much deeper. A bay of some four miles in width separates it from Pointe Brûlée, one of the most exposed and stormiest places on the lake. This point is much dreaded by the Indians, who state that they seldom round it without encountering a gale of some kind. When we passed it the wind was light, but heavy waves, raised by a storm which swept the lake the preceding day, were rolling up from the sea and breaking in a threatening manner along the shore. Outside the fringe of breakers the waves were broad and could be ridden with little danger, but it was only with the greatest difficulty and after we had been once nearly swamped, that I was able to convince my Indians of this, as they seemed to consider that the place of greatest safety was close to the shore. After weathering the point we turned to the north-west and entered a deep bay, near the bottom of which our guide pointed out to us a lobstick which marked the position of the springs of which we were in search. The shore here is rocky, but for some distance east of Pointe Brûlée is bordered with a gravel terrace.

Leave Big Island.

North shore of lake.

The springs are situated a couple of hundred yards from the shore, at the base of a low limestone cliff, which runs inland from the lake, and are three in number, each of them being surrounded with a small basin, three to four feet in diameter, filled with inspissated bitumen, while the soil and moss for some distance away is impregnated with the same material. A small quantity of pitch is annually taken from these springs and used for boat building purposes, while a much larger supply could be obtained if needed. A sulphur spring resembling those at Sulphur Point on the south shore of the lake, but much more copious, issues from the foot of the cliff in close proximity to the bituminous springs, and feeds a considerable stream.

Tar springs.

Sulphur spring.

The rock through which the petroleum ascends here is a heavily bedded greyish, rather coarsely crystalline cavernous dolomite, and is entirely unlike the bituminous beds south of the lake and down the Mackenzie, which in most cases consist of calcareous shales. The dolomite is everywhere permeated with bituminous matter, which

Rocks at tar springs.

collects in the numerous cavities, and oozing up through cracks, often forms small pools on the surface of the rock.

The age of the bituminous beds here could not be clearly ascertained, as they are entirely unfossiliferous, but it is altogether likely that they are older than the Devonian shales and limestone which outcrop along the southern shore, and are more nearly related to the dolomites which underlie the fossiliferous Devonian beds at the Nahanni Butte and at other places. The presence of bitumen in such abundance here also suggests an anticlinal which would bring up lower beds.

Tar springs.

Sulphur and tar springs are reported to occur at a point about half way between this and Fort Rae, but as I did not hear of them until I had left the lake, I was unable to visit them. A tar spring is also known to exist under the surface of the water in the deep bay immediately east of the Big Island fishery, as many of the boulders and rocks along the shore in this neighbourhood are coated with bitumen which has been washed ashore, and hummocks of ice stained with the same material are often observed. On the south shore bituminous shales and limestones outcrop at several points, and it would thus appear that the oil-bearing beds underlie the whole western part of the lake.

Glacial groovings.

The limestones along the shore near the tar springs show glacial groovings and oblong rounded hummocks, running in a general east and west direction, or nearly parallel to the shore line at this point. At Fort Rae, which I afterwards visited in the winter time, the few hummocks which appeared above the snow seemed to run about S. 30° W., or diagonally across the arm of the lake on which that fort is situated.

We left the tar springs on our return journey at noon on the 20th, and reached Pointe aux Esclaves the same night; here we were delayed for a day by a gale of wind, but on the 22nd got away, and by vigorous paddling against a head wind, succeeded in reaching Big Island fishery the same night.

THE MACKENZIE RIVER.

GREAT SLAVE LAKE TO FORT PROVIDENCE.

Mackenzie River.

Length of river.

The Mackenzie River on which we now enter is the second river in length and size of basin, but the third in actual discharge, on the North American continent, and ranks among the first dozen rivers of the world. The length of its watercourse from its source in the "Committee's Punch Bowl," near Mount Brown, by Athabasca and Slave

River, to the sea is 2,560 miles, but the length of the section to which the name is restricted is only about 1,000 miles. It drains an area of 677,400 square miles, and has an approximate discharge at a medium stage of the water, according to some rough measurements made by the writer of 500,000 square feet per second. Its basin is traversed for nearly 1,300 miles by the Rocky Mountains, and the Mackenzie is probably unique among the rivers of the world in the fact of having a large proportion of its basin situated on the farther side of a great mountain chain. Two of its principal tributaries, the Liard and Peace Rivers, pierce the Rocky Mountains and drain large areas beyond, while the third, the Athabasca, originates in the heart of the same range, and is confined entirely to the eastern slope. The country from which the Mackenzie draws its supplies is of the most varied description, and includes part of the broken plateau region west of the Rocky Mountains, the Rocky Mountains themselves through fifteen degrees of latitude, the northern part of the prairie district and the wooded and moss-covered country, which succeeds it towards the Arctic ocean, while tribute is also drawn from a wide belt of rough Laurentian country on the east, and from a portion of the "Barren Lands." From Great Slave Lake to the sea the Mackenzie is an imposing stream, averaging about a mile in width, with occasional expansions for long distances to twice this size. It is characterized by the comparative purity of its water, by its long straight reaches and by the absence of sudden bends. Its valley is usually shallow, and follows closely all the sinuosities of the stream, without the intervention of large flats. Clusters of islands obstruct its channel in a number of places, and are met with at intervals all the way down, while ranges of lofty mountains run parallel with it for part of its course, and form a fitting background to this king of northern waters.

Principal tributaries.

Character of Mackenzie.

The Mackenzie on issuing from Great Slave Lake has a width of from seven to eight miles, but is shallow and filled with islands. We passed down through the channel north of Big Island, and found the water so shallow that our canoe frequently grazed the bottom several hundred feet from the shore. In very low water loaded York boats are unable to float down this channel from the fishery, and are obliged to go around the east end of Big Island and come down the southern channel, where the water is somewhat deeper. The shore is low and fringed in many places with marshes, which are evidently submerged when the river is in flood. The low elevation of the country all around the east end of the lake makes it difficult to understand the terraces which border it at intervals, as a change in the elevation of the water

Width of river.

Low shores.

of the lake sufficient to produce these without some corresponding change in the elevation of the adjacent country would flood all the lowlands to the east, and create a channel of enormous width and carrying power. A detailed study of the lake, and the lake shores will, however, be necessary to solve this and the many other problems connected with its origin and history.

Current of river.

Fifteen miles from the lake the islands cease, and the river has contracted to about four miles, which diminishes rapidly to less than two miles as we proceed, while at the same time the current gradually increases in strength, and thirty miles from the lake is running at the rate of over four miles an honr. Some distance farther on a large island blocks the way, and the main body of water turning to the right, falls over what is commonly called "the rapid," but is scarcely one in the ordinary sense of the word, as although the current is swift it is quite smooth, and is ascended by the steamer "Wrigley" without difficulty. On the southern channel strong rapids are stated to occur.

Rocks along river.

Between Great Slave Lake and "the rapid," the country bordering the river is generally flat, with numerous marshes and muskegs separated by reaches of forest. The valley of the river is shallow, with low banks seldom exceeding thirty feet in height. Sections of a yellowish boulder clay were seen in a number of places, and near "the rapid" small exposures of the same bluish shale from which Devonian fossils were obtained on Hay River appear at tbe surface of the water.

Arrive at Fort Providence.

At "the rapid" is situated Fort Providence, where it had been arranged that I should pass the winter. I arrived there on the 24th of September, and was kindly received by Mr. Reid, the officer in charge, and by Mr. Scott, also of the H. B. C., who was staying with him, and hospitably treated by them and by the members of their households while I remained. It will be unnecessary here to more than refer to the events of the winter which passed pleasantly and quickly if somewhat monotonously. While staying at the Fort the traverses of the preceding summer were platted and a meteorological record kept, which will be found in the appendix. Some rough exploration was also undertaken.

Soil and agriculture.

Fort Providence is surrounded by flat arable lands, of good quality, and capable of producing excellent crops. Agriculture is engaged in here both by the H. B. Company and the R. C. Mission, and large quantities of farm produce are annually raised. Wheat has been sown at the H. B. Company's farm for nine years, and, according to Mr. Reid, has never been a complete failure, although on some occasions it has been slightly touched by summer frosts. It is usually sown about the 20th May, and requires about three months to ripen. As much as twenty-nine bushels has been obtained from one bushel sown. Barley is a sure crop. It is sown at the same time as the wheat, and is ripe almost a week earlier. Potatoes are planted between the 16th and 25th May, and are taken up about the 20th of September. Turnips, cabbages, beets and numerous other garden vegetables are grown with scarcely greater difficulty than in latitudes ten degrees farther south. The soil is a stiff clay, with in some places surface beds of sand, and is seldom thawed out to a greater depth than six feet. The muskegs which cover a considerable proportion of the country back from the river are permanently frozen at less than two feet from the surface. It must be borne in mind, however, in this connection, that the histories of other districts have shown that when the country is cleared and the moss burnt off, the penetrative powers of the summer thaw is at once greatly increased, and lands have become productive, which at first appeared hopelessly barren.

A number of cattle are kept at Fort Providence, but require to be fed about seven months in the year. Hay of excellent quality is obtained in abundance from neighbouring marshes.

Fort Providence to Lake Bis-tchô.

Trip to Lake Bis-tchô. On the 3rd of January an opportunity offered, of which I availed myself, of making an exploratory trip to the southwards from Fort Providence. A party was sent out with three dog trains for the purpose of bringing in furs from Lake Bis-tchô, and Mr. Reid kindly allowed me to accompany it. A traverse was made of the route passed over, but this is necessarily of a somewhat rough character, as the shortness of the days forced us to do most of our travelling at night, and besides, jogging behind dogs at the rate of five miles an hour, with the temperature at forty degrees or more below zero, is not favorable to an accurate estimate. **Character of traverse.**

From the fort we made our way with difficulty over the hummocky surface of the main channel of the river, here about a mile wide, to a large spruce covered island, which we traversed, and then crossed the back *Chenal* to the mainland, where we camped, as our late start prevented us from making more than a single "spell." In travelling in this country in mid-winter an effort is usually made to start about 3 a.m. in order to get the day's work completed by noon, the short afternoon of about two hours being required to prepare camp and cut wood for the night and morning. On the 4th we were off in good time, and quickly passing through the belt of spruce which margins the river, came out on a wide muskeg, on the farther side of which the spruce woods recommenced and continued to the base of a steep escarpment which crossed our way at a distance of about thirteen miles from the river. This escarpment runs parallel with the river, and is doubtless the northern edge of the same limestone band, or of the lower portion of it, over which Hay and Beaver rivers plunge at their falls. After making the ascent the barometer showed an elevation of 300 feet above the river. From the top of the escarpment the trail leads for some miles through a Banksian pine forest, beyond which is a wide spruce and tamarac flat which extends to Lake Ka-kī-să; on the farther side of which we made our second camp, after travelling about thirty miles. Lake Ka-kī-să is about four miles wide at the west end, where we crossed it, and is at least ten miles in length. Beaver River passes through its eastern end, according to a sketch which Chief Nelson, of the Trout Lake Indians, drew out for me.

Steep escarpment.

Lake Ka-ki-sa.

On the 5th we climbed about a mile from camp a second steppe or sudden rise in the general elevation of the country. This escarpment runs northwards, with a height of 300 feet, parallel to the southern shore of the lake. An exposure of yellowish-weathering compact limestone, lying in a horizontal position, was observed in the couleé up which the trail led, but proved to be unfossiliferous.

Exposure of limestone.

Pine forest.

The elevated country behind this second escarpment is covered for some miles by a Banksian pine (*Pinus Banksiana*) forest. This tree grows to a larger size here, and its branches are more irregular and extend out straighter from the trunk than is usual in more southern latitudes. It frequently attains a diameter of over two feet, but its wood is very soft and is regarded as much inferior to that of the white spruce (*Picea alba*), which affords by far the greatest part of the timber used in the district. Leaving the pine woods the trail leads through a succession of spruce swamps, open muskegs and wide bruleé reaches, which continue for the next twenty miles. A small tributary of Beaver River winds through this part of the country. After crossing it we passed over a pine and aspen ridge, and then descended into a swampy partly wooded plain, which we entered for four or five miles, and then camped. We passed on our left, during the day, the northern end of Lake Ta-thlī-nă, an expanded portion of Beaver River, and in the same direction, a range of hills, apparently running nearly north and south, was observed whenever an unobstructed view could be obtained. Early on the 6th we passed through a wide belt of spruce woods and reached Beaver River. This stream, where we crossed it, is about a hundred yards wide, and has a somewhat sluggish current. It

Spruce swamps.

Beaver River.

is reported to originate at the foot of a high ridge, which was now plainly visible to the south. From Beaver River we made our way for eighteen miles across a partly wooded, partly open country, intersected with muskegs, and camped in the dense spruce woods which skirt the base of the heights referred to above. The 7th was occupied in crossing this ridge, which marks the front of a third steppe, and rises to an elevation of 1,150 feet above Beaver River. The ascent is at first gradual, but near the top there is an abrupt rise of some hundreds of feet. The summit is covered with irregularly disposed steep sided hills and low interlacing ridges, which are probably of glacial origin, and suggest a comparison with the surface configuration of the Missouri Côteau of the southern plains. No exposures were observed here, and if any existed they were concealed by the snow.

Cross ridge.

From the summit we made a descent of about 200 feet to camp, and on the following day, after passing some small lakes, made a traverse of over thirty miles across a desolate looking plain, scantily covered with spruce and tamarac, to Lake Bis-tchô, on the farther side of which we found the Indian camp of which we were in search.

Lake Bis-tchô (Big Knife) is reported to be about thirty miles in length and from six to eight in width. It empties into Black River, a tributary of the Liard. At its western end it contracts in one place to a couple of miles and then opens out into a deep bay, which gives it the fancied resemblance to a knife, from which it derives its name. It has low banks, and is surrounded by a flat country wooded with spruce, birch, tamarac, &c., of fair size. Eight or ten miles to the south is a high ridge, across which the Indians make a portage to Hay River.

Lake Bis-tchô.

The latitude of Lake Bis-tchô, from a meridian altitude of the sun taken under somewhat unfavorable circumstances, was found to be 59° 43′ 30″.

We commenced our return journey on the 10th and reached the fort without mishap on the 15th.

Fort Providence to Fort Rae.

On the 21st of January a trip to Fort Rae was undertaken in company with Mr. Camsell and a number of officers of the Hudson's Bay Company. We reached our destination on the 25th, and after a pleasant stay of a few days with Mr. Wilson, the genial officer in charge, I started back on the 29th. Fort Rae has been referred to in connection with a previous description, and some agricultural statistics given. It is situated on an island in the northern arm of Great Slave

Trip to Fort Rae.

Fort Rae.

Lake, and in winter presents a somewhat inhospitable appearance to the approaching traveller, but in summer its surroundings become more agreeable. It is resorted to for trading purposes by several hundred Dog-rib Indians, whose hunting grounds extend from the north shore of the lake far into the "Barren Grounds." Fort Rae is surrounded by a deer country, and is looked on rather as a provision post than as a fur post, although it also ranks high in the latter respect. In the winter thousands of the "Barren Lands" Caribou, which have been driven south by the severity of the climate, are slaughtered in its vicinity, and their flesh converted into dry meat for use in the district.

Rocks around Fort Rae.

The unfavorable season and depth of the snow prevented me from obtaining much information in regard to the geology of the interesting country around Fort Rae, but some notes were made. The line of junction between the Archæan schists and the Palæozoic limestones passes about two miles east of the fort. Exposures of both systems were observed within a distance of half a mile, but the actual contact was not seen. The hummocks of Archæan rock which projected above the snow consisted, so far as my limited examination went, exclusively of a reddish coloured, medium grained biotite granite. The hummocks are glaciated, and have their longer axes orientated in a general S. S. W. and N. N. E. direction, which would go to show that the abrading glacier was deflected to some extent down the arm of the lake, as the groovings at the tar springs, noted on a previous page, have an approximate east and west direction. The limestone beds exposed in the vicinity of the fort have a horizontal attitude, and are usually of a somewhat massive character, and form cliffs running along the shores, but are also sometimes flaggy. They are yellowish in colour, are very compact, and are generally indistinguishable in appearance from the limestones which overlie the fossiliferous Devonian shales south of the Mackenzie. They are fossiliferous, but no specimens perfect enough for identification were obtained.

Glaciated hummocks.

Country between Fort Providence and Fort Rae

On the way back from Fort Rae an estimated traverse was made, but the country is generally monotonous and uninteresting and will not require much description. It is everywhere flat, the barometer never indicating a greater height than 200 feet above the lake, and is covered with lakes and marshes, separated by belts of spruce and pine, and by partly wooded plains and bruleés. No exposures of rock of any kind were seen on the way across. After leaving the lake on the 29th we passed through a thick spruce forest for a couple of miles, the surface rising gradually as we proceeded to an elevation of 150 feet above the lake, and then through a region more scantily clad with alternating groves of spruce, poplar, birch and alder. On the 30th the most noticeable feature of the day's journey was the number of small lakes which we crossed, and which dotted the face of the country on both sides of the trail. Some excellent spruce was seen in the middle of the day, but this thinned out and was replaced by muskegs before reaching camp. On the 31st the trail led through a well wooded country most of the way. In the forenoon of this day we made a traverse of six miles across Birch Lake, the largest lake seen on the route. On the 1st of February we made our way through the Grand Brûlée, the scene of a former destructive fire, and encamped on the far side of Lake Ta-dī-tha, and on the 2nd crossed three wide prairies, with the intervening timber belts, and arrived at Fort Providence.

Travelling with dogs.

Travelling with dogs in northern latitudes is pleasant enough when one is comfortably ensconced in a cariole and looked after by a driver, but presents itself under quite a different aspect when one is obliged to follow up on foot. The constant use of the snowshoe is almost certain to result, in the case of the novice, in sore feet, and a careless tying of the strings may bring on the dreaded "*mal de raquette*," when every step becomes an agony; and as extra supplies are never provided, no halt can be made, and the unfortunate sufferer is obliged to limp along at the rate of thirty or forty miles a day until the journey is completed. No tents are ever carried in winter, and the outfit taken along is limited strictly to absolute necessaries, even articles for washing being dispensed with by those who are desirous of being styled "men of the north."

Fort Providence to Fort Simpson.

Proceed to Fort Simpson.

After returning from Fort Rae I remained at Fort Providence until the 1st of May, and then proceeded down the river to Fort Simpson with dogs. The weather, which had remained cold and wintry up to this time, suddenly turned warm, and the walking became exceedingly disagreeable and fatiguing. We travelled at night, but even then were obliged to wade through slush most of the way, as a crust sufficiently hard to bear us only formed for a short time in the early morning. We were six days making the trip. No survey was made along this part of the route, as the course of the river had been previously laid down by Franklin and others, and the necessity for travelling at night made it impossible for me to attempt any improvement on their work.

The Mackenzie below Fort Providence.

The Mackenzie, from a point four miles above Fort Providence down to the Little Lake, a distance of twenty miles, is split up into a number of channels which have a spread of over four miles. The numerous islands in this reach are low, and as a rule are densely covered with spruce. At the upper end of some of the islands great hills of clay and boulders were noticed, which had evidently been piled up by the action of the river ice. The shores of the river are low, and show exposures of boulder-clay, underlaid in some places by bluish Devonian shales. At the Little Lake, which is simply an expansion of the river, the Mackenzie is joined from the north by Willow River. This stream is about fifty yards in width, and originates in the rear of the Horn Mountains around the eastern end of which it flows. It is navigable by canoes for a long distance, but heavy rapids are stated to occur in its upper part. The mouth of Willow River has been used for the last two seasons as a winter harbour for the steamer *Wrigley*, on account of the fact that the ice on streams coming from the north breaks up in the spring with less violence than on those coming from the south.

Horn Mountains.

The Horn Mountains, which begin abruptly about thirty miles north of the Little Lake, and are seen from various points along the river nearly all the way to Fort Simpson, have the character of a simple escarpment. They present a steep face to the south, but to the north slope away very gradually. A wide marshy plain is reported to exist at their base, between which and the river the country is well forested. To the south similar but lower escarpments, among which is Trout Mountain, extend parallel to the general course of the river.

River below Little Lake.

From Little Lake the Mackenzie continues wide and sluggish to what is known as the "Head of the Line," the point at which oars are substituted for the tracking line in ascending the river, beyond which its current becomes more rapid. Forty miles below the lake we reached Yellow Knife River, and a few miles farther on, after rounding a broad bend, came to Trout River. Both of these streams come from the south, and are reported to head in large lakes. From Trout River we followed around a northerly bend, and then crossed a long straight reach to the head of the portage. From this point a short cut leads across to the Liard, and down it to Fort Simpson, but as the thaw had made this impassable, we were obliged to take the longer route around by the river, and pick our way through the numerous "*bourdillons*" which roughened the surface of the river almost all the way to the Fort.

Geology.

Between the Little Lake and Fort Simpson, sections of yellowish-weathering boulder-clay are of constant occurrence and underlying it are exposures in a few places of the same bluish Devonian shales, which have been traced all the way from Hay River. In descending the river the shales lose their characteristic greenish-blue colour to some extent, and become darker and harder, and weather into steeper slopes, but that the two varieties are of the same age is shown by their occurrence together on the Liard.

Dr. Richardson, who descended the river in the summer time, and had a better opportunity of examining the banks, describes the geology of this part of the river in the following terms:—

"In the few spots where sections of the strata are visible a bituminous shale containing many fragments of the small pteropodous shell *Tentaculites fissurella*, indicates the formation to be the same with that on the Athabasca River and Slave Lake, which has been said above to be probably Marcellus shale. Between the old fort and Hare Skin River the basis of the bank is formed of a greyish-green shale clay, which under the influence of the weather breaks into scales like wackè, and at last forms a tenacious clay. The whole banks of the river seem to belong to a shale formation, but from the want of induration of the beds they have crumbled into a slope more or less steep, and the capping of clay, sand and boulders, has fallen down and covered the declivity." *

The two escarpments of the Horn Mountains and Trout Mountain which border the river on either side, evidently represent the outcrop of the same limestone which overlies the shales at the Hay River falls, and south of Fort Providence, as there is no reason to suspect that the succession here is different to that which obtains at those places.

Fort Simpson.

I arrived at Fort Simpson on the 6th of May, and was cordially welcomed by Mr. Camsell and by the other officers at the Fort, and as I intended to remain here until the ice broke up, and then to proceed by water, Mr. Camsell at once gave orders for a boat of the requisite size to be built. *Arrive at Fort Simpson.*

Fort Simpson is beautifully situated on an island at the mouth of the Liard, and is the headquarters of the fur trade on the Mackenzie. The various buildings are arranged around three sides of a square, open towards the river, and are of a size commensurate with the commercial importance of the place. In former days all the goods intended for consumption in the district were first brought here, and then distributed to the various posts, but since the advent of the *Wrigley* this has been done away with to a large extent, and all the posts which can be reached by the steamer are now supplied directly. Like the other posts Fort Simpson has its farm, and according to some statistics which I received from Mr. Laviolette, the various crops *Fort Simpson.* *Soil and agriculture.*

* Journal of a Boat Voyage through Rupert's Land, Vol. I, p. 164.

raised, with the exception of wheat, which does not ripen, and the dates for planting and reaping, are much the same as those previously stated for Fort Providence. Potatoes are usually planted between the 15th and 20th of May, but this season (1888) were not put in, owing to the unusually late spring, until the 28th, and require about four months to mature. In an ordinary year forty bushels of seed will yield from six to seven hundred bushels, but the crops are sometimes injured by summer frosts. Barley, which is the only cereal grown, is sown about the 20th of May, and is usually ripe by the 20th of September. No difficulty is experienced in raising such garden vegetables as cabbages, turnips, beets, &c., and Mr. Camsell seemed sanguine that even melons and tomatoes would ripen if properly tried. The soil here is a stiff clay loam.

Warm weather. The warm weather which commenced on the 1st of May continued throughout the month, and under its influence the snow quickly disappeared, and the spring advanced with astonishing rapidity. On the 20th of April, the first day the temperature rose above freezing point for nearly six months, the barking crow (*Corvus Americanus*) made its appearance. The raven (*Corvus corax*) had remained throughout the winter. On the 1st of May some Canada geese (*Branta Canadensis*) were seen at the edge of an open place in the river, accompanied by a flock of mergansers and other ducks. The 4th brought the robin (*Turdus migratorious*) and some sparrows, and on the 5th the wavies (*Anser hyperboreus*) which usually lag a few days in the rear of the Canada geese, commenced to wing their way northwards, and in a couple of days were passing in such numbers that flocks were rarely out of sight. The first goose was shot at the fort on the 5th, the successful marksman receiving, according to immemorial custom at the Hudson's Bay establishments, a present of a pound each of the two luxuries of the country, tea and tobacco. By the 10th the ground was bare in many places, and such late birds as the swallow and plover had arrived.

DISRUPTION OF THE LIARD ICE.

Break up of the ice on northward flowing streams.

On the 13th, the great event of the spring at Fort Simpson, the disruption of the ice on the Liard occurred.

Northward flowing rivers, like the Liard, relieve themselves from their winter fetters in a somewhat peculiar but forcible manner. The influence of the advancing spring is first felt near their sources, and as they break up there the fragments of ice are floated down, until they come in contact with the firm ice, where dams are formed, behind which the water accumulates until it acquires sufficient power to burst the icy barriers, and in the onrush of the escaping flood the river is usually cleared for some miles below. Another ice dam is then formed and broken in turn, and the same operation is repeated at intervals all the way to the sea. If the dam forms where the river is confined between high banks, while the country above is lower, destructive floods are apt to result, and it is this fact which creates a general feeling of uneasiness at those posts along the river which have low situations, until the danger is past. Fort Simpson has never been injured in the fifty years or so of its existence on the present site, although on one occasion the water overflowed the bank, but Fort Good Hope in 1836 was entirely destroyed, and Fort Liard and some of the other posts have been seriously threatened.

Liard ice comes down.

The breaking up of the ice at the junction of the Liard and the Mackenzie is worth witnessing. The first shove occurred about noon, and was announced by a dull roar coming from the direction of the *Gros Cap*. On hurrying out we found that the Liard ice, which a few moments before had formed an unbroken sheet, was now crushed into fragments, and was moving slowly forwards. Huge cakes of ice under the enormous pressure were constantly raising themselves on end and falling, and the whole mass urged forward by the terrible energy of the piled-up waters behind, was battering a way across the Mackenzie. The ice of the latter, fully five feet thick, and firm and solid as in midwinter, was cut through like cardboard, and in a few moments two lanes were formed across its entire width, while a third was opened for some distance below, before the force of the rush was exhausted and the movement ceased. In the afternoon the crashing of trees, in a channel behind the island, concealed from view by the intervening forest, was distinctly heard, and showed that a temporary vent had been found there, and in front of the fort intermittent fountains played at intervals from holes and crevices in the ice. At midnight the dam at the mouth of the Liard gave way, and the massive crystal structure was hurled by the liquid energy behind it against the firm ice in front with such force that the whole sheet, for some miles below the fort, was crushed into fragments by the impetuosity of the assault. After the break a stream of icy hummocks poured in tumultuous confusion past the fort. The velocity of the stream, however, gradually diminished as the river became choked below with cakes of ice, and soon ceased altogether. The situation on the island was now somewhat critical, as on the strength, or rather weakness, of the newly formed dam, depended our safety. If it was able to withstand a pressure of forty feet of water, no uncommon event, the island, from which there was no escape, would be submerged. Slowly but steadily the water with its icy load crept up the slopes, until the crests of the hummocks peered ominously over the banks. An interval of anxious suspense followed, during which the water rose within a foot of the surface, and then to our intense relief the ice commenced to move down the river, a sure sign that the dam below was broken. After the shove the water fell quickly and all danger of a flood was over.

In the lower part of the river the ice was broken up at Fort Wrigley on the 18th May, at Fort Norman on the 19th, and at Fort Good Hope on the 21st. The ice on the river above Fort Simpson, between the mouth of the Liard and Great Slave Lake did not, however, move until after the 1st of June.

Fort Simpson to Fort Norman.

Leave Fort Simpson.

On the 28th of May I left Fort Simpson with a couple of Indians whom Mr. Camsell had engaged to accompany me as far as Fort McPherson, and commenced the descent of the Mackenzie. The river was still full of floating ice, and wherever jams had occurred high cliffs of the same material lined the banks and were constantly falling in as they became undermined by the water, which had now a temperature of several degrees above freezing point. These ice cliffs at this season of the year have sometimes a continuous stretch of ten to fifteen miles along the banks, and on one or two occasions we were almost swamped by sudden squalls before we could get past them and find a landing place. Opposite Fort Simpson the main channel of the Mackenzie is almost exactly a mile wide, and it maintains and often exceeds this width for many miles below. Its course, as far as the Great Bend, a distance of seventy miles, is N.N.W., and its current in average stages of the water has a velocity of about four miles an hour. The banks of the valley appear low owing to the great size of the river, but in reality have often a height of two hundred feet or over. The appearance of this part of the Mackenzie, and of the unending spruce forests which border it is monotonous and uninteresting, and is only relieved by the majesty inseparable from the silent sweep of a river of its magnitude.

Ice cliffs.

Appearance of river.

Rocks along valley.

Four miles below the fort on the right hand bank is an exposure of the same Devonian shales which were noticed opposite the mouth of the Liard. They are overlain by arenaceous boulder-clay and by sand. Two miles farther down, Martin River comes in from the south, and below it are sections of stratified sands belonging to the upper part of the glacial deposits. Scarped banks, showing boulder-clay overlaid by sands, appeared at intervals as we descended the river, but no further exposures of the underlying rocks were noticed until the Great Bend was reached.

Twenty miles or so above the Great Bend the elevation of the country suddenly decreases, and we enter a flat plain, evidently alluvial in its origin, which extends almost to the foot of the mountains. The river here widens out and encloses numerous islands, and its banks are low and sandy. The Liard crosses a similar plain in that part of its course where it skirts the Rockies, and the two plains as stated in the description of that river may be connected by a continuous depression running along the base of the mountains. **Alluvial plain.**

The Nahanni River joins the Mackenzie at the Great Bend. This stream is reported to head near the sources of a second stream of the same name, which empties into the Liard at the Nahanni butte, and canoes can be taken from one to the other. It is upwards of a quarter of a mile wide at its mouth, but is shallow and filled with islands and gravel bars. **Nahanni River.**

After leaving Fort Simpson the Mackenzie gradually approaches the mountains, and at the Great Bend it strikes against them, and is then deflected to the north. I spent a day here on a tramp inland. A walk of about four miles across a marshy spruce-covered plain intersected with muskegs, and over numerous drifts of fast melting snow, brought us to the foot of the mountain, and a further walk of a mile up a gradually increasing gradient to the cliffs which lined its summit, where a stiff climb of about 500 feet awaited us, or rather one of us, as the Indian I had brought along declined risking his neck and remained below. The mountain I ascended has a height above the river, measured by the aneroid barometer of 3,000 feet, but is greatly exceeded in this respect by some of the ranges in the rear, which must approach 5,000 feet in height. From the summit the usual prospect presented itself. To the N. E. a vast expanse of forested country deversified with occasional lakes and marshes spread beyond the line of sight, and in an opposite direction appeared a multitudinous succession of partly snow-clad limestone ridges. The limestones here have a general westerly dip at low inclinations, and in some of the flat-topped ranges of the interior appear to become nearly horizontal. **A walk inland.**

The first range at this point, the only one I had an opportunity of examining, is composed throughout of a great series of magnesian and ordinary limestones. The lowest beds seen consist mainly of heavily bedded dolomites of the Castle Mountain type alternating with some limestone. The dolomites are rather coarse-grained as a rule, faintly striped in places, and some beds are cavernous, the interior of the cavities being lined in some cases with quartz crystals, and in others **Rocks in mountains.**

with calc spar. In the upper part of the section the dolomites are replaced to a great extent by greyish limestones, but are never entirely absent. No fossils were obtained in the lower part of the section, and the upper beds yielded only some badly preserved corals, somewhat resembling those which characterize the Intermediate limestone of the Bow River section. The whole series is evidently older than the flat lying Devonian shales and associated limestones exposed along the river, and I have little hesitation in referring the lower part of it at least, mainly on lithological grounds, to the widely distributed Castle Mountain group. The upper part has a greater resemblance to the Intermediate limestone, and probably belongs to the lower part of the Devonian.

On the way back to the river I found *Anemone patens,* the first flower of the season (May 31), in full bloom in sunny exposures along the base of the mountains.

Continue on down river.

On June 1st we continued on down the river, and after passing the mouth of the Nahanni River bent away to the north. The river is now bordered on the left, at a distance of three to four miles, by lofty ranges of steep-faced mountains, and on the right by a wooded plain. Twelve miles below the Nahanni River we passed the mouth of a large stream coming in from the west, and twenty miles farther on, after travelling for some distance behind a long island, reached Willow River. Since leaving the Great Bend the banks have been low, and with the exception of boulder-clays have afforded no exposures.

Mackenzie enters mountains.

At Willow River the Mackenzie may be said to enter the mountains, as a range, low at first, but soon attaining a height of 4,000 feet or over, now appears on the right-hand side. This range does not cross the river, and must mark the beginning of an entirely new line of disturbance. It affords a good example of the *echelon* arrangement so frequently affected by the Rockies. On the left-hand side, the mountains have receded to some distance from the river, and are flanked by a high wooded ridge, behind which some naked limestone peaks can be seen.

Four miles below Willow River a high hill abuts against the right-hand bank of the Mackenzie, the face of which is scored by a deep coulée, cut out of soft dark shales, interstratified with some ironstone. These shales are unfossiliferous, but resemble exactly some which I afterwards found below the "Rock by the River side," and which held Devonian fossils. Fifteen miles farther down we reached Fort Wrigley, an outpost of Fort Simpson. Opposite the fort are a couple of small islands, built of heavily bedded dark grey limestone, holding *Zaphrentis* and *Atrypa.* Between the islands and the right-hand bank

Fort Wrigley.

rapids are stated to occur in low water, but they are not evident when the river is in flood.

River below Fort Wrigley.

Seven miles below Fort Wrigley, stratified sands and gravels, cemented by carbonate of lime into a hard conglomerate, were observed to overlie the boulder-clay. The river at this point has a width of three-quarters of a mile and a current of five miles an hour. The valley is about 500 feet deep. Rugged ranges of lofty mountains border it on either hand at a distance of about fifteen miles, and are separated from it by a plain relieved occasionally by isolated hills, small ridges and plateau edges. Four miles below the conglomerates just noted an exposure of Devonian shales occurs, below which boulder-clay and associated sands and gravels occupy the banks all the way to near the "Rock by the River side." Three miles above this rock are a couple of well marked terraces. These form a somewhat unusual feature in the structure of the valley and were noticed and described by Richardson.*

"Three miles higher up the stream there are two river terraces, more complete than any I noticed elsewhere on the Mackenzie, though in many places a high and low bank can be traced. These terraces are composed of fine sand, and the slope between them is so steep as to require to be ascended on all fours. Both terraces are very regular in their outline, and are covered with well grown *Pinus Banksiana*. The uppermost is about two hundred and fifty feet above the river."

Rock by the River side.

The "Rock by the River side" was ascended in 1789 by Sir Alexander Mackenzie. It forms part of a small range which crosses the river here in a direction somewhat diagonal to the general course of the main ranges. It presents a steep face towards the river, above which it rises to a height of 1,500 feet. This hill is built mainly of limestones, striking almost north and south, and dipping to the west at an angle of between 60 and 70 degrees. The lowest rocks seen here consist of unfossiliferous dolomites, associated with some hard quartzites, all of which I referred to the Castle Mountain group. Above these come a couple of thousand feet of the greyish and bluish well bedded limestones of the Devonian. Some of the beds of this terrane are almost exclusively composed of corals of various kinds, and in others I obtained some specimens of *Productella aculeata*, var. *cataracta*, an *Actinopteria*; a *Paracyclas*, a fragment of a *Gyroceras*, and the pygidia of a couple of trilobites.

Some of this limestone is slightly bituminous, and a mineral spring said by Richardson to resemble sea water in its composition, trickles down over its face.

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* Journal of a Boat Voyage through Rupert's Land. Vol. I, p. 185.

Immediately below the "Rock by the River side" is a section showing stratified sands and gravels, overlaid by a heavy bed of typical boulder-clay. Those beds occupy the same position as the pre-glacial gravels so extensively developed in the basin of the Saskatchewan, and to which I have elsewhere applied the name of the Saskatchewan gravels, and it will be as well to retain the same name for them here. On the southern plains this gravel is composed almost exclusively of quartzite pebbles, but here it contains in addition pebbles of limestone and of gneiss and granite, all well rolled. Six miles below the "Rock by the River side" is a cut bank about 250 feet high, showing dark greyish shales, interstratified with ironstone and holding Devonian fossils. These shales are horizontal, but are soon cut off by a pre-glacial depression filled with stratified sands and gravels. Six miles farther down exposures of greyish-green Devonian shales appear again and recur at intervals for several miles, and are then succeeded by the stratified sands and gravels of the drift which continue to the Blackwater and beyond.

Saskatchewan gravels.

Visit plateau.

Ten miles above the Blackwater a visit was made to a small plateau which here borders the river at a distance of three or four miles, and which showed exposures, which from the river resembled sandstone. The valley of the Mackenzie here has a depth of two hundred feet. After leaving it we crossed a level plain which stretches eastwards to the foot of the plateau. This plain proved to be exceedingly wet and swampy, and most of the way across we were wading knee-deep through yielding moss or ice-cold water. It is partially wooded with small pine, spruce, aspen and tamarac, none of which have a diameter exceeding six inches. At the foot of the plateau *Anemone patens* and *A. parviflora* were found in bloom (June 6). The plateau faces westwards, with a height of 1,000 feet above the plain at its base, and is built of westerly dipping Devonian limestones. From the top of the plateau, the main range of the Rocky Mountains, which is here too far from the left bank of the river to be seen from the valley, came into sight, while in an opposite direction a good view was obtained of the rocky range which borders the river to the east. The plain between these ranges, through which the river flows, has a width of sixty or seventy miles. It shows numerous lines of wooded heights running parallel with the river, but possesses no conspicuous elevations.

View from plateau.

The Blackwater.

The Blackwater has a width of seventy-five yards. It is the outlet of a lake situated on the farther side of the range east of the river. Two miles below the Blackwater the Mackenzie makes a sudden bend of three miles to the left, below which it receives from the west a stream about a hundred yards in width, the name of which I was unable to obtain. The banks of the valley around the bend are about three hundred feet in height, and show boulder-clay overlying sixty feet of Saskatchewan gravels and passing upward into yellowish stratified silts.

Three miles below the bend is a section of greyish sandy shales, overlaid by soft greyish and yellowish sandstone, which I have little doubt represents the Cretaceous. The beds enclose layers and solitary nodules of ironstone, and have a thickness of three hundred feet. No fossils were obtained here, but somewhat similar beds further down the river yielded fragments of the test of an *Inoceramus*. After entering the Cretaceous basin, the proportion of sandstone and quartzite pebbles in the wash of the stream and in the banks becomes greatly increased. The Cretaceous beds here are horizontal, and have suffered much from pre-glacial denudation. Three miles below the exposure first noted, an eroded trough in their surface is filled with 140 feet of Saskatchewan gravels, topped with fifty feet of boulder clay. The Saskatchewan gravels here hold rounded quartzite pebbles from the size of a man's head downwards. These gravels in some places form two thick bands, separated by sandy beds, but in other places sand and pebble beds alternate throughout the section. Three miles farther down, Cretaceous beds are again exposed on the left bank of the river and consist here of two hundred feet of sandy shales, bluish and yellowish sandstone and ironstone. Some of the sandstone beds were coated with selenite, and crystals of the same mineral were found scattered over the surface of the section. Fragments of *Inocerami* occur in this section. The Cretaceous beds do not extend far east of the river, as limestone was found in a ridge which follows the river at a distance of about four miles. West of the river its limits were not observed, but it probably covers most of the plain which intervenes between the river and the mountains. This plain has here a width of about forty miles. Cretaceous section.

Proceeding down the river, boulder-clay and associated beds are frequently exposed, but sections of Cretaceous rocks were not again observed.

Twelve miles below the Cretaceous outcrop a large stream joins the Mackenzie from the west, which Petitot marks on his map as the Rivière du Gravois. Below it the river dilates to a couple of miles in width, and encloses some large islands. Along this part of the river a range of lofty mountains, culminating in Mount Clark, a flat topped elevation from 3,000 to 4,000 feet high, runs parallel with the river on the east, at a distance of eight to ten miles; but on the west the mountains are so distant that only occasional glimpses of the highest peaks, faintly outlined against the horizon, can be obtained. Mount Clark.

Dark boulder clays.

For some miles below Rivière du Gravois the banks of the Mackenzie are formed of a dark plastic clay, eminently liable to slides, which at a distance resembles the Pierre shales, but on closer examination proved to be a boulder-clay. This clay in places is interstratified with beds of gravel, and for long reaches is almost destitute of boulders. It is from two to three hundred feet thick, and is overlain by stratified sandy deposits. It is underlain by the Saskatchewan gravels, small exposures of which are occasionally seen at the water level. A layer of flattened gneissic and quartzose boulders was noticed in some instances at the base of the clay. The pebbles of the Saskatchewan gravels in the neighborhood of Bear Lake River include occasional examples of a hard reddish shale, which closely resembles the rocks of the Nepigon series of the Lake Superior district, and possibly indicate the presence of a Cambrian area somewhere in the neighborhood

Old Fort Norman.

A few miles below the Rivière du Gravois we pass on the left the site on which Fort Norman stood at the time of Richardson's journey. The fort has since been removed to the mouth of Bear Lake River. A couple of miles below the old site, I noticed in the eastern bank a thick bed of marl, destitute of stratification and filled with fresh water shells. It lies above the boulder clay, and is now covered with a thick coating of moss. The river here and for some miles below is from two to three miles in width, and divides around an almost continuous series of alluvial islands. At this season of the year the passage of these islands in small boats is attended with some danger. The soil above the river is still frozen, while below the surface of the water it is gradually thawed out and carried away. The unsupported mass above frequently breaks off, and is precipitated into the water with a violence sufficient, in some cases, to produce huge waves, which often sweep the river with great impetuosity from side to side. On the night of the 8th of June we were awakened by a loud roar, and hurrying out could see through the gloom a white mass travelling rapidly towards us. A moment later, although we were fully fifty feet from the shore, we were standing ankle deep in water. Our boat, which fortunately was well secured, escaped uninjured, but this was entirely due to the fact that a submerged bar, a hundred yards from the shore, broke to a large extent the force of the wave. The next morning we found that a narrow strip of land, fully half a mile long, had detached itself from an island directly opposite our camp, and had fallen into the water.

Numerous islands.

Land-slides.

Opposite the islands the banks of the valley have been broken down by numerous land-slides, and rise in a succession of irregular steps. The bare clayey slopes are covered in places with saline efforesence, and in this and other respects simulate so exactly the ruinous appearance of banks formed of Pierre shales, that I had to land at several points in order to assure myself that this was not the case. Pebbles and boulders are much scarcer in this clay than is usually the case with boulder clays, but a careful examination of a section usually revealed their presence in some quantities.

Bear River Tertiary.

About twenty miles below the site of old Fort Norman, the soft clays and sands of the Bear River Tertiary beds appear in the banks. Reddish burnt shales were found along the beach some miles farther up, and indicate an extension of the basin towards the south, but the beds are hidden in this direction beneath boulder-clay slides. The first good sections met with in descending the river occur on the left bank, about twenty-four miles above the mouth of Bear River. My attention was drawn to this section by the presence in it of a conspicuous white bed, which is noticeable from the opposite side of the river. Tertiary beds are exposed here along the banks of the river for a distance of two miles. They dip up stream at the rate of about a hundred feet to the mile, and have a minimum thickness of four hundred feet. The lowest seen consist of yellowish and greyish, slightly indurated sands. The sands show cross-bedding, and hold occasional layers of pebbles. They are overlaid by thirty or forty feet of bluish and yellowish sandy shales, above which comes three to four feet of woody lignite. The lignite is succeeded by a thin bed of yellowish clay, and then by fifteen feet of a whitish-weathering arenaceous shale. This shale is very soft, and towards its base is rich in fossil leaves. The beds above the leaf shales consist of clays, sands and a couple of beds of lignite, each three to four feet thick, but they are not very well exposed. The lignite has been burnt in many places, and has hardened and reddened the enclosing shales. These baked shales when separated often exhibit beautiful impressions of leaves and fruits. The various beds are extremely irregular both in thickness and composition, and in passing along the strike, thick beds soon thin out and disappear, and clays, sands and pebbles are found to succeed one another with great rapidity. A noticeable feature of the section is the slight induration to which the various beds have been subjected. Some of the sandy layers are as loose as the sand on the bars in the present river channel, and none are hard enough to resist crushing between the fingers. In this respect and also in their lithological composition, the beds here bear a closer resemblance to the Miocene

Bear River Tertiary beds.

Description of beds.

of the Cypress Hills and Swift Current Creek plareaus than to the Laramie. The following section illustrates the alteration of the beds:—

	Feet.	Inches.
1. Reddish baked shale	2	..
2. Cream-colored baked clay	0	9
3. Greyish sand	3	..
4. Fossil wood	1	..
5. Yellowish clay	1	6
6. Whitish-weathering sandy shales holding fossil leaves	15	..
7. Sulphur-yellow clay	0	2
8. Woody lignite	4	..
9. Sandy clay	30	..
10. Lignite	3	..
11. False bedded yellowish and greyish sands, with layers of pebbles (lowest beds exposed)	40	..
	100	5

Fossil leaves and fruits.

In bed No. 6 a number of fossil leaves and fruits was collected. On my return these were placed in the hands of Sir William Dawson, and furnished the subject of a short paper which was read by him before the Royal Society of Canada, from which I extract the following:—*

POPULUS ARCTICA, *Heer*.—This is much the most abundant species in Mr. McConnell's collection, and seems to show that then, as now, this genus was dominant. This is an European, as well as an American and Greenland species, and presents a great variety in the size and forms of the leaves which has given rise to the formation of several species. Mr. McConnell's specimens show a great number of gradations in form, from a broad oval to a very broad reniform, and in size from one inch to four in diameter. Its occurrence in the Laramie of western Canada is noticed in my paper on Laramie plants (Trans. Roy. Soc. Can., 1886).

There seems to be some uncertainty as to the reference of this leaf to *Populus*. Saporta thinks that it may really be a *Menospermum*, allied to the modern M. *Virginicum*. If a poplar, it is remarkable that its nearest living ally seems to be P. *Euphratica* of the banks of the Euphrates and Jordan.

POPULUS ARCTICA, *var*. LATIOR.

POPULUS HOOKERI, *Heer*.—This species, found thus far only at Mackenzie River, has small leaves resembling those of P. *Arctica* in form, but differing somewhat in venation, in which it approaches slightly to P. *tremuloides*, the common aspen.

* Transactions of the Royal Society of Canada, Vol. VII., Section iv., 1889.

TAXITES OLRIKI, *Heer*.—This large and beautiful Taxine plant occurs in the Eocene of Europe, and is found also in Alaska and Greenland. It is abundant in the collections of Dr. Selwyn from Souris River, described by me in the Report of the Geological Survey of Canada (1879-80). It does not seem as yet to have been recognized in the United States, and is probably a distinctively northern form. It is said by Schimper to resemble closely a species of *Cephalotaxus* found in China and Japan.

SEQUOIA LANGSDORFII, *Brongt*.—This species is very widely distributed in time and space, if all the forms referred to it are really of one species. It ranges from the Upper Cretaceous into the Miocene, and in reality is not very remote in its characters from the living *Sequoia sempervirens* of California, which may be a modern variety. It occurs in Greenland, in the Laramie of various places in the United States, and is widely distributed in Europe. Both leafy twigs and remains of cones occur in the Mackenzie collection. In the Belly River Group of Canada the species S. *Reichenbachii* replaces it, and the species referred to *S. Langsdorfii* from the Upper Cretaceous of Nanaimo, Vancouver Island appears to be *S. Smithiana*, which also occurs in the Kootanie of the Rocky Mountains. It seems therefore uncertain if in Canada it is as old as the Cretaceous, and it may in any case be regarded as specially characteristic of the Upper Laramie or Eocene flora.

PTERIS SITKENSIS, *Heer*.—This fern, not previously collected on the Mackenzie, was originally collected near Sitka in Alaska, and constitutes another link of connection between the flora of the Pacific coast and that of the interior region in the early Eocene age.

NORDENSKIÖLDIA BOREALIS, *Heer*.—This is a beautiful fruit, divided into lobes at top and supposed to be allied to Tiliaceæ. These fruits occur in Greenland and Spitzbergen and have been discovered by Mr. McConnell for the first time in Canada. It is by some referred to the genus *Cistus* or to *Diospyros*.

CARPOLITHES.—Oval, flattened bodies, probably seeds or fruits, about one centimetre in length and without distinct markings. They may be seeds possibly of Taxites, but their affinities for the present must remain uncertain, and I do not give them a specific name, in the hope of additional facts being discovered.

LEGUMINOSITES ? BOREALIS, *Dawson*.—Pods of unequally obovate form, apparently arranged on the side of a stem. They are grooved or ribbed longitudinally, and resemble L. *arachnoides* Lesq., except in their smaller size and broader form. One shows what seems to be the remains of a sheath or calyx.

CALLISTEMOPHYLLUM LATUM, *Dawson.*—Leaf entire, obovate, without petiole. Midrib distinct, secondary veins obsolete; indications of delicate reticulation. This is probably a Myrtaceous leaf and may, provisionally at least, be placed in the genus above named. It seems quite different from the other described species.

PYRITIZED AND FERRUGINOUS WOOD.—The collection contains several branches and portions of stems evidently of Exogenous trees, but in a state of preservation which does not admit of distinct determination. Shroeter, as already stated, has described fossil wood from these beds, one species of which, his *Sequoia Canadensis*, may be the wood of *Sequoia Langsdorffii*. Another is not improbably that of *Platanus Ungeri*. Another of his species of fossil wood is referred to the genus *Ginkgo*, but it may have belonged to *Taxites Olriki*.

After reviewing the evidence afforded by the collections of fossil leaves and fruits which have been brought out by various explorers and examined by Heer and others, Sir William Dawson arrives at the following conclusion:—

Age of beds.

"The general conclusion indicated by the above facts is the strong resemblance of the flora of the Mackenzie River beds with that of the Laramie of other parts of Canada and the United States, and also with the Tertiary of Greenland, Spitzbergen, Alaska and the Hebrides. They thus confirm the inferences as to this similarity, and as to the Lower Eocene age of the Upper Laramie stated by the author in 'The Report on the 49th Parallel' in 1875, in subsequent 'Reports of the Geological Survey,' and in previous volumes of these Transactions."

Lignite seams on fire.

The stratigraphical side of the question will be stated later on. On the right hand side of the river, mud slides derived from the boulder-clay conceal the underlying beds for the next five or six miles, and then the plant beds appear again, and are almost continuously exposed all the way to the mouth of Bear River. The lignite seams in this reach are on fire in several places, and have been burning since the locality was first visited by Sir Alexander Mackenzie, just a century ago. The *bocannes* are now active along the valley for five or six miles only, but reddened shales, baked by former fires, were noticed for a much greater distance. Nine miles above the mouth of Bear River a band of yellowish and greyish soft sandstone, overlain by a great thickness of unstratified clay, forms the side of the valley. A couple of miles farther down sections of the same sandstone, 125 feet in thickness, are exposed. This sandstone is very soft, but has sufficient coherency to enable it to weather in rather steep cliffs. It is filled with pebbles, most of which are under half an inch in diameter, but it also contains some larger ones, ranging in size up to nine or ten inches in diameter. A peculiarity of the larger ones is their flattened spheroidal shape. The pebbles form small beds, running in irregnlar manner through the sandstone, but never extending without interruption for any great distance along the strike. They also occur scattered through the sandstone beds. The pebbles consist mostly of well rolled fragments of quartzite and hard siliceous slate. Gneissic and dioritic examples were also observed, but are not common. An *Ammonite*, probably derived from the Cretaceous beds which underlie the Tertiary farther up the river, was found in the loose conglomerate. It was changed into ironstone, and was almost structureless, but preserved its outer shape. Fragments of the stems and branches of trees fossilified to some extent by iron and frequently surrounded by a carbonized layer, are very abundant in some parts of the section. The structure of the wood in most cases is too imperfectly preserved to admit of identification. Small coaly beds, an inch or so in thickness, and of limited length occur throughout the section. Resting on the sandstone and conglomerate is a layer of gneissic boulders, above which comes fifty feet of almost boulderless boulder-clay. Half a mile farther down the beds become more argillaceous, and hold several seams of lignite, from two to three feet thick, some of which are in an active state of combustion, while others are burnt out. The face of the section here was covered with debris washed down from above, and no accurate measurement of the beds was possible. The most interesting part of this section was under water at the time of my visit, and can only be examined in the autumn. The plant bed from which Richardson obtained his specimens was entirely covered, and this was also the case with the nine foot seam of lignite which he mentions. The edible clay bed referred to by him was just visible below the surface of the water, and a specimen was dug up with the paddle. This clay is of a light yellowish color, and is highly plastic. It is used for whitewashing purposes, and in former times served the Indians as a substitute for soap.

Description of beds.

Plant bed.

Edible clay.

Tertiary beds, similar in character to those just described, extend along the Mackenzie almost to the foot of Bear Mountain. They are then replaced on the right bank of the river, for some miles, by the limestones and shales of the Devonian, but reappear again twelve miles below the mouth of Bear River, and are exposed along the valley for about half a mile, when they finally disappear. At this

Thickness of beds.

point they dip down stream at an angle of fifteen degrees, which would give them a minimum thickness of 600 feet. On the left bank the limestone interruption does not occur, and the section is more continuous.

Distribution of Tertiary beds.

The Bear River Tertiary basin, measured along the Mackenzie, has a length of about forty miles. Its width was not ascertained, but Tertiary beds probably underlie the flat country which borders Bear River for twenty miles above its mouth. They cannot extend more than fifteen or twenty miles in a westerly direction, as a lofty limestone range runs parallel with the river at about that distance. The distribution of the beds is thus limited to an area forty or fifty miles in length, and thirty or forty in width, and may be considerably less.

Age of Tertiary beds.

The beds of this Tertiary basin are evidently lacustral in their origin, and both in lithological character and stratigraphical position have a much closer resemblance to the Miocene (White River) of the Cypress Hills and neighboring areas than to the Laramie with which their fossil flora correlates them. Like the Cypress Hills beds they are characterized by their irregular deposition, by their slight induration and by the large proportion of gravel and pebble beds which they contain, and a further degree of relationship is evidenced by the fact that they both rest unconformably on the beds beneath. Mere lithological similarity in the case of two such widely separated detrital terranes is of very little value in determining age, and in the present instance might be disregarded, were it not supported by the more important feature of a corresponding structural break. In the area of the Great Plains, and even in the Rocky Mountains, the Laramie is everywhere conformable to the Cretaceous beds below, but sustains a discordant relation to the overlying Tertiaries, and it has been found that its termination was synchronous with a widespread elevation of the land and the formation of fresh water lakes, in which the succeeding deposits were laid down. At the mouth of Bear River, instead of a conformable passage from the Cretaceous to the Tertiary, we have evidence that the former was elevated and subjected to a prolonged denudation before the latter was deposited. In order to reconcile the stratigraphical position of the Bear River beds with a Laramie age, it will therefore be necessary to assume that this part of the continent was, towards the end of the Cretaceous period, affected by extensive movements of elevation and depression in which the central part did not participate.

I was delayed a couple of days at Fort Norman, and while there ascended Bear Rock. This elevation is situated in the angle formed by the junction of Bear River with the Mackenzie, and runs in a northerly direction for three or four miles, with a width of about a mile. It was found to have a height of 1,400 feet. From its summit an extensive view over the surrounding country was obtained. The Mackenzie valley here presents the same general features which have characterized it since leaving the great bend. It cuts through a forested plain fifty to sixty miles in width, which is broken by low plateaus and hills, and rimmed in on either side by lofty limestone ranges still wrapped in their winter covering. To the southeast, Mount Clark, forty to fifty miles away, formed the background to a lake-dotted and forest-clad plain which swept up to its base. From the northern shoulder of this mountain a line of lower elevations extended to Bear River, and crossing it continued in a northerly direction beyond the range of sight. Bear River lying almost at our feet, and making a great curve to the left could be traced winding through an almost level plain until it entered and was lost in the wide gap which it has cut through the range detached from Mount Clark. Looking across the river in a southwesterly direction the view was bounded at a distance of twenty-five or thirty miles by an irregular range of limestone peaks and ridges which ran north-west and south-east as far as the eye could reach. A number of streams descending from the mountains united to form a considerable river which, after a short course, empties into the Mackenzie a few miles below Bear River. I was somewhat surprised at the extent and apparent thickness of the snow fields, which still covered the flanks and summits of the higher elevations, but on enquiry was informed that they all disappear before the end of the summer.

Ascend Bear Rock.

View from Bear Rock.

Bear Rock is separated from the main range, and is built of limestones, quartzites and shales, bent into the form of an anticlinal. A small stream cuts deeply into the heart of the mountain and exposes a very good section. The lowest beds seen consist of reddish and greenish shales, alternating with layers of pink colored gypsum, and cut by numerous veins and seams of a white fibrous variety of the same mineral. The gypsum in parts of the section replaces the shales almost altogether, and the layers are separated by mere films of greenish and reddish argilaceous material. The base of the gypsiferous shales was not seen, but they are at least several hundred feet in thickness. They are overlain by a series of dolomites, quartzites and limestones six to seven hundred feet thick, and then by the bluish coral bearing limestones of the Devonian. Some of the limestone is bituminous, and emits a fetid odor when struck, and Franklin states

Structure of Bear Rock

Gypsum.

that he saw* "sulphureous springs and streams of mineral pitch issuing from the lower parts of the limestone strata." These were not seen by Richardson when he descended the river in 1826, on account of the height of the water, and they were also hidden at the time of my visit.

Fort Norman to Fort Good Hope.

Leave Fort Norman.

We left Fort Norman on the 12th of June, and crossing the clear, cold water of Bear River paddled along the base of Bear Rock and continued our way down the Mackenzie. At this date the trees were still leafless, but the various species of willows and birches had hung out their catkins, and the early flowering anemones, accompanied by *Hedysarum boreale*, *Lupinus arcticus*, *Potentilla nivea* and others, brightened the valley with color. Blocks of ice, accumulated in places into cliffs, still lined the shores, but were fast disappearing.

Mackenzie below Fort Norman.

From the mouth of Bear River the Mackenzie runs in a general west-north-westerly direction for eighty miles to Roche Carcajou, and then turns due west towards the East and West Mountains of the rapid. In this distance it has an average width of over a mile, and occasionally expands around islands to over ten miles in width. Its current is at the rate of three or four miles an hour. Rugged limestone ranges are visible all along this reach on both sides of the river, but seldom approach within thirty miles of each other. The plains between and lower slopes of the mountain are continuously clothed with forests of small spruce and aspen. The depression in which the river flows has a depth of from one to four hundred feet and a width of from two to three miles. River flats are seldom present, and the banks of the valley slope more or less steeply up from the edge of the water.

Below Bear River, as stated before, the Bear River Tertiary beds are exposed in the banks of the valley for a mile or more, and are then replaced by Devonian limestones brought up by the Bear Mountain anticlinal. This uplift must have been produced, at least partially, in post-Tertiary times, as it has affected the plant beds to some extent. In their reappearance some distance farther down they are found dipping down the river, or away from the north-western limb of the anticlinal, while in the upper part of the basin they dip at a small angle in the opposite direction.

Age of uplift.

Twelve miles below the mouth of the river we cross the north-western boundary of the Tertiary basin, and three miles farther on

* See Appendix to Franklin's second journey.

Devonian shales are exposed in the banks on the left-hand side of the river. These shales are horizontal, and are overlain by some soft shales, sandstone and nodular beds holding fossil oysters, which are probably of Cretaceous age. In the next twenty-five miles small sections of bluish shale, shaly sandstones and limestones, holding Devonian fossils, are exposed at intervals. Farther down this series sinks below the surface, and is succeeded by post-Tertiary sands, gravels and shales, which resemble in appearance the Tertiary beds at the mouth of Bear River, but are distinguished from them by holding fragments of lignite, which are evidently derived from the latter. They are overlain by soft marly beds, holding recent fresh-water shells. The river here is over two miles wide, but is obstructed by numerous islands and bars. In the next interval of ten miles there are no exposures, and then scarped banks appear again. Here the rocks consist of rusty, reddish-weathering shales, interstratified with small beds of sandstone and ironstone, and holding fragments of *Inocerami* of Cretaceous age. These rocks are very similar to the Cretaceous beds found above the Bear River Tertiary area, and probably represent a part of the same basin cut off by denudation. Rocks below Fort Norman

Below this exposure the beach is shelving, and at the time of our visit was covered with great blocks of ice, piled up so as to form a vertical cliff facing the river twenty to thirty feet high, and extending in an unbroken line for miles. While passing along this a strong gale sprang up, blowing directly across the river, which is here over a mile and-a-half wide, and placed us in a position of some danger. The ice cliffs, from which great blocks were constantly falling, prevented us from landing, while the waves, becoming momentarily larger, threatened to swamp our overladen boat, and we were only kept afloat by incessant bailing. The severity of the gale rendered any attempt to gain the opposite shore hopeless, and our only chance of safety lay in finding, and that speedily, a break in the ice wall, which stretched out apparently interminably before us. Fortunately for us, such a break, formed by a small side stream which had cut its way through the icy embankment, was soon reached. These ice cliffs are the remains of ice dams formed when the river is breaking up in the spring. When the dam is forced by the pressure of the water behind, the central part floats away, but the masses which have been shoved up on the shore remain there until melted by the sun. Ice cliff. Sudden gale.

Near the mouth of the river at which we landed, is a small cliff formed of a yellowish-weathering coralline limestone. Some of the beds are brecciated, and the appearance of the whole section is remarkably like that seen at the mouth of Buffalo River on Great Slave Lake. Three Coralline limestone.

miles below this section the river widens out, and shortly afterwards Cretaceous shales appear in the bank, and are then continuously exposed all the way to Roche Carcajou, a distance of over fifteen miles. The shales are dark in color, and enclose numerous nodules and nodular beds of ironstone. Some of the nodules when broken afforded specimens of *Ammonites* and *Inocerami.*

Cretaceous shales.

Roche Carcajou* rises about a thousand feet above the river, and is formed by an uplift of the Devonian limestones. On the south-western side of the anticline the beds plunge steeply down towards the river, but to the north-east the dip is much easier. Cretaceous beds rest on the flanks of the hill, and on the opposite side of the river the banks of the valley exhibit the dark shales and bluish sandstones of the same formation.

Roche Carcajou.

Well marked glacial striæ were observed crossing the summit of Roche Carcajou, and striking about fifteen degrees north of west, or nearly in the direction of this portion of the valley of the Mackenzie.

Glacial striae.

North-eastwards from Roche Carcajou, the mountains appear to be broken into a series of short ranges, none of which attain any considerable elevation, but to the south-west a well defined range of rugged peaks can be traced stretching away in a north-westerly direction until they sink below the horizon. This great range, broken at intervals by outflowing streams, has been followed from near Fort Liard on the Liard River, a distance measured in a straight line of nearly five hundred miles. Below this point the river bends away to the north, and the range is not seen again until Peel River is reached.

View from Roche Carcajou.

From Roche Carcajou, the Mackenzie runs almost due west for fifteen miles to the East and West Mountains of the rapid, and then bends more to the north before falling over the Sans Sault Rapid. In the upper part of this reach it is somewhat contracted, but before reaching the mountains it expands considerably, and is split up into several channels by islands. Between the two mountains it contracts again, and continues somewhat narrow as far as the rapid.

River below Roche Carcajou.

The banks of the valley below Roche Carcajou show numerous exposures of the shales and sandstones of the Cretaceous, holding fossiliferous ironstone nodules. At the expansion referred to above the Cretaceous beds are overlaid by post-Tertiary sands.

Cretaceous shales.

The East Mountain of the rapid, like Roche Carcajou, Bear Mountain, and numerous other elevations in the Mackenzie valley, represents an anticlinal uplift of the Devonian limestone. The West Mountain of the rapid is situated at some distance from the river, and was

East Mountain of rapid.

* So called from the fancied resemblance of a weathered knob of rock which stands prominently out from the face of the hill, to the animal of this name.

not closely examined, but as far as could be seen it is of the same nature. At the East Mountain the limestones come down to the river, and are exposed along the shelving shore of the eastern bank for some distance. On the opposite side, the banks when scarped show the shales, sandstones and ironstones of the Cretaceous. The two formations appear to be conformable or nearly so, and have been folded by the same movements.

Sans Sault Rapid.

The Sans Sault Rapid is the most important obstruction to the navigation of the Mackenzie from Great Slave Lake to the sea. In high water the rapid is almost drowned out, and little difficulty is experienced by the steamer *Wrigley* in ascending it, but in low water the fall is greatly increased, and is sufficient to prevent ordinary navigation. Part way down the rapid the river is divided into two channels by an island. The western channel, which we descended, presented at the existing stage of water, nothing beyond an accelerated current. The eastern channel appeared more formidable, and the numerous spots of white water spoke forcibly of sunken rocks and other obstructions.

Cretaceous rocks.

Cretaceous rocks, undulating at low angles, are well exposed on the left bank all along the rapid. As elsewhere they consist of dark shales and sandstones, alternating with some nodular ironstone beds. The latter are sparingly fossiliferous, and yielded an *Inoceramus*, a fragment of an *Ammonite*, a *Camptonectes*, a small *Trigonia* and some other lamellibranch and gasteropod shells, too fragmentary to admit of even generic determination. Five miles below the Sans Sault Rapid, on the right bank, is an exposure of whitish and yellowish sandstone, the age of which is uncertain, overlain by the shales, sandstones and ironstones of the Cretaceous. Some of the beds of sandstone are conglomeritic, and hold pebbles of quartzite and slate, while others enclose fragments of carbonized vegetable remains. Three miles farther down Devonian limestones appear again, and form a projection called Beavertail Point. The limestones are filled with corals, and dip in a westerly direction at an angle of about 15°.

Beavertail Point.

Beavertail Point to the Ramparts.

From Beavertail Point to the Ramparts, a distance of about twenty-five miles, the river is very much expanded, and has an average width of nearly two miles. The banks are generally low, and are principally built of post-Tertiary sands, clays and gravels; but Cretaceous shales and ironstones were also observed at one or two points.

The Ramparts.

The Ramparts form one of the most interesting features of the Mackenzie. For some distance above, the river is expanded beyond its usual size, but here suddenly contracts to about five hundred yards in width, and bending to the east runs for three or four miles between vertical walls of limestone and shale. At the upper end of the gorge the bounding cliffs are a hundred and twenty-five feet in height, but increase towards the lower end to about two hundred and fifty feet.

Current in Ramparts.

The current is steady and runs at the rate of four or five miles an hour. In high water there is no sign of a rapid, but in low water a considerable fall occurs near the head, and it is only with difficulty that York boats are taken up. The caves and turretted rocks mentioned by Franklin* were not seen by me, and were probably covered by the high water. The Ramparts are frequently the scene of great ice jams in the spring, and the dammed-back water is stated to have risen on one occasion, over a hundred feet, and on its recession left a boat stranded on the heights above.

Geology of Ramparts.

Above the Ramparts Cretaceous shales and ironstones are exposed for a couple of miles, dipping at a low angle up the river, but the actual contact of these with the limestones was not seen. At the head of the ramparts Devonian limestones rise from beneath the Cretaceous, and it is through these that the cañon is cut. The limestone undulates at low angles, but also rises steadily in the walls of the cañon as we descend, at the rate of about fifty feet to the mile. In the upper part of the cañon the walls are precipitous, and consist of limestone throughout. The limestones are generally granular in texture and weather to a light cream colour. Some of the upper beds are brecciated and lower down in the band a large proportion of the mass of the rock consists of various species of corals. Thin beds of shale attenuated to mere films in some instances, are interstratified with the limestone, and increase in importance towards the base. This band of limestone has a thickness of between 150 and 200 feet. Part way down the cañon bluish green shales holding beds of limestone at intervals, appear below the limestone band, and increasing gradually in height form the basal part of the walls of the cañon the rest of the way. The banks here weather into a steep slope below, but are crowned with almost vertical cliffs above. These shales are precisely similar to those found in the Liard on Hay River, and underlie a similar limestone. The fossil evidence demonstrates that they occupy the same horizon in the Devonian series. This close resemblance is somewhat remarkable when we bear in mind that the two localities are separated by a distance of five hundred and seventy miles.

Fossils.

The shales and interstratified limestones are filled with corals, brachiopods and other fossils which weather out of the soft rocks in almost

* Second Journey, p. 22.

perfect condition. A large collection was made in the couple of hours which I devoted to this purpose, from among which the following forms have been identified by Mr. Whiteaves:—

Cyathophyllum arcticum, Meek.
Aulophyllum Richardsoni, Meek.
Cystiphyllum Americanum var. *arcticum*, Meek.
Pachypora cervicornis, De Blainville.
Alveolites vallorum. Meek.
Spirorbis omphalodes, Goldfuss.
Cornulites (Ortonia) sublævis, Whiteaves.
Hederella Canadensis, Nicholson.
Paleschara quadrangularis, Nicholson.
Chonetes Logani var. *Aurora*, Hall.
Productella lachrymosa var. *lima*, Conrad.
Orthis striatula, Schlotheim (= *O. Iowensis*, Hall.)
Spirifera glabra, var. *Franklini*, Meek.
Cyrtina Hamiltonensis, Hall.
Atrypa reticularis, Linnæus.
Atrypa reticularis var. *aspera*, Schlotheim.
Rhynchonella pugnus, Martin.
Rhynchonella castanea, Meek.
Pentamerus galeatus, Dalman.
Stringocephalus Burtini, Defrance.
Cryptonella Calvini, Hall and Whitfield.
Rensselæria lævis, Meek, not Hall.
Paracyclas elliptica, Hall.
Straparollus flexistriatus, Whiteaves.

Fort Good Hope.

This fort is situated a short distance below the Ramparts and is the lowest fort on the Mackenzie. It was originally built over one hundred miles lower down, and has been moved several times before the present site was finally selected. It is situated only a few miles south of the Arctic circle, but this does not prevent some gardening from being attempted. Potatoes, turnips and other garden vegetables are raised in some quantity, and even barley has occasionally been ripened, although the ground is permanently frozen three or four feet from the surface. Cattle and poultry are kept at the fort, but the former have to be fed over seven months in the year.

Gardening at Fort Good Hope

I remained at Good Hope a day, and while there ascended a neighbouring hill about three hundred feet high, which promised to afford a

View from hill. view of the surrounding country. From the summit a low ridge running northwards from the Ramparts was noticed, and farther on several peaks in the direction of the Sans Sault Rapid came into view. The range west of the river had completely disappeared, and a tree-covered plain extends to the horizon. Innumerable muskegs and lakes of all sizes could be seen in every direction, and here and there bright patches of yellowish reindeer moss relieved the monotony of the landscape.

Flowering plants. In returning from the hill a number of early flowering plants were collected, among others *Anemone patens*, *A. parviflora*, *A. Richardsoni*, *Draba incana* var. *confusa*, *Potentilla nivea*, *Petasites frigida* and *Plantago maritima*. The birch (*Betula papyrifera*) the willows *Salix rostrata*, *S. glauca*, *S. speciosa*, the red current *Ribes rubrum*, and other shrubs were in bloom (June 17), but the general forest still remained leafless.

Fort Good Hope to the Mouth of Peel River.

Hareskin River. We left Good Hope on the 18th, and continued our journey. Three miles below the fort we passed the mouth of Hareskin River on the right. This stream heads near Great Bear Lake, and was explored by Macfarlane in 1857, on his return from the Anderson River.* Opposite the mouth of the Hareskin the Mackenzie is a mile and a half wide, and has a current of three miles an hour. Three miles below the Hareskin River, Devonian shales are exposed on the right bank. Here they are overlain by the Saskatchewan gravels, on top of which rests the boulder-clay, but two miles farther down the gravels disappear, and the boulder-clay comes directly in contact with the shales. Five miles below, on the opposite side of the river, the shales which are evidently the same as those found at the Ramparts, are overlain by yellowish limestone. In the next twenty-five miles, or as far as the Grand View, Devonian shales overlain occasionally by yellowish-weathering fossiliferous limestones, are exposed at intervals all along. The left bank of the river on this reach is usually low and sloping, but the right is bounded for some miles by high limestone cliffs similar to those at the Ramparts. At the head of the Grand View the cliffs leave the river and bend more to the north. Richardson states that the upper portion of the cliffs consists of sandstones and shales, which, from his description, evidently belong to the Cretaceous. Where I examined them limestone alone was seen, but it is possible that this may be capped in places by outliers of the Cretaceous rocks which rest on the Devonian limestones above the Ramparts.

Rocks in valley below the Ramparts.

* Canadian Record of Science, January. 1890.

The "Grand View" is a name given to an expanded portion of the Mackenzie, about twenty miles in length. The river here is almost straight, but curves gently to the north, and is from two to three miles wide. Its great width gives it more the appearance of a lake than a river, and in no other part of the Mackenzie is the magnitude of the mighty volume of water which this river carries to the sea impressed so forcibly on the mind. The banks are low and the sinuous shorelines show a succession of wooded points stretching out until concealed by the haze of the atmosphere. The bordering plains slope gently down almost to the water's edge, and are covered with a scattered growth of willow, spruce and tamarac, with here and there patches of aspens on the drier ridges. The spruce along part of this reach presents a remarkably stunted and dwarfish appearance, but this is due more to the marshy character of the ground than to climatic severity, as the same tree, straight and well grown, was found much further north. Very little change in the character of the forest was observed in descending the Mackenzie, and with the exception of the banksian pine, (*Pinus Banksiana*) which disappears south of Bear River, the same species, as previously noticed by Richardson, are found from Great Slave Lake to the mouth of Peel River.

The Grand View.

Character of forest.

The rocks exposed along the Grand View consist of dark argillaceous shales, some of which are bituminous, and dark greyish sandy shales. Both varieties are fissile and split easily into large thin plates. The sections are small and the shale outcrops only along the water's edge. It is much harder than the shales at the Ramparts, but evidently belongs to the same horizon. Some fossils were collected here, among which are *Atrypa reticularis, L. A. aspera, Schloth. Productella spinulicosta,* Hall, and a *Proetus,* probably identical with *P. Haldemani,* Hall.

Rocks at the Grand View.

Fifteen miles below the Grand View my attention was attracted by a small plateau situated some distance east of the river, the face of which showed red patches somewhat similar to those occurring in the burnt Tertiary shales at the mouth of Bear River and other places. No sections had been seen for some miles above, and as I was apprehensive of some new formation appearing which might not be exposed in the valley I decided on visiting it. Two hours of extremely difficult walking through tangled willows and small spruce, alternating with flooded muskegs, brought me to the foot of the plateau. It proved to be formed of Devonian shales, associated with some sandstone and shaly limestones, from which I obtained specimens of the ubiquitous *Atrypa reticularis,* and of a few other forms which have not been determined. No lignitic or coaly seams were observed, the burning of which might color the associated rocks, but the shales were found to

Visit plateau.

be highly charged with bitumen, and the red coloration is undoubtedly due to the combustion of this mineral. The fires have not been very intense, as the shales are only reddened on the surface, and are not baked and vitrified like those found near the burnt lignite seams at the mouth of Bear River. Some combustion is evidently going on at the present time, as a distinct bituminous odour was detected near the hill, but no flames or smoke were visible.

Burnt shales.

Eight miles below the plateau just described, stratified sands of the age of the Saskatchewan gravels, overlain by boulder-clay, are exposed in the right bank, and seven miles farther on Devonian shales are again found. The shales here are black in color, evenly bedded and highly bituminous. The laminæ, when freshly separated, are moistened on the surface with an oily liquid, and burn when thrown into the fire, and patches of red shales, marking the sites of former fires, alternate with the dark varieties. The shales are exposed in the right bank for some miles, or almost as far as old Fort Good Hope. They dip down the river at a low angle, and are overlain by the Saskatchewan gravels and boulder-clay.

Bituminous shales.

Saskatchewan gravels.

The material of the Saskatchewan gravels here, while mainly quartzitic, includes also a considerable quantity of gneissic and dioritic pebbles of Archæan origin, the proportion of which seems to increase as we descend the river. In addition to these, large angular masses of the shales and limestone of the underlying Devonian are frequently present, and also small beds and disseminated particles and blocks of lignite derived from the Tertiary. The beds of this terrane are seldom consolidated to any extent, either by pressure or by a cementing agent, and the sands and gravels of which it consists succeed one another in an extremely irregular manner, and when not too coarse almost invariably exhibit cross-bedding and other evidences of rapid deposition.

Character of Mackenzie.

From old Fort Good Hope the Mackenzie bends to the west, and maintains a general westerly course for the next fifty or sixty miles, or almost to the mouth of Red River. In this reach the river has a width of a mile to a mile and-a-half, and a current of from two to three miles an hour. It is bordered by wooded plains, and no mountains are visible on either side, although low escarpments appear at various points. Groves of white spruce were seen along this reach, containing trees measuring over fifteen inches in diameter, but the average tree does not exceed six inches.

Above old Fort Good Hope the Devonian shales dip below the surface of the river and were not seen again, and the valley for some distance shows only the boulder-clay and associated sands and gravel deposits. The boulder-clay is somewhat plastic in places, and shows the same disposition towards landslides which characterized it above the mouth of Bear River. The valley here is about two hundred feet deep, and its banks, when not broken up by slides, present remarkably even slopes, on which I found growing in some abundance the familiar sage bush of the plains, *Artemisia frigida*, along with the juniper and various grasses.

Rocks near old Fort Good Hope

Re-appearance of Cretaceous shales.

Twenty miles below old Fort Good Hope, shales were observed the right bank, which are plainly different from those occurring farther up the river. They are dark greyish in colour, and rather soft, but enclose some harder beds, and pass in places into a shaly sandstone. Some ironstone is also present. No determinable fossils were found here, but the surface of some of the beds is covered in places with fragments of leaves and small carbonized stems of plants. I was at first somewhat doubtful in regard to the horizon of these shales, but evidence obtained afterwards proved them to belong to the Cretaceous. Resting on the shales at this point is a layer of large Archæan boulders, well worn and flattened, above which comes the Saskatchewan sands and gravels. In the next fifteen miles the shales are exposed at a number of points, but proved to be remarkably destitute of fossils. A careful search was made at several favorable looking localities, but nothing was obtained except an almost unrecognizable fragment of an ammonite, which was found at the base of one of the sections.

Below the sections just referred to, an interval of fifteen or twenty miles occurs, in which the banks show only boulder-clay, underlain by Saskatchewan gravels, and then the shales reappear, and are exposed for many miles below. They are harder here than when first seen, and weather into steep cliffs, which line both banks of the valley, and for some miles form a kind of wide cañon, which has received the name of the Lower Ramparts or the Narrows.

Lower Ramparts.

At these Ramparts the valley makes a sudden horse-shoe-shaped bend to the north of ten or twelve miles in length. The river is over half a mile wide at the narrowest point, and for most of the distance exceeds a mile in width. There is no sign of a rapid, and the current has nowhere a rate of over five miles an hour.

Rocks at Lower Ramparts.

The Cretaceous rocks at the Lower Ramparts are horizontal, and consist of dark greyish shales passing into a shaly sandstone, along with more heavily bedded bluish sandstones. The rocks are all somewhat ferruginous and weather to a rusty color. About two hundred feet is exposed. The sandstone holds numerous coaly particles disseminated irregularly through the beds, and in one or two instances by the addition of whitish quartz pebbles, was observed to pass into a fine grained conglomerate. The surfaces of some of the beds are covered with a network of the impressions of narrow leaved plants, but nothing determinable was obtained.

Franklin mentioned the occurrence of limestone in the cliffs at the Narrows, but this, if present, must have been concealed by the high water when I passed through, as it was not noticed.

Loucheux Indians.

Immediately below the Narrows we passed on the left the mouth of Red River, and seven miles farther down came to a large encampment of Loucheux. These Indians have evidently encroached somewhat on the territory of the Eskimo since the days of the early travellers, as Richardson describes the Lower Ramparts as being the boundary at that time. The Loucheux have now a church north of that point, and have undisputed possession of the river as far as Point Separation. I remained over night at the Indian encampment, and before leaving in the morning engaged one of the Loucheux to accompany us in the capacity of interpreter, in case we should fall in with the Eskimo. The Loucheux are on friendly terms with the Eskimo, and most of them can speak the Eskimo language. My crew was now a somewhat heterogenous one, and consisted of a Slave Indian from Fort Simpson, a Hare Indian from Fort Good Hope, and a Loucheux from the mouth of Red River. In order to communicate with the latter I had first to speak to the Fort Simpson Indian, who understood a little English, and he passed it on with some difficulty to the Good Hope Indian, who in turn interpreted it in a more or less changed form to the Loucheux, and the answer was then returned in the same cumbrous manner. The dialects of the various Tinneh tribes scattered along the Mackenzie differ very markedly, and the Indians from the upper part of the river have considerable trouble in making themselves understood by those at the lower posts.

Character of crew.

Reach head of delta.

Ten miles below the Indian encampment we came to what may be considered the head of the delta of the Mackenzie. The Cretaceous shales and sandstones have disappeared, and the banks, now composed of alluvial sands and clays, have decreased in height to fifteen or twenty feet, while the river, which at once opens out to more than ten times its former width, completes its journey to the sea through a network of interlacing channels.

From the head of the enlargement we took the left hand channel and followed it for ten or twelve miles to the mouth of Peel River. The coast here is low and sandy, and is exposed to the full rigour of the arctic storms, and the general vegetation of the bordering plains is stunted and diminutive in appearance, but is relieved by the presence of a few large spruce trees, which look like survivors from an ancient

Character of forest.

and more luxuriant forest. Some of these trees have a girth of over six feet, and are tall and well shaped, while the average spruce in this latitude does not exceed six or seven inches in diameter.

Before reaching Peel River we fell in with a small band of Eskimo who were on their way to Fort Macpherson to make their spring trade. We had been warned that they would probably prove troublesome if we met them returning from the fort, and were, therefore, somewhat relieved to find that the backwardness of the spring had prevented them from ascending the Mackenzie as soon as usual, and that they had not visited the fort yet, and were consequently still on their good behaviour. As soon as we came abreast ot the encampment a small fleet of kyaks were launched and we were soon surrounded by all the males of the party, but beyond a general demand for tobacco they did not offer to molest us in any way.

Fall in with Eskimo.

The Mackenzie River Eskimos, or a part of them at least, spend a few days every spring trading at Fort Macpherson, but with this exception, and the chance meeting with a few travellers, have had little intercourse with white men, and have not been affected by them to any noticeable extent. The forbidding and inhospitable character of the country they inhabit, has not prevented missionaries from endeavouring on one or two occasions to establish themselves among them, but the efforts of these have, up to the present, met with little success. The Mackenzie River Eskimos, unlike their Indian neighbours, do not buy clothing from the traders, and still dress in sealskins, trimmed when possible with the fur of the carcajou, in the manner described by the early travellers. Labrets are still worn in the cheeks, and long, broad bladed knives of their own manufacture carried on all occasions naked in the hands. Bows and arrows are still their principal weapons, but are gradually being replaced by rifles and revolvers obtained in trade to the west, from whalers.

Notes on the Eskimo.

PEEL RIVER.

We entered Peel River shortly after noon on the 23rd of June, and ascended it the same day for eight or ten miles. Towards evening, when preparing to camp, we were somewhat surprised to see a Peterborough canoe shoot around a bend in the stream ahead and rapidly approach us. A moment afterwards we were hailed by a member of Mr. Ogilvie's party, and had the pleasure of learning that that explorer was just behind. He appeared in a second canoe in a few minutes, and the next day being Sunday we decided to allow ourselves a holiday to spend it together. Ogilvie was jubilant at the successful completion of his arduous journey across the mountains, and was congratu-

Enter Peel River.

lating himself that the hardest part of his journey was over, but his description of the rapid current of the Yukon, and the difficulties attending its ascent did not serve to raise my spirits.

We separated on the 25th, and I continued on up the Peel, and arrived at Fort Macpherson the same afternoon.

Peel River splits up before joining the Mackenzie, and enters the latter through several channels. Ten miles above its mouth the various streams unite, and from this on, as far as the fort, it preserves an average width of four or five hundred yards. The current at the time of my visit ran at the rate of four miles an hour. The banks and bordering plains are low, and are formed of alluvial sands and clays. No older rocks were seen until the bluff on which the fort is built was reached. Here shales are exposed which are evidently of Cretaceous age, although no fossils were found. These shales are dark in colour, rather soft, and crumble away under the influence of the weather into a steep talus of small glistening flakes. Scattered through them are numerous small pebble-like concretions of ironstone. The shales are surrounded on all sides by alluvial deposits, and must have formed an island in the sheet of water in which the latter was laid down.

Current of Peel River.

Rocks on Peel River.

Exploration of Peel River.

Peel River, above Fort Macpherson, was explored in 1839 by Mr. Bell, clerk in the employ of the Hudson's Bay Company, and a description of his trip is given in the proceedings of the Royal Geographical Society,* by Mr. Isbister. According to this account the river winds along the base of the mountain through a low alluvial country for thirty miles above the fort. A rapid was then encountered, caused "by a contraction of the banks of the river which here begins to flow over a hard pebbly bottom." Above the rapid the current becomes much swifter, and the river seems gradually to approach the mountains and soon afterwards to enter them. "The banks of the river had now entirely changed their aspect, and instead of through the low, unvarying mud cliffs, with the sombre and cheerless appearance which the recent deposit of alluvium had imparted to them, the water course was not unfrequently through bold romantic defiles, so steep and lofty as often to hide the mid-day sun from view." Mr. Bell ascended the river with boat and canoe as far as it could be navigated, and then continued on up it on foot, until it had dwindled down to an insignificant stream, fifteen or twenty yards in width. The two main feeders he named the Simpson and Macpherson rivers. Peel River has a length of about three hundred miles, and its course is almost parallel to that of the Mackenzie. It is the largest river which empties into the Mackenzie north of the Liard.

* Journal of the Royal Georgaphical Society, Vol. XV., 1845, p. 332.

An interesting result of the explorations of Mr. Bell, is the proof it affords of the continuity of the Rocky Mountains northwards. This range is lost sight of in descending the Mackenzie near the Sans Sault Rapid, and is not seen again until the traveller emerges from the Lower Ramparts, a distance of over three hundred miles, and it has been stated by some geographers that it bends to the west and follows an easterly course through the centre of Alaska. There is little doubt, however, that with the exception of the gap through which the Liard flows this range is continuous from the International Boundary to the shores of the Arctic ocean. Continuity of Rocky Mountains.

Rat River.

Fort Macpherson was reached on the 25th of June, and as the Mackenzie steamer from which I expected to obtain supplies was not expected down until the 10th of July, a short trip was made up Rat River while awaiting its arrival. At the fort I was informed that neither boats nor canoes could be obtained west of the mountains, but that the boat I had used on the Mackenzie might be portaged across by taking it up Rat River and then through the MacDougal pass to Bell River on the other side. This plan was adopted, and five Indians were sent to try to take it across. They made the portage in seven days. Reach Fort Macpherson.

Rat River is represented in Isbister's map of Peel River, published in 1845, in the journal of the Royal Geograpical Society, as rising on the western side of the Rocky Mountains and flowing directly across them. This error was probably caused by the same name being used by the Indians to designate the two streams flowing east and west from the summit of the range. Rat River (east) discharges its waters by two mouths. The north branch empties into one of the delta streams of the Mackenzie, and has not yet been explored, while the south branch joins Peel River about nine miles below Fort Macpherson. When Peel River is in flood the current in the south branch is reversed. Rat River.

Rat River for some miles above its mouth, winds through a flat alluvial plain, forming part of the Peel-Mackenzie delta. Its width is about fifty yards, and the current is uniform and easy. Above this reach it enters a lake region, and for several miles connects by short channels a number of small irregular-shaped willow-fringed lakes lying in shallow depressions in the delta. West of the lake region the declivity of the stream rapidly increases, and a few hours hard paddling brought us to the foot of a series of strong rapids which mark the beginning of the ascent towards the mountains. Leaving our canoe here we tramped eight miles across a marshy plain to the foot of the first range, our objective point. For part of the way we travelled along Leave canoe.

the top of a low narrow ridge, which is probably of morainic origin, and is composed, so far as I could learn from the surface, of quartzite pebbles and boulders carried eastwards from the mountains.

Geology of eastern range of Rockies.

The eastern range of the Rockies where broken through by Rat River, has a nearly north and south trend, and rises to an elevation of about 2,800 feet. It is built throughout of evenly bedded hard sandstones and quartzites, dipping to the east at an angle of about 30°. No fossils were found in rocks *in situ*, but in the wash of Long-stick Creek, a tributary of Rat River, which descends from the same range and was crossed on the way, *Ammonites* and other fossils of Cretaceous age were found. These occur in angular sandstone blocks, evidently derived from the neighbouring mountains, and I have little doubt characterize the formation of which the latter are composed. No limestones, gneisses or granites, were observed.

A sub-angular gneissic boulder, representing the eastern drift, was found on the eastern slope of the mountains at a height of 1,500 feet.

Peel River Portage.

On July 10th I decided not to waste any more time waiting for the steamer, as it was impossible to tell how long it might be delayed, and to trust to the chance of finding supplies at Rampart House. I had sent part of my outfit across by some Indians who were returning to Lapierre House, and Mr. Hodgson, after some trouble, succeeded in engaging five others to accompany me and to carry the remainder. The ordinary load for an Indian on this portage is forty pounds, exclusive of blanket and supplies for the trip, and the tariff for this load is fifteen skins, or seven dollars and a-half, paid in goods. The portage is about sixty miles long, and from four to five days are occupied in the trip.

Indian packers.

Leave Fort Macpherson.

We left the fort late in the afternoon, and ascending the river for a mile and a-half, landed on the opposite side and strapped on our packs, while some dogs owned by the Indians were loaded so heavily that they were unable to climb the bank of the river and had to be assisted up. After leaving the river we marched for three miles through a thick spruce forest, and then reached the steep edge of a terrace about one hundred and fifty feet high, up which we climbed. From the top of the terrace, a swampy plain destitute of trees, but covered with willows chiefly of the species *Salix arctica* and *S. glauca*, stretches west for nearly four miles, and then a second slope, longer and higher than the first, has to be ascended, at the summit of which the barometer registered a height of twelve hundred feet above the river at the fort. At this

Terraces at base of mountains.

elevation the forest has ceased, and the shrubs which occur so abundantly on the first terrace have almost disappeared, and are only represented by an occasional stunted specimen of the arctic willow (*S. arctica*). A small larch (*Larix Americana*) still survives, but barely attains a height of six or eight feet and a diameter of one to two inches.

From the second slope a wide plain reaches westwards to the mountains. The walking here is exceedingly difficult, as the surface is covered with the rounded grassy sods which go in the country by the name of *Tetes des femmes.* These project a foot or more above the clayey soil, and are the cause of constant stumbling which becomes somewhat exasperating when one is weighted down with a pack. An attempt to walk on the top of the mounds soon becomes excessively fatiguing on account of the irregular length of the strides, and a slight miscalculation as to distance precipitates the unlucky traveller down into the muddy depths between. When down, the resolve is usually made, and adhered to for awhile, to keep to the lower levels, but the effort required to step over the intervening hillocks presents obvious disadvantages of a different kind. **Difficult walking.**

A walk of five hours, at the rate of about a mile and a-half an hour, brought us to a deep valley occupied by a swift mountain stream, which we forded, and then camped on the opposite bank. This stream, half a mile below camp, joins a small river which falls into Peel River three or four miles above the fort. Its channel is filled with sandstone, and quartzite slabs derived from its banks and from the neighboring mountains. **Mountain stream.**

On the 11th we climbed out of the valley, and following up the main stream, soon reached the "Gap" from which it emerges from the mountains. A halt of a couple of hours was called here for the purpose of allowing the Indians to add to their store of provisions by killing a mountain sheep which one of them observed on a ledge above. The hunt was successful, and the victim proved to be the interesting *Ovis Montani*, var. *Dalli.* This animal resembles the bighorn of the Rocky Mountains to the south in form, but is much smaller, weighing scarcely a hundred pounds, and its hair, instead of being tawny, is almost a pure white. The change in color and size towards the north is evidently a gradual one, as the saddle-backed sheep of the upper Yukon presents characters intermediate between the two extreme varieties. **Mountain sheep hunt.**

At the "Gap" the pass through the mountains is eight to ten miles in width, but gradually contracts as we advance, and at our second camp, six miles from the mouth, was reduced to about two miles. The en-

Character of mountains. closing mountains are regular in outline and somewhat tame in appearance, and rise to elevations above the valley from one thousand to two thousand five hundred feet. The bottom of the valley and the lower slopes of the mountains are clothed with coarse grasses and mosses, above which project naked and often precipitous quartzite cliffs. The stream which occupies the valley at the present time is insignificant in size, and is doing little or no erosive work, and this great cleft through the hard quartzite strata is evidently the product of an earlier age, marked by a much greater precipitation than the present one.

Wide valley. From our second camp a walk of two miles brought us through the first range and out on a wide longitudinal valley which traverses the mountains in a nearly north and south direction. The stream we had been following up divides here into two branches, and the principal one, reduced now to a large sized brook, bends away to the south. After leaving it the trail leads up a long slope covered with *Tetes des femmes,* and then directly across the valley to an opening in the range ahead. On the farther side of the valley we reached and followed up for a couple of miles a small stream which runs north to Rat River, and directly afterwards crossed the watershed between the Mackenzie and the Yukon and commenced our descent to the latter. The watershed has an elevation measured by the barometer of 2,600 feet above the starting point on Peel River, or about 2,650 above the sea, while the neighboring mountains rise about a thousand feet higher.

Elevation of water-shed.

Two miles west of the watershed the mountains turn suddenly to the north, and the westward-flowing stream which we were following, plunges down a steep decline of fully 1,200 feet. At the base of this declivity it is joined by a large tributary from the south, which swells it to a small river. At the confluence of the two streams is a large flat covered with small groves of the white spruce (*Picea Alba.*) The elevation here is over a thousand feet higher than the point at which this tree disappeared on the eastern side of the range.

High tableland. From the foot of the mountains a high tableland, swelling occasionally into considerable eminences, stretches to the westward. Through this plateau the branch of Bell River, down which the trail leads, has cut a wild and gloomy chasm fully a thousand feet deep. The walls of the cañon are formed of flat-lying sandstones and hard quartzites, and are naked and precipitous above, but fall away in easier slopes below. The bottom of the valley is generally soft and marshy, but hard gravelly terraces, affording good walking, are occasionally crossed. Seven miles from the head of the cañon a large stream comes in from the right, and two miles and a half farther on, a second and more impetuous one pours into the main stream from the same direction. After crossing the latter we camped on some firm ground on the farther side.

On the 13th we continued our way down the cañon. Three miles from camp the river washes up against the walls on the right hand side, and the trail, which has hitherto followed the right bank, crosses over to the left. The ford is a difficult one, as the stream is here deep and rapid, and its channel is paved with treacherous quartzite boulders. The greatest caution is necessary in crossing, as a stumble or false step would almost certainly be fatal to one encumbered with a heavy pack. In fording these swift mountain torrents, it is customary to adopt a communistic plan. The party line up behind a long pole, and keeping a firm hold of it advance into the stream abreast. In this case the person above sustains the full brunt of the current, but is held up by those below, and a stumbler receives the support of those who have kept their footing.

Mode of crossing streams.

Two miles and a half below the ford the flanking plateau drops suddenly several hundred feet in elevation, and the cañon disappears. A second crossing is necessary here, as the river after escaping from the confining walls of the cañon bends away to the south. At this point the river is wide and shallow, and the crossing was made without difficulty. The stony banks were gay with the yellow flowers of *Senecio lugens*. Four miles farther on the river is again encountered returning from its southern bend, and is crossed for the last time. The river is bordered here by a marshy flat, about two miles in width, through which we waded. Beyond the marsh the trail winds up the steep edge of a high terrace, and then a four mile tramp across a succession of muskegs, brought us to the end of this stage of our journey, and we thankfully threw down our packs on the banks of Bell River.

Character of mountains.

The Rocky Mountains, along the Peel River portage, present features which differ greatly from those which characterize them farther to the south. They consist here essentially of two ranges, separated by a wide longitudinal valley, and flanked on either side by high plateaus. The eastern range has a width of seven miles, and its higher peaks were estimated to reach an altitude of 2,500 feet above the level of the pass, or about 4,000 feet above the sea. The western range is much narrower, and north of the pass does not exceed four miles in width, but spreads out somewhat more towards the south. The valley of Peel River, which skirts the eastern base of the range is fully 1,200 feet lower than the valley of Rat River on the western side, and the drainage of the mountains is mostly towards the former.

The geological section obtained is somewhat imperfect, as our scanty

Geological section.

supplies allowed of no delay, but sufficient was learnt to show that the range has on the whole an anticlinal structure, although the general anticline is obscured in places by subordinate folds, and is probably broken by faults. In the eastern plateau the beds are nearly horizontal, but approaching the mountains they incline greatly to the eastwards, and in the centre of the eastern range have dips of from 30° to 70° in the same direction. In the western range the same dip prevails, but the inclination is much less, and the beds flatten out when the mountains are replaced by the elevated western plateau. The horizontal attitude is maintained for some miles, but before reaching the western edge of the plateau the beds bend down and dip gently to the west.

No limestones were observed along this section, and the rocks consist of sandstones, quartzites and shales, all of which are probably referrable to the Cretaceous. At the starting point on Peel River the banks are formed of shales, interbedded with some hard sandstones holding carbonized fragments of wood and leaves. In the first fourteen miles the beds are concealed, but shales and sandstones are again exposed on the banks of the valley in which we made our first camp.

Fossils.

Some fossils were collected here, among which is a *Discina*, like *D. pileolus*, Whiteaves, a *Mactra* and a *Yoldia*, both of which are probably new, but the specimens are too imperfectly preserved to admit of specific determination. Six miles farther west, at the entrance to the "Gap," the trail passes over beds of a bluish, rather compact calcareous sandstone. The beds are coated in places with calc-spar, are highly ferruginous, and weather to a rusty yellow. A *Cardium* and some other poorly preserved fossils were obtained here. In the valley of the river the sandstones are underlain by dark shales. After entering the mountains, only alternating sandstones and quartzites were seen. The beds of this series are greyish in colour, are evenly stratified and are very uniform in appearance all across the range. They have an estimated minimum thickness of 5,000 feet, and may possibly greatly exceed this. The western plateau is built of compact greyish sandstones, passing in places into quartzites, similar to those found in the mountains and evidently belonging to the same formation.

No limestones or schists in mountains.

Both Isbister and Petitot mention limestone, schists, and granites, as being found in this section of the mountains, but these rocks were not seen in the section examined by me, nor were pebbles derived from them found in the wash of any of the streams which we crossed. In the valley of the Mackenzie, however, the Devonian limestones immediately underlie the sandstones and shales of the Cretaceous, and it is highly probable that in parts of the range the disturbance has been sufficient to bring these to the surface.

On arriving at Bell River we crossed over to Lapierre House, which is situated on a flat on the western side, but found the post deserted by all but Indians, the officer in charge having left some time before for Fort Macpherson. Lapierre House is simply an outpost of Fort Macpherson, and is kept up principally to facilitate the transit of goods and furs across the mountains, although some trading is also done both with the Loucheux and the Eskimo. It has been in existence about thirty-five years. No farming of any kind is attempted either here or at Fort Macpherson.

Lapierre House.

The boat which I had sent across the mountains by the McDougal Pass, I was glad to find had reached its destination in good order, and no time was lost in preparing for the descent of Bell River and the Porcupine. My crew down these rivers consisted, besides myself, of one man, an Orkneyman and ex-employé of the Hudson's Bay Company named Skee, whom I met at Fort Macpherson on his way out of the country, and was fortunately able to induce to come with me and go out by way of the Yukon.

Prepare for descent of the Porcupine.

The upper part of Bell River has not been explored. At the fort it is a small sluggish stream of forty to fifty yards in width, and a current of less than two miles an hour. The banks are low and alluvial, and the bordering region is covered with willows, birch, aspen and spruce belonging to the same species as those noticed east of the mountains. Below Lapierre House Bell River runs a few degrees east of south for seven or eight miles, and then bending to the south-west flows by Sinclair's Rock with a somewhat accelerated current, and continues on in the same direction to Stony River, a stream nearly equal in size to itself. From Stony River its course is north-west or nearly opposite to its direction in the first reach, for seven or eight miles, and then it bends gradually around to the south-west, and keeps this course until it empties into the Porcupine. Its length from Lapierre House to its mouth is about thirty miles. Besides Stony River, which comes in from the left, it receives a short distance farther down, from the same side, the waters of Eagle River, a stream of about a hundred feet in width. Below its junction with these two streams Bell River becomes considerably enlarged, and in its lower part expands to about a hundred yards in width. No rapids were met with below Lapierre House, and the current seldom exceeds three miles an hour, and is usually much slower.

Character of Bell River.

The valley of Bell River is shallow, and no rock sections occur in the banks below Lapierre House until the cliff at Sinclair's Rock is reached. At this point the river cuts through a range of hills, and coarse arenaceous shales are uncovered, which probably represent an

Geology of Bell River.

extension of the same beds that in the mountains are hardened into quartzites. The shales are unevenly bedded, and under the influence of the weather crumble into a talus of sharp, angular fragments. For some miles below Sinclair's Rock the banks are formed of alluvial clays and sands, but shales are again exposed about half a mile below Eagle River. The beds here are softer and darker in colour than those found in Sinclair's Rock, and are better stratified and separate into thinner laminæ. They alternate with some beds of sandstone and ironstone. The dip is S. 65° W. $<$. 20°. Beds of a similar character are exposed again four miles farther down. Here they are horizontal when first seen, but in a short distance bend down and assume a vertical attitude. Below this point dark fissile shales, alternating occasionally with beds of sandstone and ironstone, undulate at all angles in the bank of the river, and are almost continuously exposed until within a few miles of the mouth of the river, when they are overlain and concealed by recent clays and sands.

The rocks exposed along Bell River are unfossiliferous, but are closely related lithologically to the Cretaceous shales and sandstones of the lower Mackenzie and the mountains, and I have little hesitation in referring them to the same horizon.

Porcupine River.

Bell River to Driftwood River.

Very little information was available in regard to the Porcupine before the present exploration was undertaken. Short accounts derived from hearsay evidence, are given by Richardson and others, but it was not personally visited by any of the numerous travellers who have written of the Mackenzie and the Yukon, although it has been used by the Hudson's Bay Company as a trade route since 1847, and its navigation presents no special difficulty.

Porcupine River.

The Porcupine heads within thirty miles of the Pelly-Yukon, approximately in latitude 65°.30′ N., and after describing a great semicircular curve to the northeast, falls into the same river a hundred and fifty miles farther down. At its most easterly point it approaches within eighty miles of the Mackenzie, but is separated from it by the main range of the Rocky Mountains. Its total length approximates to five hundred miles.

Exploration of the Porcupine.

The upper part of the Porcupine was explored by Mr. Ogilvie in the early part of the present summer. Ogilvie reached the head of the river by a winter traverse from the Pelly-Yukon, and descended it as far as the mouth of Bell River. An account of this part of the river will be found in his report. The present description treats of the part below Bell River.

From Bell River to Driftwood River, a distance of about thirty miles in a straight line, but over forty by the course of the river, the Porcupine has a general north-westerly trend, but makes a couple of minor bends to the north-east. Its width varies from one hundred and fifty to two hundred yards, and its current barely averages two miles an hour. The valley is generally rather wide and shallow, but at one point about ten miles below Bell River, becomes somewhat contracted, and for some miles has the appearance of a wide cañon. The banks here are high and steep, and are formed of broken fragments of hard quartzite. Below the contraction it resumes its usual character. The bordering country is very uneven and swells in places into hills and ridges, most of which appear to have a northerly trend. None of these elevations attain any considerable altitude, and like the lowlands they are clothed with the same monotonous forest of spruce and aspen which has been so often described. **Character of the Porcupine.**

In this reach the river cuts through a very interesting series of Cretaceous beds, but the haste with which we were travelling prevented me from examining these in as satisfactory a manner as might be desired. In the first ten miles below the mouth of Bell Biver, alluvial sands and clays form the banks of the valley, and then hard sandstones and quartzites appear, and are continuously exposed for the next three miles The sandstones are greyish in colour, very hard, and pass gradually into a compact quartzite. In weathering they break into sharp angular fragments, and the lower slopes of the banks are covered with a steep talus of this material. The dip here is nearly east, and the rocks exposed have a thickness of between three and four thousand feet. **Cretaceous section.** **Sandstone and quartzite series.**

The sandstone series is succeeded and underlain by dark shales interbedded with ironstone. The shales have a light easterly dip, and an approximate thickness of eight hundred feet. They yielded some fossils, among which is a very large belemnite, a finely ribbed ventricose scaphite, which has some resemblance to *Scaphites ventricosus*, and a peculiar ammonitoid shell, which shows a ribbed central portion, while the outer whorl is quite smooth. Mr. Whiteaves states that the fossils are probably Benton, but the specimens are too imperfect to make the correlation certain. **Shale series.**

The shales are exposed for about a mile, and are then replaced by shales, hard shaly sandstones and quartzites, interstratified with occasional conglomeritic beds. The sandstones are often somewhat green-

Sandstone, quartzite and conglomerate series.

ish on a fresh fracture, but weather to a yellowish or rusty colour. These beds are brought up by a light easterly dip from beneath the shales, and occur in frequent exposures for a distance of two miles. They have a minimum thickness of two thousand feet. Some of the shaly sandstones of this series are fossiliferous, affording numerous specimens of an *Ostrea*, along with a *Pecten*, a *Rhynchonella* and an apparently undescribed species of *Pteria*. These fossils do not afford any definite proof in regard to the age of the formation, but are not at variance with its reference to the Dakota, to which the stratigraphical evidence would assign it.

Continuing down the river, an interval of about a mile occurs in which the beds are concealed, and then sandstones are again exposed, forming the floor of a wide shelving beach on the right hand side of the river. The dip is still easterly, and the descending section has evidently been continuous. The sandstone here is a hard greyish variety, and in its compact texture it approaches a quartzite. It is fossiliferous, and some of the beds are covered with casts of *Aucella mosquensis* var. *concentrica*, the characteristic fossil of the Queen Charlotte Islands formation. This formation occurs in British Columbia, at the base of the Cretaceous, and has been referred by Mr. Whiteaves, on fossil evidence, to a position immediately below the Dakota, a reference which is apparently justified by the facts detailed in the section just described.

Aucella beds.

Below the point on the river at which the Aucella beds are exposed, the section becomes so confused and is interrupted by so many concealed intervals, that it was found impossible to follow closely the sequence of the terranes.

A mile and a half below the Aucella beds, yellowish-weathering shales and sandstones are exposed, which probably belong to the same series. The easterly dip, which has been maintained for so long, changes here, and the inclination of the beds becomes more variable, and is not infrequently to the west. The sandstones are followed after an interval of three miles by black bituminous looking shales, the relations of which are somewhat obscure, and these by a hard conglomerate, the dip of which is to the south. Five miles farther down ferruginous rusty-weathering shales, striking nearly east and west, and dipping up stream, are again exposed. The beds first seen are very fissile, and are lighter coloured than is usually the case, but are underlain by a black carbonaceous variety resembling the Devonian shales seen along the Grand View on the Mackenzie. Fragments of a brachiopod shell were collected here, but the specimens are too indefinite for determination.

Change of dip.

The shales are underlain by a great thickness of yellowish-coloured coarse-textured conglomerate, occurring in massive beds and lying in an almost horizontal position. The pebbles of this conglomerate, besides the usual quartzose and slate varieties, include boulders of limestone often exceeding a foot in diameter. A high range of hills, which follows the left bank of the valley for some miles, is evidently built of this rock. Coarse conglomerate.

The conglomerate is succeeded by soft bluish-looking shales, but the junction of the two formations was not observed. The shales after a short interval, are concealed, but reappear four miles farther down, and are replaced shortly afterwards by the conglomerates with which they are associated. The latter evidently constitute the local base of the Cretaceous, as they are underlaid by hard bluish unfossiliferous dolomites dipping at high angles, which have a decided Palæozoic appearance. Bluish shales. Dolomites.

Below the dolomites the section is again interrupted for a short distance, and the next exposures show soft, bluish, lightly undulating shales, similar to those seen farther up. The shales are interstratified with some harder calcareous strata, the surfaces of which are occasionally blackened with carbonized fragments of leaves. The shales form the banks as far as Driftwood River and beyond.

The section obtained in the reach of the Porcupine between the mouth of the Bell River and the Driftwood may be summarized as consisting in descending order of three or four thousand feet of barren quartzites and sandstone, a band of dark shales, probably of Benton age, and a great series of sandstone shales and conglomerates, characterized by holding *Aucella mosquensis* var. *concentrica*, the base of which was not determined. The conglomerates and shales which alternate with one another in the lower part of the reach, may possibly represent in a somewhat modified condition, the two lower divisions just enumerated, but their relations were not definitely ascertained. They form the base of the Cretaceous, as Palæozoic limestone rises from beneath them in the higher undulations. Summary of section.

Driftwood River to the Head of the Ramparts.

Below Driftwood River the Porcupine makes a sudden bend of several miles to the north, and then turning to the west it follows a general bearing of about 15° south of west to the head of the Ramparts. The distance between these two points, measured in a straight line, is about fifty miles, but measured along the tortuous course of the river, exceeds seventy-five miles. The river in this reach has a width of from two to three hundred yards. No rapids were met with, and the Character of the Porcupine below Driftwood River.

current does not average over two miles an hour. Alluvial islands occur at long intervals, and sand and gravel bars are more numerous than in the upper part. The valley varies from one to two hundred feet in depth, and occasionally expands to over three miles in width, and in such cases encloses large wooded flats. The volume of the Porcupine is swelled in this reach by two considerable tributaries, besides a number of smaller streams. Old Crow River enters it from the north about half way down, and Blue-fish River from the south a few miles above the head of the Ramparts. The bordering region is undulating and wooded, and is broken below the Old Crow River by a short range culminating in high bare peaks, the summits of which attain elevations of over two thousand feet above the river. This range has been called the Old Crow mountains, after a Loucheux chief of that name, in whose hunting grounds they are. The outlines of a number of similar ranges, all apparently independent of one another, were observed cutting the horizon at various points.

Geological section. The geological section becomes much simpler below Driftwood River. Soft bluish shales, with occasional harder calcareous layers, are exposed at the mouth of the river, and again three miles lower down. They are nearly horizontal, but can be seen to undulate slightly in the banks. They are succeeded and underlaid by a band of hard sandstones and quartzites, which are white on a fresh fracture, but weather to a bright conspicuous yellow. A mile farther down the quartzite band folds over a sudden anticlinal, the central part of which consists of a hard, compact bluish limestone, alternating with a more shaly variety of the same rock. The harder limestone beds have a cracked appearance, and are covered with a network of reticulating calcite veins. They are filled in places with broken crinoid stems and other fossils, and are undoubtedly Palæozoic. The contact between the limestones and the overlying Cretaceous rocks has the appearance from the river of being slightly discordant.

Recent disturbance. The anticlinal swell just referred to, projects above the surface as a hill, and affords evidence in itself of the comparatively recent age of the disturbance which produced it, if denudation be accepted as a measure of time. The curve of the strata is still unbroken by denudation, although the fractured condition of the beds shows that they were bent near the surface and not under any great pressure.

Three miles below the anticlinal the same bluish shales which are exposed above it commence again, and are shown in all the scarped banks until within a short distance of Fishing River. They are horizontal, or are subject to almost inappreciable dips. As we descend the river they become much softer and lose the fissile shaly cleavage which characterized them where first seen. Interstratified with the shales are occasional harder beds of dark sandstones, which pass in some instances into a conglomeritic condition. The sandstones often show well marked slickensided surfaces, a feature somewhat unusual in soft, apparently undisturbed strata, and the jointage planes are occasionally lined with a thin film of a pinkish mineral, the identity of which has not been made out. Broken coaly particles form a constituent of the shales in some places, but no lignite beds were seen. Limestone concretions, ranging in size up to six feet in diameter, and either arranged in lines or scattered irregularly through the shales, are abundant in some of the sections, and hold fragments of bones and pieces of the test and occasionally entire specimens of a large *Inoceramus*.

Slickensided surfaces in horizontal strata.

The recent deposits overlying the shales consist of alluvial silts, sands, clays and gravels, and no boulder-clays or other beds referable to the glacial period are seen after leaving the Mackenzie.

Recent deposits.

Half a mile above Fishing River, the dark Cretaceous shales are overlain uncomformably by soft, scarcely stratified, whitish and yellowish clays and sands. No fossils were found in these beds, but they evidently represent some horizon in the Tertiary, and their stratigraphical relations would correlate them with the Bear River Tertiary beds of the Mackenzie, which have been referred by Sir William Dawson, on the evidence of their flora, to the Laramie. Two miles below the first exposure, Tertiary beds are again shown in a scarped bank on the left-hand side of the river. They consist here of yellowish and whitish sands and sandstones, interbedded with a greyish, rather hard conglomerate, made up of quartzite pebbles, fragments of shale, and scales of a silvery micaceous schist, unlike any rocks which I have seen in the country. In the next few miles the coloured Tertiary rocks are exposed at all the bends of the river. Eight miles above the mouth of Old Crow River they are raised up by an anticlinal, and the bluish shales and sandstones of the Cretaceous appear unconformably beneath them. The Cretaceous beds are marked here with numerous impressions of a large *Inoceramus*, some of which exceed three feet in length, but the crumbling character of the rock prevented me from obtaining specimens.

Tertiary beds.

The Cretaceous shales have a very limited exposure here, and are again replaced in the course of a few hundred yards by the Tertiary. Two miles below the Cretaceous outcrop, a small bed of shaly lignite was observed among the Tertiary beds exposed on the banks.

At the mouth of Old Crow River, the dark shales of the Cretaceous again rise to the surface and outcrop along the right bank for a short distance. They are brought up here by the same disturbance to which the Old Crow Mountains, which are directly opposite, owe their existence.

Re-appearance of Cretaceous.

Old Crow Mountains.

The Old Crow Mountains were not examined closely, but they appear to belong to the same system of anticlinal uplifts, examples of which are met with so frequently in the valleys of both the Porcupine and the Mackenzie. The lower slopes of the range show dark shales of Cretaceous age, while the higher peaks, judging by the wash in the streams which descend from them, are built principally of hard quartzites similar to those which characterize the Cretaceous farther up the river.

Re-enter Tertiary basin.

Two miles below the mouth of Old Crow River, the Porcupine bends to the left and enters the Tertiary basin again. At the extremity of the bend the Tertiary beds are well exposed, and consist of whitish and light yellowish sands, clays and gravels. The beds have little coherency, and can be crushed between the fingers. Small nodules and beds of ironstone are developed in some places, but none of these proved to be fossiliferous. In the next twenty miles, or as far as the head of the Ramparts, the sands, clays and gravels of the Tertiary appear with little variety in the scarped banks washed out by the river at the elbows of the various bends. The sections have a general whitish appearance when viewed from a distance, but a closer inspection reveals an alternation of whitish, light yellowish and reddish tints. The rocks of this terrane show little induration, but have sufficient coherency when freshly uncovered to enable them to stand in almost vertical cliffs of from one hundred to two hundred feet in height; but under a long exposure the face of an escarpment crumbles down into a gentle slope, from which the harder beds occasionally project. The following section was measured a short distance above the head of the Ramparts :—

	Feet.
Light coloured, slightly indurated sands	10
Greyish sandy clays	20
Friable pebble conglomerate	8
Reddish clays	1
Cream coloured clays	5
Light yellowish soft sandy beds	15
	59

The rocks change rapidly in composition when traced along the strike, and beds of sand are replaced by clays or conglomerates in the course of a few hundred feet.

At the head of the Ramparts the Tertiary rocks overlap the Cretaceous and rest directly on hard limestones and quartzites which are probably Palæozoic.

Before entering the Ramparts the Porcupine makes a sudden bend to the south. Its course is then comparatively straight along a bearing of S. 60° W. for a distance of thirty miles. Beyond this it bends more to the south, and its direction as far as Rampart House, a further distance of twelve miles, is S. 22° W. Before reaching Rampart House both valley and river run in an easterly direction for about a mile, and then turning again to the southwest the valley becomes somewhat enlarged, and a small flat is interposed between its northern bank and the river, on which the fort is situated. Direction of river.

The Porcupine while passing through the Ramparts contracts considerably, and in places does not exceed seventy-five yards in width. Its current is more rapid than in the upper part, and was estimated to run at the rate of about three or four miles and a half an hour. Short riffles, with a much greater velocity than this occur occasionally, but no rapids or other obstructions were met with, which would prevent the navigation of the stream by small steamers. Character of river.

The Ramparts is a local name employed by the traders to designate a contracted walled valley or cañon. The portion of the valley of the Porcupine which passes under this name is exceedingly picturesque. In the upper part the banks rise steeply from the water's edge on both sides to heights of from three to five hundred feet, and their green slopes are everywhere broken by shattered pinnacles and bold crags and cliffs of brilliantly tinted dolomites and quartzites standing almost on edge. As we descend the enclosing walls become higher and steeper, and the lighter shades are replaced by more sombre colours. Some miles above Rapid River a band of basalt edged with vertical cliffs, appears above, and gradually descends in the banks of the cañon until it reaches the bottom, and from this on the gorge is bounded by even, precipitous walls carved out of this rock. The uniformity of this part of the valley is interrupted at intervals by deep gashes cut by tributary streams through the basaltic covering. Of these the principal one is Rapid River, which enters the Porcupine about seven miles above the post. A mile below Rapid River is the half-way pillar, a projecting column of rock, which was supposed by the traders to be equidistant from Lapierre House and Fort Yukon. Picturesque valley. Band of basalt.

The geology of the Ramparts proved to be too complicated to be unravelled in the few hours which I was able to devote to it, and can only be indicated in a general way.

At the head of the Ramparts the soft unconsolidated Tertiary strata are underlain, as above stated, by a different and much older series. The beds first seen consist of greyish granular dolomites, interstratified with a close textured, very compact variety of the same rock, striking nearly

Rocks in Ramparts.

north and south, and dipping to the west at an angle of 35°. Farther down the dolomites are associated with limestones, quartzites and a band of dark calcareous shales. The rocks have all been subjected to considerable crushing, due to volcanic action, and in some instances have been so shattered that they crumble completely under the influence of the weather or when struck with the hammer.

Varied colouration.

The most important rock in the first twenty miles is a peculiar fresh-looking dolomite, the texture of which is so hard and compact that it might readily be mistaken in some cases for a quartzite. It contains, however, very little siliceous matter, and dissolves almost completely in hydrochloric acid. A remarkable feature of this rock is the varied and changing colouration which it exhibits along the valley. The colours range from pure white through light and dark yellow to a bright red, and appear in some places to have an irregular distribution, as if due to subsequent infiltration. The beds are usually tilted at high angles, and the harder strata project above the surface in a more or less ruinous condition, and when brightly coloured, stand out in strong relief against the back ground of dark green.

Band of shales.

A band of dark calcareous shales, several hundred feet in thickness, is repeated at several points, and was carefully searched for fossils, but without success. The shales are interstratified at some points with bedded traps, and a number of irregular intrusions of the same rock were also noticed cutting the bedding. They pass occasionally into light coloured schists, and often show slaty cleavage.

Quartzites.

Whitish and coloured quartzites, often holding black plumbaginous looking scales, form an important constituent of the section, and granular dolomites and lead-coloured limestones are also well developed, and occasionally form high cliffs.

Decayed rocks.

A noticeable feature of the section is the peculiar alternation of strata softened and decayed for many feet below the surface, with unweathered varieties of apparently the same, or only slightly different rocks. I was at first inclined to believe that some of the soft Tertiary beds which overlie the dolomites and associated rocks at the head of the Ramparts had been folded up with the latter, but was led on farther examination to abandon this view.

The succession of the different terranes was not ascertained, as the section is very much confused, and is broken through repeatedly by trap dykes, and would require considerable time for its elucidation.

Ten miles above Rapid River the Porcupine has cut through a thick sheet of basalt. The basalt is first seen crowning in long cliffs the banks of the valley, but is brought down by a light westerly inclination to the surface of the water, in a distance of six miles. Beyond this it undulates at low angles along the valley, and occasionally rises sufficiently to expose the underlying shales, quartzites, dolomites and limestones.

The basalt shows no evident columnar structure. A well marked horizontal divisional plane was traced for some distance, and may possibly indicate the junction of two flows, as slight differences in coloration were noted above and below it. In texture the basalt ranges from fine grained to a moderately granular condition, but also becomes vesicular in places, and passes into an amygdaloid. It is composed principally of augite and olivine, with some magnetite and titaniferous iron, and is almost destitute, at least in the hand specimens collected, of plagioclase. Character of basalt.

At Rapid River, and for some distance above and below, the basalt sheet rises in the banks, and the underlying rocks, consisting here of dark shales, old looking cleaved slates, quartzites and dolomites, all dipping at considerable angles, are brought into view. Two miles below Rapid River the basalt dips below the surface, and the older rocks are not seen until near Rampart House. Rocks underlying basalt.

Rampart House to the Mouth of the Porcupine.

We reached Rampart House on the 20th July, the descent of the river from Lapierre House having occupied four days. We travelled mostly at night, in order to avoid a strong head wind which blew up the river every day. It is customary, however, in these latitudes to work in the night rather than in the day, during the period of six weeks or so in which the sun remains above the horizon. The light is sufficient, while the temperature is somewhat lower, and the mosquitoes are less troublesome. Reach Rampart House. Travel by night.

Rampart House is the most distant of the Hudson Bay Company's posts, and was established to replace Fort Yukon, after the site of the latter had been determined to be in Alaskan territory. This post was originally situated twelve miles farther down the river, but the position of the buildings in regard to the boundary being doubtful, these were burnt by the Hudson's Bay Company, and new buildings were erected on the present site. As a fur post it barely pays expenses, owing to the heavy cost incurred in the transportation of furs and goods, and is kept up mainly as a protection against the encroachments of traders from the west. Rampart House.

The Indian hunters trading at Rampart House number about eighty. They belong to the Loucheux branch of the Tinneh family, but speak a slightly different dialect from that used by the Mackenzie River Lou-

Indians at Rampart House.

cheux. They are Christianized, and missionaries sent out by the Church Missionary Society have been working among them for some years. A small church has been built in the vicinity of the post.

Arrangements for trip.

I remained a few hours at Rampart House for the purpose of taking an observation for latitude, and making arrangements for the trip to Fort Yukon. An Indian was engaged to accompany us, and I was fortunately able to obtain a supply of dried meat from Mr. Firth, the officer in charge of the post. A report had reached the fort that a steamer belonging to the Alaska Fur Company would pass Fort Yukon on its way to Forty Mile Creek, in a few days, and I decided, as we would now traverse Alaskan Territory, and had no object for delay, to hurry down to the forks as fast as possible and endeavour to secure a passage on the steamer up the Yukon as far as the Canadian boundary. We descended the river, battling against a strong head wind the whole way, in three days, but learned on our arrival, much to our disappointment, that the boat had already passed.

The distance from Rampart House to the mouth of the Porcupine, measured in a straight line, is about one hundred miles, but is fully one hundred and fifty by the course of the river. The general direction is about S. 60° W. The current is uniform, with few riffles and no rapids, and has an average rate of about three miles an hour.

Rocks below basalt.

The Ramparts continue for two miles below the fort, and present the same features which characterize them above. Opposite the fort, the basalt sheet rises again, and alternating bands of shales, slates, limestones, dolomites and quartzites, with in one place a white cliff of coarsely crystalline calcspar, are seen beneath. Eight miles farther down, it sinks beneath the surface, and massive walls of basalt and amygdaloid then border the river as far as Howling-Dog-Rock, at the foot of the Ramparts.

Wide gravel flat.

Tertiary rocks.

Below Howling-Dog-Rock, the river intersects for some miles a wide gravel flat, the former site of the fort, and then bends away to the north. An exposure here of clays, greyish and yellowish sands and soft pebbly conglomerate, shows that the river has entered a second Tertiary basin. The rocks are all very soft, and are similar in appearance to those occurring above the Ramparts. No fossils were obtained from them. Sections of unconsolidated Tertiary strata are exposed again at the extremity of the bend, and at several points in the next five miles, and are then replaced by shales and slates of an older series. They are overlain by recent silts, sands and gravels.

Width of Tertiary basin.

The width of the Tertiary basin along the river does not exceed seven miles, but it is highly improbable that this represents its full size, and the appearance of the flat country to the north would seem to show that it extends for a considerable distance in that direction.

The shales and slates which succeed the Tertiary are overlain in the course of a mile by basalt. The basalt is exposed for a short distance on the left hand bank, and probably represents a projecting spur from the main sheet. It was not seen again. Two miles below the basalt exposure the shales and slates are associated with rusty coloured limestones, and at the mouth of Succor River, three miles farther down, the same rocks are again seen. In the next fifteen miles yellowish-weathering limestones, rising occasionally into abrupt cliffs, are exposed in a number of places. This part of the valley goes by the name of the Lower Ramparts, but the rocky walls are low and disconnected, and are seldom developed on both sides of the valley so as to form a cañon. The limestones yielded *Atrypa reticularis*, together with some fragmentary specimens of corals, and are probably referable in part at least to the Devonian. At the lower end of the Lower Ramparts, the limestones are interbedded with dark shales similar to those associated with them above Succor River. The shales are unfossiliferous, but from their position are probably Cretaceous. They are exposed at intervals for two miles, and are then overlain unconformably by the yellowish and light reddish clays and sands of the Tertiary, and the latter in turn sinks in a short distance, beneath alluvial sands, clays and gravels.

Exposure of basalt.

Lower Ramparts.

Age of limestones.

From this point on to the mouth of the river, a distance in a direct line of sixty miles, no further exposures of the older rocks are seen. The valley disappears, and the river serpentines through a wide plain, elevated only a few feet above its surface. At the elbows of the numerous bends the cut banks show small sections of clays and false-bedded sands and gravels, either alluvial or lacustral in their origin. The bordering plains extend to the horizon on either side, unbroken by a single elevation, and their extent and uniformity taken in connection with the character of the beds seen along the valley afford strong grounds for the assumption that a lake basin or abnormal expansion of the river once existed here and has since been silted up.

Wide plain.

The principal streams which the Porcupine receives in this part of its course are the Salmon from the right, and Black River and Little Black River from the left. For some miles above its mouth it divides around numerous islands, and branching channels become so frequent that care has to be exercised to select the right one. Before reaching the Yukon we left the main stream, and turning to the left entered a small channel which is reported to flow in opposite directions, depend-

Tributaries of Porcupine.

ing on the relative heights of the water in the two rivers. Our hopes that the current would set in our favour were doomed to disappointment, as we no sooner rounded the bend than we passed from the brown water of the Porcupine into the milky flood of the Yukon, and found ourselves struggling against an impetuous current of five or six miles an hour. Fort Yukon is situated a mile and a half above the confluence of the two streams, and it required nearly two hours of hard work to ascend that distance.

Old Fort Yukon to Forty Mile Creek.

At Fort Yukon I had the pleasure of meeting the Rev. Mr. Canahan, of the Church Missionary Society, who was on his way to Meklukahyèt to take charge of a mission. Mr. Canahan's news was far from cheering, as he informed us that the steamer which we expected to meet had passed up the day before.

Routes to the coast.

Two courses were now open to us in order to reach the coast and outside communication; either to descend the river to St. Michaels and sail from that point to Victoria or San Francisco, or to face the nine hundred miles or so of rapid current and difficult navigation above, and ascend it to the head of the Lewes, and then cross the Coast Range by the Chilkoot Pass. The former is by far the easier route, as the lower Yukon possesses a strong steady current, and is free from dangerous rapids, and the temptation to adopt it was almost irresistible, but as it lay altogether outside of Canadian territory I decided, if possible, to try and ascend the stream. To do this, however, promised to be a matter of no ordinary difficulty. The short, square-sterned boat which I had hitherto used, was built to carry a load down stream and was altogether unsuitable to make an up-stream journey in, and an attempt to force it for hundreds of miles against a five or six mile an hour current seemed well nigh hopeless, but no other was available. Our provisions were also running short, but Mr. Canahan kindly supplied our deficiencies in this respect to some extent, and we expected to be able to obtain fish from the Indians along the river. Trader John, the Indian who piloted us down from Rampart House, and had proved himself a capable and willing fellow, was induced, after some persuasion, to accompany us as far as Forty Mile Creek, and on the 25th of July, after a delay of four days, we succeeded in making a start.

Early exploration.

A sketch of early exploration on the Yukon has been given by Dr. G. M. Dawson, in Part B, Annual Report of the Geological Survey for 1887-88, and it will be unnecessary to repeat it here. Fort Yukon, which was originally one of the best built forts in the north, is now a thing of the past, and with the exception of one of the outbuildings, which has probably also disappeared by this time, has been torn down to supply wood for the steamers plying on the river.

Gardening at Fort Yukon.

While in possession of the Hudson's Bay Company some gardening was done in the vicinity of the fort, notwithstanding the fact that it is situated almost on the Arctic circle. Potatoes and other vegetables were raised, and barley is reported to have ripened. On the Mackenzie River, gardening ceases to the north at almost the same latitude.

Numerous channels.

Above Fort Yukon the river cuts through the same low wooded plain which has been described as bordering the Porcupine above its mouth, and like the latter, only on a much greater scale, its waters flow by numberless interbranching channels through a labyrinth of islands. Its width in this reach is reported to range from three to ten miles or more, but as we kept the left bank the whole way up, and the opposite shore was always concealed by islands, I was unable to verify this statement. The river however has here, practically, no confining valley, and the soft sands and clays which underlie the adjoining plain offer little obstruction to an indefinite expansion. New channels are opened up with each succeeding flood, and older ones blocked by the deposition of sediment. Notwithstanding the great width, the velocity of the current is undiminished, and the upstream navigation of this part, especially in high water, is attended with greater difficulty than any other portion of the river. Beaches are seldom present, and tracking is impossible except for trifling distances at long intervals. The water along the cut banks is too deep a few feet from the shore for poling, and to advance we were obliged to combine the use of an oar on the outside, a pole on the inside, while I steered and paddled behind. Even this complicated method of propulsion often became impracticable, and progression in some places was only attainable by clinging to the overhanging branches and pulling ourselves up foot by foot. For long reaches the banks are undermined by the wash of the stream, and as the boat creeps along beneath the overhanging wall from which masses of sand and other material are momentarily falling, it is constantly threatened with destruction. Vexatious delays are also caused by the numerous trees which have been undermined and have fallen forwards into the stream, but still cling to the bank by their roots. Above these, driftwood accumulates until it forms a projecting point around which the current swirls with redoubled velocity; and to pass them is often the work of hours. The width of the river is so great that difficult spots cannot be avoided as in other streams by crossing to the opposite bank, and the ascent must be made entirely on one side. The eastern side is usually preferred.

Difficult navigation.

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Length of island-filled stretch.

The length of this expanded island-filled stretch above the mouth of the Porcupine was estimated at seventy miles, although a miner, the only one so far as I could hear, who had ascended it, assured me that it could not be less than three hundred and fifty miles. His estimate must, however, be taken rather as a measure of the difficulties he encountered than of the true length. We made the ascent in five days, but to do this were obliged to work at our full capacity for fourteen or fifteen hours a day. With a proper boat much better time could have been made.

Older rocks hidden.

The older rocks along this stretch are deeply buried beneath a thick accumulation of recent sands, clays and gravels, and no exposures were anywhere seen.

Chief Senatee.

Before reaching the head of the islands we crossed to the right bank, and on our sixth day passed the camp of Senatee, the head of the Fort Yukon Indians, and the most powerful chief in the whole Yukon country. Many stories are told of cruel murders and rapes committed by Senatee in days gone by, but time has now tamed his ferocious disposition, and changing circumstances have shorn him of much of his once absolute authority. He received us hospitably, and after an exchange of fish for tobacco had been made, commenced a long oration, descriptive of his enduring love for the English (Hudson's Bay Company) and his regret that they had left the country, and his general dislike of the Yankees (Alaska Fur Company), but as time was precious the harangue was cut short by the present of a couple of handfulls of tea, the probable object for which it was made, and we proceeded on our journey.

River contracts.

Above the Indian camp the river commences to contract. It bends more to the east, and is bordered by narrow beaches, a welcome change, which enabled us, much to our relief, to substitute the tracking line for the poles and oars, and to make better progress with less exertion. The shore here is strewn with blocks of dark carbonaceous looking cleavable shales, and on the eastern side of the river bedded rocks, probably of the same description, could be seen *in situ*, but were not examined, as a crossing meant the loss of several miles wearisomely won, and was only made when rendered necessary by the exigencies of the navigation.

Increased elevation of bordering region.

The elevation of the country bordering the river is here higher, and a considerable valley is developed. Fifteen miles above the Indian camp the river is reduced to about half a mile in width, and assumes an easterly direction. A crossing to the eastern side was effected here, and a line of cliffs which made their appearance seven miles below, was found to consist of massive eruptive rocks, which

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are described in my notes as basalts and fine and coarse grained dolomites, but unfortunately the specimens have mis-carried. The volcanic rocks here are, as a rule, coarser textured and older looking than those seen at the Ramparts on the Porcupine, and no amygdaloids or vesicular varieties such as occur there were noticed. It is uncertain whether they form parts of the same flow or not, although the relative position of the two areas and the northerly trend of the elevated country leads to the supposition that they do, and in this case the westerly edge of the flow would correspond in a general manner with the eastern boundary of the great plain which extends up the Pelly-Yukon and Porcupine from their confluence. **Occurrence of basalts.**

The basalt and associated igneous rocks enclose numerous detached masses of shales derived from the underlying terranes, and dark shales and limestones tilted at high angles project up into them in many places in a similar manner to that noticed on the Porcupine. They were traced along the river for fifteen or twenty miles, and are then replaced by a confused succession of shales and limestones, probably referable to a large extent to the Carboniferous, alternating with the dark shales, sandstones and quartzites of the Cretaceous. The whole series is greatly disturbed, and folded closely together, and the beds often show vertical dips. The general strike is S. S. E. The shales and associated limestones and sandstones are exposed in continuous sections for seven or eight miles, and are then again almost buried beneath a second basaltic occurrence, and only the higher points of the old rugose surface rise into view above the bottom of the valley. **Contact of basalt sheet with underlying rocks.** **Second basaltic occurrence.**

The line of contact of the Tertiary basalts with the underlying sedimentaries in this region, both on the Yukon and the Porcupine is, speaking generally, nearly coincident with the present level of the rivers.

The second basaltic area where cut by the river has a width of ten or twelve miles. Above it the rocks are concealed on the eastern side for some distance, and then the shales and sandstones of the Cretaceous outcrop on the banks, and are present all the way to the Tatonduc, a distance of about thirty-five miles. The beds are sometimes horizontal, but usually undulate at varying angles, but seldom to such an extent as to expose the underlying Palæozoic limestones. Conglomerates consisting largely of small pebbles of schist, quartzite and slate, imbedded in a hard sandstone matrix, are occasionally associated with the shales and sandstones, and in one place about eight miles above Charlie's village, attain a great development. They overlie the shales at this point. Some miles below the mouth of the Tatonduc speci- **Width of igneous area.** **Conglomerates.**

mens of the characteristic Queen Charlotte Islands' formation fossil *Aucella Mosquensis* var. *concentrica*, were collected from the beds below the conglomerates.

Depth of valley.

The valley of the Pelly-Yukon becomes gradually deeper as we ascend, and above Charlie's village the banks were estimated to have an elevation in places of from eight hundred to a thousand feet.

Foldings.

Above the mouth of the Tatonduc the foldings increase in severity, and the Palæozoic limestones and shales are brought up and alternate in broad bands with the shales, sandstones and conglomerates of the Cretaceous. A black carbonaceous variety of shale is repeated at a number of points, and often shows polished slickensided surfaces, due to the crushing to which it has been subjected, which simulate very closely the appearance of anthracite. The alternation of the Cretaceous beds with the older limestones and shales continues until near the boundary, a distance measured along the river of about forty miles. No fossils were found in this part of the river, but lack of time prevented a careful search for them.*

Schistose rocks replace shales, limestones, etc.

A short distance below the boundary the rocks referred to above are replaced by a very different looking set, consisting mainly of altered volcanic rocks, and characterized by a general greenish colour. Among them are important bands of serpentine, hard quartzose, sheared and altered greenish schists, softer greenish chloritic looking schists, silvery mica-schists, diabases, shales and slates. Picrolite was noticed in several places, and beds of chert are not uncommon. The schistose beds must underlie the limestone series, (Carboniferous ?) although the dip would place them above, as the latter is overlain directly in many

* Mr. Ogilvie has furnished me with the following geological notes obtained on his traverse from the mouth of the Tatonduc across to the head water of the Porcupine and down the latter stream to its confluence with Bell River :—Dark shales overlain by fine grained conglomerates which are doubtless the equivalents of the Cretaceous beds observed on the Pelly-Yukon, occur along the Tatonduc for twenty-seven miles from its mouth. At two points in this distance limestones rise to the surface from beneath the shales and by their superior hardness contract the valley into short cañons. The conglomerates are described by Ogilvie as weathering in some of the ridges and mountains into picturesque castellated cliffs. In the upper part of the valley of the Tatonduc the Cretaceous shales and conglomerates are replaced by greyish Palæozoic limestones. Similar limestones were also met with all across the watershed separating the Tatonduc from the Porcupine where they form a range of high mountains and down the latter stream as far as the Cathedral Rocks. At two points on the Porcupine, viz. : two miles and ten miles respectively below the forks, the limestones are underlain by reddish mottled sandstones similar in appearance to those occurring at Sault Ste. Marie. Below the Cathedral Rocks dark shales of Cretaceous age appear again, and were the only rocks observed all the way to the mouth of Bell River, where connection was made with my traverse down the Porcupine.

An interesting fact noted by Ogilvie is the emission, near Sheep Mountains, of sulphuretted hydrogen gas in large quantities from the surface, and he states that he was informed by his guide that a small lake a short distance from the trail is kept constantly agitated by the escape of similar gas, and that the sulphureous fumes prove fatal to all animals which venture near. East of the Rocky Mountains sulphuretted hydrogen gas issues in numerous places from the petroliferous limestones of the Devonian, but it is possible that its presence here is due to volcanic action.

places farther down the river by the shales, sandstones and conglomerates of the Cretaceous.

East of the river above the boundary, and running parallel with it for some distance, is a high naked range, built of limestones striking in a south-easterly direction and dipping at high angles towards the river. Resting on these, and apparently overlying them, are the rocks just described. Limestone range.

The schistose beds alternate occasionally with limestone bands, altered in places into marble, and are traversed in all directions by quartz veins. They are exposed all the way to Forty Mile Creek and beyond. They are of the greatest economic importance, as they constitute the gold bearing rocks of the district, and are on the strike of the same metalliferous zone on which Cassiar and the other principal mining camps to the south are situated, and which has now been traced northwards across Canadian territory from the 49th parallel to the eastern boundary of Alaska, a distance of fully twelve hundred miles. Economic importance of schist belt.

Four miles below the mouth of Forty Mile Creek, a small stream was passed coming in from the opposite side, on which a coal seam is reported to occur, but nothing definite was learned about it. Coal seam.

Forty Mile Creek.

We arrived at Forty Mile Creek on the 9th August, fourteen days having been occupied on the journey up from Fort Yukon. This is the headquarters of the miners on the Yukon, and thirty or forty men were camped here waiting for reports from the various prospecting parties which were exploring the surrounding country, and ready to start at a moment's notice. The present season proved very unfavourable for mining operations on account of the persistent high water, and with the exception of a short period early in the summer, very little work was done on Forty Mile Creek, and the amount of gold taken out was estimated at scarcely $15,000. A few days before my arrival a stampede had been made for Beaver River, a northern tributary of the Yukon, which is stated to enter the latter about a hundred and twenty miles below the mouth of the Porcupine, but with somewhat disastrous results. The amount of information required to stampede a mining camp is very small, and in the present case was almost ridiculous. A report was brought up by the men on the steamer that a miner had boarded the boat at the mouth of Beaver River, and after talking in a hurried manner to the captain, had suddenly departed, and in his haste had left his purse behind him. The miners reasoned that

Arrive at Forty Mile Creek.

Unfavourable season.

Yield of gold.

Stampede of miners.

nothing but a rich find would cause such an excitement, and a hundred and fifty men immediately loaded their boats and started on a wild goose chase down the river, only to meet with disappointment at the end of their journey. A few received a passage up again on the steamer, but the greater number drifted on down towards St. Michaels, and left the mining country altogether.

Difficulties in prospecting.

Prospecting in the Yukon country is attended with peculiar disadvantages, and requires men of more than ordinary perseverence and endurance for its successful prosecution. The Yukon itself is very swift and difficult to navigate, but is easy as compared with many of the tributary streams which are simply a long succession of cañons, whirlpools and rapids, and skill and courage in a high degree, in addition to a golden bait, are necessary in order to brave the perils of their ascent. Provisions are high priced and scarce, and in the upper part of the river cannot be obtained at all, and supplies for the summer must be packed across the Coast Range in the early spring and sledded for two hundred miles down the river to the lower end of Lake Labarge before the break up of the ice, in order to be on hand when the season opens. Added to this is the shortness of the period available for work, which under the most favourable circumstances never exceeds three months, and in seasons of exceptional high water, such as the present, is very much less. In view of these drawbacks prospecting must proceed slowly, and up to the present has been confined almost entirely to the larger and more accessible streams.

Yield of gold.

The most important strike made so far has been on Forty Mile Creek, on which coarse gold was discovered in 1886. This discovery occasioned a rush towards the creek of nearly all the miners in the district. In 1887 over 200 men were actively and successfully employed along the numerous bars, and the total yield for the season was variously estimated from $65,000 up to $150,000. The present season has proved much less remunerative, partly owing to the unfavourable state of the water and partly to the fact that the rich claims first discovered have been worked out, the auriferous gravels being of little depth and easily exhausted. The most productive part of this stream is west of the Alaska boundary. It has a total length, according to the miners, of about 150 miles, of which only the lower twenty miles are in Canadian territory, and in this part very little work is now being done. The average value of labor is $10 a day, and bars which yield less than this are soon abandoned.

No important strike was made anywhere in the district in 1888.

Argentiferous galena.

A lode of argentiferous galena crosses Forty Mile Creek a short distance above its mouth, and a specimen brought back by Mr. Ogilvie was assayed in this office by Mr. Hoffmann, and found to contain $38 \cdot \frac{64}{100}$ oz. of silver to the ton. Tellurium is reported from the head of the stream, and seams of coarse serpentine asbestus occur near its mouth.

Some days were spent at Forty Mile Creek in making preparations for the long trip up the river and, in building a long, narrow, sharp-ended boat, modelled after the pattern of those used by miners in ascending swift streams. Trader John, who had helped us gallantly in the ascent from Fort Yukon, eturned home from here, and a miner named Buckley, was engaged for the remainder of the trip. Prepare for trip up river.

Forty Mile Creek to the Mouth of the Stewart.

We left Forty Mile Creek shortly after noon on the 14th August, and passed the mouth of the Stewart early on the morning of the 19th. The distance measured along the river is about 120 miles. The direction as far as Fort Reliance is nearly east, but beyond that point the river bends slowly round and runs almost west for a few miles, after which it maintains a general southerly course to the mouth of the Stewart. The width of the river in the lower portion seldom exceeds half a mile, but above Fort Reliance it gradually enlarges, and in the southerly reach occasionally exceeds a mile in width. In the expanded stretch, however, much of the surface is occupied by islands. The current is swift and uniform, and at a medium state of the water runs at the rate of five miles an hour. Beaches line the shore, and tracking, except at very high water, is possible nearly the whole way. Leave Forty Mile Creek. Character of river.

The valley of the Yukon between Forty Mile Creek and the Stewart, and on to the mouth of the Pelly, is cut through an elevated undulating plateau, on which rest numerous low ranges of rounded and partially bare hills, but is not crossed by any well defined mountain range. It is somewhat uniform in appearance, but affords many picturesque and even grand views. Bluffs of rock of a more or less precipitous nature, are of constant occurrence, and bold rampart-like ranges of interrupted cliffs, separated and continued upwards by steep grassy or wooded slopes, characterize the banks for long reaches. The flats are few and unimportant, and as a rule the river washes the base of the banks on both sides. The width of the valley varies from one to three miles, and its depth from five to fifteen hundred feet. Its great size, taken in connection with the hard character of the crystalline rocks through which it has been excavated, afford evidence of great age, and point to an origin long antecedent to the glacial period. Character of valley. Age of valley.

The same fact is also emphasized by the remarkably uniform grade which the river has worn across terranes of heterogeneous hardness, ranging through the whole geological scale in its long course from Rink Rapid to the sea, a distance of nearly 1,700 miles.

Rocks observed.

Rock sections are numerous along the valley, but the geology is intricate and difficult, and somewhat confusing to a traveller passing hurriedly through along one line. Above Forty Mile Creek the same series of micaceous and altered greenish schists and slates which obtain below are continued for six or eight miles, and are then replaced by greyish granite. The schists are traversed by both quartz and calcite veins, usually of small size. They dip at high angles, and have a general south-south-easterly strike. The granite is a medium-grained, somewhat altered variety, showing no distinct foliation. It is composed principally of quartz, plagioclase, orthoclase, muscovite, biotite and epidote. From the central granitic mass a set of dykes radiate out into the surrounding schists. The dykes often pass in between the beds, but were also seen cutting across them. Above the granite boss the schistose series resumes again and continues as far as the bend above Fort Reliance. These rocks are broken up in several places by granite intrusions, and the granite appeared to be itself cut in one place by a darker and more basic igneous rock of which I did not obtain specimens. A specimen of rather coarse textured granite, collected above Fort Reliance, holds numerous grains of copper pyrites, and may possibly be auriferous, but has not been analyzed. The schists occasionally show copper stains running parallel with the foliation.

Dykes.

Some miles above Fort Reliance a band of dark argillites, interbedded with limestones, crosses the river. Like the schists it is traversed by numerous quartz veins. It is followed for several miles by schists of various kinds, but usually more or less micaceous, and occasionally passing into a well foliated rather fine grained mica-gneiss. The latter increases in relative proportion, and assumes a coarser texture as we ascend the river. Igneous granitic intrusions occur every few miles.

Granite intrusions.

Fifteen miles below Sixty Mile Creek, a peculiar looking soft greenish rock consisting of glossy talc, and green serpentine was found at several horizons interbedded with the schists. The square columnar crystals from which the serpentine has been derived still preserve their original form, and penetrate in all directions the lighter coloured talcose matrix. They show under the microscope traces of the quadrangular cleavage of augite, but are otherwise completely altered.

Exposures opposite Sixty Mile Creek.

Opposite Sixty Mile Creek the exposures show lustrous muscovite-mica-schists, dark biotite-mica-schists grading into mica-gneisses, hornblende gneissic schists and compact felsitic rocks indistinctly foliated. With these are associated greyish biotite granites, and a coloured granitoid or syenitic rock, consisting of orthoclase, plagioclase quartz, clorite and epidote. The proportion of quartz in this rock is small and the crystals are greatly crushed and broken. A second variety of this rock shows large, coloured crystals of felspar, porphyritically distributed through a fine-grained micro-crystalline base.

Rocks between Sixty Mile Creek and the Stewart.

From the vicinity of Sixty Mile Creek to the mouth of the Stewart, the rocks are older looking and more distinctly gneissic than those observed farther down the river. The most abundant variety is a light reddish-coloured, medium-grained, well foliated mica-gneiss, composed of quartz, orthoclase, plagioclase, biotite and muscovite. Epidote, clorite, calcite and ilmenite are also nearly always present. In some cases the micas are replaced altogether by chlorite. With the gneisses are associated several varieties of mica-schists, and occasionally some hornblendic schists. Numerous veins of coarse pegmatite, quartz, and less frequently calcite, cut the beds in all directions, and are present in nearly every section.

STEWART RIVER TO THE PELLY.

The Stewart River.

The Stewart River has not been explored. At the mouth it is two hundred yards wide, but the current is not rapid, and it apparently carries less water than either the Pelly or the Porcupine. It is reported to be navigable for two hundred miles above its mouth. Gold was discovered on it in 1885, and in that and the following year, gold to the value of $100,000 was obtained from it, according to an estimate made by Dr. Dawson on information from miners. The principal bars were, however, exhausted in these two years, and in 1887 the yield diminished to about $5,000, but this was partly due to the withdrawal of most of the miners to Forty Mile Creek. In the present year an attempt was made by two prospectors to trace the gold to its source but without success. "Colours" were present as far as they ascended, but not in paying quantities, and no tributaries were found down which the gold in the lower part of the river might have descended. They report that the river grows in its upper part by the reception of numerous small streams heading in swamps, none of which are gold-bearing. An important feature of the river is the constant recurrence along it of high gravel terraces, most of which are more or less auriferous, and occasionally yield as high as a cent a pan, and could probably be worked profitably on a large scale. It is possible that the gold found on the bars in the river is concentrated from these.

Yield of gold.

High gravel terraces.

From the mouth of the Stewart the Pelly-Yukon trends in a south-westerly direction for ten miles to its junction with White River. In this reach it averages a mile in width, and is filled with islands. The banks of the valley are steep and rocky, and were estimated at from 800 to 1000 feet in heigth. Garnetiferous mica-schist was noticed a short distance above the Stewart, and dark hard mica-schists and light reddish well foliated gneisses are exposed all along. An extensive system of quartz veins is developed along here, and gold-bearing quartz is reported to have been found.

White River.

White River, like the Stewart, has not been explored, and has only been ascended by miners for a distance of sixty miles from its mouth. A view up it from the opposite bank of the Pelly-Yukon showed a wide valley filled with countless bars and islands between which the divided stream threaded its tortuous course. Its current is swift, and it precipitates itself into the Yukon with a force sufficient to drive its muddy water half way across, but scarcely to force it up on the opposite bank in the manner described by Schwatka, and the two streams flow side by side for several miles before their waters become completely fused. The turbid character of the White River is famous, and sufficient sediment is brought down to change the colour of the whole Pelly-Yukon flood from a pale green to a milky white. White River is reported to head in glaciers descending from high mountains, but nothing very definite is known concerning it. "Colours" of gold have been obtained from it, but no paying bars have so far been discovered.

White River to the Pelly.

From White River to the Pelly the distance is ninety miles. The direction is at first south-westerly, but the river soon bends round to the east and follows an E. S. E. bearing the greater part of the way. The width of the river is somewhat reduced, and varies from a quarter to half a mile, while the current averages about five miles an hour. Islands occur at intervals, but are less numerous than in the reaches below. The valley preserves its usual depth of from 800 to 1,000 feet, but for some distance above White River the banks are more wooded and show rocky bluffs above supported on steep slopes below. Farther up it is again bordered by steep gneissic and basaltic cliffs. Gravel terraces occur occasionally and appeared to increase in height as we ascended.

Character of rocks.

The prevalent rock for many miles above White River is a hard, granular and often moderately coarse-grained, Archæan looking mica-gneiss of somewhat varied mineralogical composition. This occasionally passes into mica-, chlorite- and hornblende-schists. The minerals most commonly present are quartz, plagioclase, orthoclase, biotite, muscovite, chlorite, hornblende, epidote, calcite, magnetite and ilmenite. In some cases the rock is greatly crushed and altered, and the micas and hornblendes are replaced almost entirely by chlorite. Plagioclase is always present and often in greater abundance than orthoclase. Quartz veins occur less frequently as we ascend, and are replaced by veins of coarse pegmatite. Igneous rocks are almost absent in the lower part of this reach, but coarse granites and diorites were met with about twenty-five miles below the mouth of the Pelly. Three miles above this point the older rocks are covered with vesicular lavas of Tertiary age. The lavas are exposed for a short distance and then recede from the river at a bend which the latter makes around a high terrace built of coarse gravels. Resting on this terrace is a small bed of white volcanic ash, frequent occurences of which were noticed on the Pelly by Dr. Dawson, and are described in Part B., Annual Report, 1887-88. Above the gravel terrace the lavas resume, and are present all the way to the Pelly. They are underlain by gneisses similar to those described before, and by granites and diorites. A specimen of diabase-porphyry composed of crystals of augite and plagioclase porphritically distributed through a micro-crystalline chloritic base, was obtained from the cliffs west of the flat on which Fort Selkirk was situated.

Tertiary lavas.

After reaching the site of Old Fort Selkirk, at the confluence of the Pelly and Lewes rivers, my journey was continued up the last-named stream and over the Chilkoot Pass to the sea, which was reached on the 15th September, 1888. This part of my route, therefore, coincides with that followed and examined in 1887 by Dr. Dawson, and is described by him in Part B., Annual Report of the Geological Survey, 1887-88.

APPENDIX.

METEOROLOGICAL OBSERVATIONS.

The barometer readings are those of a pocket aneroid.
The temperature is stated in degrees Fahrenheit.
The force of the wind, when given, is estimated according to Beaufort's scale.
The character of the clouds is denoted by the usual letters or combination of letters (Howard's classification).

LOCALITY.	Date.	Hour.	Bar.	Therm.		Wind.	Clouds.	Weather at time.	REMARKS.
				Air.	Min.				
	1887.			°	°				
Forks of the Liard and Dease, 30 ft. above river	June 25	8 p.m.	27.79	......	......	....	....	Cloudy.	Showery in afternoon.
" "	" 26	8 a.m.	27.81	......	......	Variable.	S.	"	
Liard River, mouth of Highland River	" 26	7 p.m.	27.75	58	......	S.W.light.	K.S.	"	Tem. of water, 48°.
" "	" 27	6 a.m.	27.77	48	47	....	K.S.	Overcast.	
Little Cañon, Liard River	" 27	7 p.m.	27.85	59	......	Westerly.	C.K.	Cloudy.	Tem. of water, 51°.
" "	" 28	6 a.m.	28.03	47	40	Variable.	K.S.	"	Showery in afternoon.
Porcupine Bar	" 28	7 p.m.	28.00	59	......	S.W.	K.S.	"	
" "	" 29	6 a.m.	28.06	50	50	....	C.S.	"	Passing showers.
Cranberry Portage	" 29	7 p.m.	28.05	60	......	S.W.	C.S.	"	Passing showers.
" "	" 30	6 a.m.	28.09	46	37	S.E	S.C.S.	"	
Foot of Rapids near Mud River	" 30	7 p.m.	28.06	55	......	E.N.E.	K.S.	"	Showery in afternoon.
" "	July 1	6 a.m.	28.15	49	41	....	K.S.	Overcast.	
" "	" 1	7 p.m.	28.02	64	......	S.W.	K.S.	Cloudy.	Raining in afternoon.
" "	" 2	6 a.m.	28.04	51	40	....	C.K.S.	"	Temp. of water, 52°.
Two miles below mouth of Mud River	" 2	8 p.m.	28.00	57	......	E.N.E.	N.	Raining.	Thunder showers.
" "	" 3	6 a.m.	28.07	47	45	....	....	Clear.	Cleared up during night.
Mountain Portage, Liard River	" 3	7 p.m.	28.06	57	..	....	C.S.	Cloudy.	Showery.
" "	" 4	6 a.m.	28.05	42	31	....	N.	Raining.	
Second Portage, Liard River	" 4	10 p.m.	28.00	50	......	....	N.	Showery.	Showery weather.
" "	" 5	6 a.m.	28.175	52	40	....	K.C.S.	Cloudy.	Tem. of water, 51° 30′.
Head Portage Brulé	" 5	7 p.m.	28.265	55	......	West'ly l't.	K.S.	"	
" "	" 6	6 a.m.	28.350	56	41	S.W.light.	K.S.	"	
" "	" 6	7 p.m.	28.26	58	......	....	C.S.	"	Thunder showers all day.
" "	" 7	6 a.m.	28.26	47	37	S.W.	S.	Overcast.	
Foot Portage Brulé	" 7	7 p.m.	28.30	52	......	W.S.W.	K.S.	Cloudy.	Heavy thunder showers at noon.
"	" 8	6 a.m.	28.25	46	33	S.E.	C.K.S.	"	

Thirty miles below Portage Brulé	July	8	7 p.m.	28.24	49	......	....	S.	Overcast.	
" "	"	9	6 a.m.	28.33	40	39	W.	N.	Raining.	
Head Devil's Portage..................	"	9	9 p.m.	28.50	48	......	Westerly.	K.S.	Squally.	Showery, disagreeable day.
"	"	10	8 a.m.	28.57	51	40	W.	C.S.	"	Squally weather.
"	"	10	8 p.m.	28.49	56	......	S.W.	....	Clear.	
"	"	11	6 a.m.	28 60	52	44	S.S.W.	S.K.S.	Raining.	Showery.
"	"	11	7 p.m.	28.55	52	......	S. W.	N.	Cloudy.	Tem. of water, 51°.
"	"	12	7 a.m.	28 64	48	35	W.	C.S.	"	Passing showers.
Foot of Devil's Portage................	"	12	7 p.m.	28.55	52	......	W.S.W.	K.	"	
"	"	13	6 a.m.	28.55	46	30	E.	C.	"	
"	"	13	7 p.m.	28 375	58	......	W.	S.	Misty.	Misty.
"	"	14	6 a.m.	28.56	44	37	S.E.	C.S.	Cloudy.	
"	"	14	7 p.m.	28.60	57	......	N.W.	C.S.	Overcast.	Overcast.
"	"	15	6 a.m.	28.70	46	36	N.N.W.	Haze.	"	River falling. [53°.
"	"	15	8 p.m.	28.65	52	......	S.S.W.	Haze.	"	Raining in afternoon ; tem. of water,
"	"	16	6 a.m.	28.68	54	41	S.S.W.	S.	"	Raining during night.
"	"	16	7 p.m.	28.675	55	......	S.W.	....	....	Showery in afternoon.
"	"	17	6 a.m.	28.765	48	32	W.	....	....	Raining during night.
Six miles below Devil's Portage.......	"	17	7 p.m.	28.765	52	......	W.	N.	Overcast.	Raining about noon.
" "	"	18	6 a.m.	28.825	60	41	....	S.C.S.	Cloudy.	
Twenty-two "	"	18	7 p.m.	28.88	65	......	S.W.	C.S.	"	
" "	"	19	7 a.m.	28 91	51	38	E.	K.	"	Passing showers.
Twenty-six "	"	19	7 p.m.	28.94	65	......	E.	C.S.	"	
" "	"	20	7 a.m.	29.09	57	54	E.	S.	"	
" "	"	20	8 p.m.	28.93	68	......	....	S.K.	"	First summer weather since leaving
" "	"	21	6 a.m.	28.95	51	47	S.E.	....	Clear.	Telegraph Creek; water in river
Foot of Big Cañon....................	"	21	7 p.m.	28.85	66	......	E.	C.	Cloudy.	commencing to rise.
"	"	22	6 a.m	28.965	58	51	S.S.E.	K.C.S.	"	
"	"	22	8 p.m.	28 95	73	......	N.W.	K.	"	River rising rapidly.
"	"	23	6 a.m.	29.04	63	61	....	K.	"	Tem. of water, 59°.
"	"	23	8 p.m.	29.15	62	......	S.W.2.	C.K S.	"	Showery.
"	"	24	6 a.m.	29.24	53	51	....	....	Fóg.	
"	"	24	7 p.m.	29.05	62	......	N.W.4.	....	Clear.	Clear.
"	"	25	6 a.m.	29.12	51	43	....	....	....	
Mouth of Nahanni River	"	25	7 p.m.	29.37	57	......	E.2.	S.	Overcast.	Light showers.
" "	"	26	6 a.m.	29.36	53	49	E.1.	S.	"	Fine weather.
Above mouth of Nelson River.........	"	26	8 p.m.	29.375	67	......	N.E.2.	C.	Cloudy.	
" "	"	27	6 a.m.	29.35	53	44	E. light.	C.	"	
Near mouth of the Nelson	"	27	7 p.m.	29.05	70	......	S.E.	S.C.	"	River falling.
" "	"	28	6 a.m.	29.00	53	45	....	S.	"	
Thirty miles above Fort Liard.........	"	28	8 p.m.	29.17	63	......	N.	S.	Overcast.	
" "	"	29	4 a.m.	29.16	58	58	N.E.	S.	"	Showers during day.
Fort Liard, 20 ft. above river level....	"	29	8 p.m.	29.37	52	......	N.5.	C.S.	Cloudy.	Raining in afternoon.
" "	"	30	6 a.m.	29.40	51	47	N.W.	S.	Overcast.	
" "	"	30	8 p.m.	29.18	61	......	N.E.3.	K.S.	Cloudy.	Lightning in west.
" "	"	31	6 a.m.	29 12	56	44	W.2.	S.	"	Cloudy.
" "	"	31	8 p.m.	29.10	53	......	S.2.	N.	Raining.	
" "	Aug.	1	6 a.m.	29.04	50	50	S.E.3.	S.C.S.	Overcast.	Raining most of night.
" "	"	1	8 p.m.	28.90*	50	43	S.E.2.	C.S.	Cloudy.	Clearing.
" "	"	2	6 a.m.	28.96	56	......	S.E.1.	K.S.	"	

* Bar. used from this on reads .165 lower than the one previously read.

LOCALITY.	Date.	Hour.	Bar.	Therm. Air.	Therm. Min.	Wind.	Clouds.	Weather at time.	REMARKS.
	1887.			°	°				
Fort Liard, 20 ft. above river level	Aug. 2	7 p.m.	29.18	50	......	N.	N.	Raining.	Water falling in river.
" "	" 3	7 a.m.	29.38	55	48	E.4.	K.S.	Overcast.	
" "	" 3	8 p.m.	29.26	67	......	S.W.4.	S.K.S.	Cloudy.	
" "	" 4	6 a.m.	29.16	61	52	S.4.	S.K.	"	
" "	" 4	7 p.m.	29.03	64	......	S.W.3.	S.C.S.	"	
" "	" 5	6 a.m.	28.98	52	46	S.W.1.	K.	"	Tem. of water, 57°.
Forty miles below Fort Liard	" 5	8 p.m.	29.03	71	......	N.2.	C.S.S.	"	Passing showers.
" "	" 6	6 a.m.	29.23	52	44	N.W.2.	S.	Overcast.	
Mouth Nahanni River	" 6	8 p.m.	29.45	52	......	N.W.1.	S.C.S.	Cloudy.	Raining in afternoon.
" "	" 7	4 a.m.	29.48	48	44	....	K.S.	"	
Twenty-five miles below Nahanni Riv.	" 7	9 p.m.	29.42	59	.....		....	Clear.	
" "	" 8	5 a.m.	29.30	41	37	S.W. light.	C.	Fog.	
Twenty miles above mouth of the Liard	" 8	8 p.m.	28.95	55	......	S.W.	S.C.S.	Cloudy.	Showery.
" "	" 9	4 a.m.	28.97	51	50	N.E.1.	S.C.S.	"	
Fort Simpson	" 9	9 p.m.	29.35	62	......	N.E.1.	S.K.S.	"	Passing showers.
"	" 10	8 a.m.	29.42	56	52	N.W.	C.S.	"	
"	" 10	8 p.m.	29.40	62	......	N.W.	S.	"	
"	" 11	7 a.m.	29.40	55	44	....	K.S.	"	Fine weather.
"	" 11	7 p.m.	29.30	66	......	N.W.	S.	"	
"	" 12	7 a.m.	28.40	54	50	....	S.C.S.	"	
"	" 12	8 p.m.	28.50	49	......	N.W.	S.C.S.	Overcast.	Passing showers.
"	" 13	7 a.m.	29.52	44	44	S.	N,	Raining.	
"	" 13	8 p.m.	29.55	50	......	S.W.	S.	Cloudy.	Clearing.
"	" 14	6 a.m.	29.60	51	42	S.W.	S.	"	
"	" 14	8 p.m.	29.30	42	......	....	N.	"	Rainy day.
"	" 15	6 a.m.	29.22	38	36	N.N.W.	....	Fog.	Dense fog.
	On H.	B. steamer	15-25 Au	g., no	obser	vations tak	en.	Cloudy.	
Slave River, mouth of Salt River	" 25	8 p.m.	29.35	60	......	....	S.C.S.	"	Passing showers.
" "	" 26	7 a.m.	29.30	54	45	S.E.	C.S.	Overcast.	
Salt Springs, Salt River	" 26	8 p.m.	29.17	64	......	S.E.	S.	Cloudy.	Thunder shower in afternoon.
" "	" 27	6 a.m.	29.04	50	42	....	S.C.S.	"	
Slave River, ten miles below mouth Salt River	" 27	8 p.m.	28.94	68	......	S.E.	S.C.S.	"	
	" 28	6 a.m.	28.93	60	56	N.E.	K.C.C.S.	Raining.	
Fifty miles below mouth of Salt River.	" 28	8 p.m.	28.82	58	......	N.E.	N.	Cloudy.	Raining since noon.
" "	" 29	6 a.m.	28.84	54	50	N.E.	S.C.S.	"	
Big Island, Slave River	" 29	8 p.m.	29.10	61	......	N.	C.C.S.	"	
" "	" 30	4 a.m.	29.25	53	53	N.	C.S.	Raining.	Changeable.
Below Pointe Seul, Slave River	" 30	8 p.m.	29.25	58	......	S.S.W.	N.	Cloudy.	Showery.
" "	" 31	5 a.m.	29.30	51	50	S.E.	C.C.S.	"	
Fort Resolution	" 31	8 p.m.	29.29	61	......	S.W.	K.C.S.	"	Passing showers.
"	Sept. 1	5 a.m.	29.25	56	54	S.S.W.	C.S.	"	

Fort Resolution	Sept.	1	7 p.m.	29.25	66	.....	......	C.	Cloudy.	
"	"	2	6 a.m.	29 25	55	53	S.E.	C.	"	
Near mouth of Buffalo River, Great Slave Lake	"	2	8 p.m.	29.20	59	.....	S.E.	C.C.S.	"	Wind bound on 3rd, heavy wind [storm.
"	"	3	6 a.m.	29.18	54	52	S.W.	C.S.	"	
" "	"	3	8 p.m.	29 35	60	.....	S.W.	S.C.S.	"	Passing showers.
" "	"	4	6 a.m.	29.40	49	45	S.E.	K.S.C.S.	"	
Sulphur Point, Great Slave Lake	"	4	8 p.m.	29.22	54	.....	Var.	K.S.	"	Wind bound 5th to 7th inc.; furious gale blowing on lake.
" "	"	5	6 a.m.	29.31	50	49	N.W.	N.	Raining.	
" "	"	5	8 p.m.	29.52	45	.....	N.	K.S.	Cloudy.	
" "	"	6	6 a.m.	29.51	40	36	N.	C.S.	"	
" "	"	6	8 p.m.	29.20	47	.....	N.W.	C.C.S.	"	
" "	"	7	6 a.m.	29.10	40	38	N.N.W.	C.C.S.	Overcast.	Raining during night.
" "	"	7	8 p.m.	29.30	42	.....	N.W.	C.C.S.	Cloudy.	Showery.
" "	"	8	6 a.m.	29.49	36	31	S.E.	S.C.S.	"	
Mouth of Hay River	"	8	7 p.m.	29.45	40	.....	E.	S.C.	"	
"	"	9	6 a.m.	29.30	38	36	E.N.E.	S.	"	
Hay River, 15 miles above mouth	"	9	6 p.m.	29.08	58	.....	N.W.	C.C.S.	"	
" "	"	10	7 a.m.	28.95	47	45	N.W.	N.	Raining.	Cleared up at noon.
" 21 "	"	10	8 p.m.	29.22	52	.....	N.N.W.	K.C.	Cloudy.	
" "	"	11	7 a.m.	29.46	37	33	N.W.	......	Clear.	
" 37 "	"	11	8 p.m.	29.48	46	.....	N.W.	......	"	
" "	"	12	6 a.m.	29.375	26	26	......	C.C.S.	Cloudy.	Changeable.
" Falls	"	12	7 p.m.	29.20	44	.....	N.W.	S.	"	
"	"	13	6 a.m.	29.10	28	23	......	......	Clear.	
"	"	13	7 p.m.	29.325	42	.....	N.N.W.	N.	Raining.	Stopped raining at midnight.
"	"	14	6 a.m.	29.50	40	39	S.W.	C.S.K.	Cloudy.	
" 4 miles above mouth	"	14	7 p.m.	29.70	37	.....	S.E.	S.	"	Cloudy to clear.
" "	"	15	6 a.m.	29.70	39	27	......	......	Clear.	
Pt. de Roche, Slave Lake	"	15	7 p.m.	29.625	40	.....	E.S.E.	S.C.S.	Cloudy.	
"	"	16	5 a.m.	29.525	25	25	......	C.S.C.S.	"	
Big Island, "	"	16	7 p.m.	29.50	38	.....	N.N.W.	C.S.	"	
" "	"	17	6 a.m.	29.475	23	22	N.E.	......	Clear.	
" Fishery	"	17	7 p.m.	29.525	42	.....	N.N.E.	C.	Cloudy.	Stormy wind.
"	"	18	6 a.m.	29.70	29	27	N.E.	C.S.	"	
"	"	18	7 p.m.	29 61	35	.....	E.S.E.	S.C.	"	
"	"	19	6 a.m.	29.68	26	25	S.	......	Clear.	
Pt. aux Esclaves	"	19	7 p.m.	29.62	38	.....	E.S.E.	......	"	
"	"	20	6 a.m.	29.65	25	25	N.E.	......	"	
"	"	20	8 p.m.	29.80	36	.....	E.S.E.	......	"	Clear bright weather.
"	"	21	6 a.m.	29.75	27	27	S.E.	......	"	
"	"	21	8 p.m.	29.65	48	.....	S.	......	"	Blowing a gale all day.
Big Island Fishery	"	22	6 a.m.	29.50	43	40	S.	C.	Cloudy.	
"	"	22	8 p.m.	29.30	48	.....	N.W.	S.C.	"	
Mackenzie River, 15 miles above Fort Providence	"	23	6 a.m.	29.42	42	42	W.N.W.	C.S.	"	Strong wind.
"	"	23	7 p.m.	29.80	27	.....	N.	C.S.	"	
"	"	24	6 a.m.	29.51	34	23	S.S.E.	S.	Overcast.	
Fort Providence	"	24	7 p.m.	29.32	38	.....	E.N.E.	N.	Raining.	
"	"	25	6 a.m.	29.47	36	35	N.W.	N.	"	Heavy rain.
"	"	25	7 p.m.	......	.....	.....	......	......	......	
"	"	26	6 a.m.	......	.....	.....	......	......	......	

LOCALITY.	Date.	Hour.	Bar.	Therm.		Wind.	Clouds.	Weather at time.	REMARKS.
				Air.	Min.				
	1887.			°	°				
Mouth of Willow River	Sept. 26	7 p.m.	29.30	42	......	....	C.S.	Cloudy.	Raining in afternoon.
" "	" 27	6 a.m.	29 22	38	36	N.N.W.	Fog.	Fog.	
" "	" 27	7 p.m.	29.32	38	......	....	C.S.	Cloudy.	Clear at noon.
" "	" 28	6 a.m.	29.26	25	25	E.N.E.	S.	"	
" "	" 28	7 p.m.	28 88	40	......	E.N.E.	N.	Raining.	
" "	" 29	6 a.m.	29.30	39	39	S.E.	C.S.	Cloudy.	Clearing.
" "	" 29	7 p.m.	29.59	42	......	N.N.E.	S.	Overcast.	
" "	" 30	6 a.m.	29.70	38	38	N.E.	S.	"	
" "	" 30	8 p.m.	28.89	40	......	N.N.E.	N.	Raining.	
" "	Oct. 1	6 a.m.	29.10	35	34	N.N.E.	N.	Snowing.	First snow of the season.
" "	" 1	8 p.m.	29.45	36	......	N.	N.	"	
" "	" 2	6 a.m.	29 65	20	17	N.	C.S.S.	Overcast.	
" "	" 2	8 p.m.	29.65	22	......	N.N.E.	S.	"	Cold, disagreeable weather.
" "	" 3	6 a.m.	29.58	15	15	E.N.E.	S.	"	
" "	" 3	8 p.m.	29.55	34	......	N.E.	S.	"	
" "	" 4	6 a.m.	29.51	30	15	N.E.	S.	"	
Fort Providence	" 4	8 p.m.	....	......	......	....	....	....	

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE, SEASON 1888-9.

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.		Weather at time.	REMARKS.
			Air.	Max.	Min.	Direction.	Force.	Kind.	Amt.		
1887.											
Oct. 4	8 p.m.	29.32	39	......	......	N.E.	......	S.	......	Overcast.	Some rain in afternoon.
" 5	9 a.m.	29 43	33	......	33	N.E.	......	N.	......	Showery.	
" 5	6 p.m.	29.52	33	......	......	N.	......	S.	......	Overcast.	Clearing.
" 6	9 a.m.	29.66	26	......	21	N.N.E.	......	......	......	Clear.	
" 6	5 p.m.	29.70	33	41	......	S.E.	1	......	......	"	
" 7	9 a.m.	29.63	24	......	16	......	......	......	......	"	
" 7	5 p.m.	29.50	29	35	......	E.N.E.	3	C.S.	......	Cloudy.	
" 8	9 a.m	29.44	27	......	25	N.	1	N.	......	Snowing.	
" 8	5 p.m.	29.45	33	38	......	N.E.	Light.	S.	......	Overcast.	Light fall of snow.
" 9	9 a.m.	29.80	34	......	31	W.N.W.	1	S.	......	"	
" 9	5 p.m.	29 90	33	36	......	N.W.	1	S.	......	"	
" 10	9 a.m.	29 90	37	......	33	E.	1	S.	......	Cloudy.	
" 10	5 p.m.	29.54	33	35	......	E.	3	S.	......	Overcast.	
" 11	9 a.m.	29 00	33	......	33	S.W.	5	N.	......	Snowing.	
" 11	5 p.m.	29.50	30	34	......	N.W.	3	S.	......	Overcast.	Five inches of snow.
" 12	9 a.m.	29.50	31	......	29	W.	2	......	......	Clear.	
" 12	5 p.m.	29.65	31	35	......	......	......	S.C.S.	......	Cloudy.	
" 13	9 a.m.	29.30	26	......	25	N.W.	2	S.C.S.	......	"	
" 13	5 p.m.	29.05	34	35	......	N.W.	1	N.	......	Rain and snow.	Fog, rain and snow.
" 14	9 a.m.	28.95	32	. .	32	W.	1	N.	......	Mist.	
" 14	5 p.m.	29.25	33	35	......	N.N.W.	Light.	C.C.S.	......	Cloudy.	Passing showers.
" 15	9 a.m.	29.20	29	......	28	N.E.	"	S.	......	Overcast.	Snowing.
" 15	5 p.m.	29.40	33	34	......	W.	"	S.	......	"	Snowing.
" 16	9 a.m.	29.51	32	......	31	N.N.W.	1	N.	......	Snowing.	Light fall of snow.
" 16	5 p.m.	29.42	32	34	......	E.	Very light.	S.	......	Overcast.	
" 17	9 a.m.	29.375	32	......	31	N.E.	1	N.	......	Snowing.	
" 17	5 p.m.	29 15	32	32	......	N.E.	3	S.	......	Overcast.	
" 18	9 a.m.	28.80	30	......	24	......	......	S.	......	"	
" 18	5 p.m.	29.08	27	33	......	N.	2	S.	......	"	
" 19	9 a.m.	29.42	28	......	24	W.N.W.	1	S.C.S.	......	"	Robins seen.
" 19	5 p.m.	29.47	32	35	......	S.W.	1	C.S.	......	Cloudy.	
" 20	9 a.m.	29.49	29	......	18	......	......	......	......	Foggy.	
" 20	5 p.m.	29.49	29	31	......	N.N.W.	1	S.	......	Overcast.	Foggy.
" 21	9 a.m.	29.85	8	......	8	N.	4	N.	......	Snowing.	Light fall of snow.
" 21	5 p.m.	29.98	10	11	......	N.	1	S.	......	Overcast.	First winter's day; ice floating in river.
" 22	9 a.m.	30.20	5	......	2	N.	1	S.C.S	......	Cloudy.	Clearing.
" 22	5 p.m.	30.31	7	9	......	N.	2	S.C.S	......	"	
" 23	9 a.m.	30.30	7	......	3	N.	2	S.	......	Overcast.	
" 23	5 p.m.	30.14	8	9	......	W.N.W.	1	C.S.	......	Cloudy.	Cloudy day.

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE—*Continued.*

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.		Weather at time.	REMARKS.
			Air.	Max.	Min.	Direction.	Force.	Kind.	Amt.		
1887.											
Oct. 24	9 a.m.	29.60	2	......	—3	E.	1	....	......	Clear.	Clearing.
" 24	5 p.m.	29.61	10	12	......	N.E.	1	S.	......	Overcast.	Cloudy and cold.
" 25	9 a.m.	29.67	6	......	5	E.N.E.	1	....	......	Clear.	
" 25	5 p.m.	29 55	12	15	......	E.N.E.	1	S.	......	Overcast.	
" 26	9 a.m.	29.35	10	......	9	E.N.E.	2	S.	......	"	
" 26	5 p.m.	29.26	18	18	......	E.N.E.	1	C.S.	......	Cloudy.	
" 27	9 a.m.	29.23	18	......	18	E.N.E.	2	S.	......	Overcast.	
" 27	5 p.m.	29.33	24	24	......	E.	1	C.S.	......	Cloudy.	
" 28	9 a.m.	29.36	20	......	15	N.E.	1	S.	......	"	
" 28	5 p.m.	28.92	32	32	......	N.E.	1	S.	......	Overcast.	[chinook.
" 29	9 a.m.	29 00	41	......	32	S.W.	2	C.S.	......	Cloudy.	Wind blew hard during night, felt like a
" 29	5 p.m.	29.18	41	52	......	N.	1	....	......	Clear.	
" 30	9 a.m.	29.57	17	......	17	N.	2	S.	......	Overcast.	
" 30	5 p.m.	29.61	23	25	......	N.N.E.	1	S.	......	"	Very cloudy weather.
" 31	9 a.m.	29.10	23	......	17	E.N.E.	3	S.	......	"	Strong wind during night.
" 31	5 p.m.	29.21	21	24	......	N.N.W.	2	S.	......	"	
Nov. 1	9 a.m.	29.54	9	......	7	N.	1	C.S.	......	Cloudy.	
" 1	5 p.m.	29 C6	8	11	......	N.	1	S.	......	Overcast.	
" 2	9 a.m.	29.46	7	......	5	N.N.E.	1	S.C.S.	......	Cloudy	Very cloudy weather.
" 2	5 p.m.	29.55	8	12	......	N.	1	S.	......	Overcast.	
" 3	9 a.m.	29.47	13	......	10	N.E.	Very light.	S.	......	"	
" 3	5 p.m.	29 25	23	23	......	E.N.E.	2	S.	......	"	
" 4	9 a.m.	28.82	32	......	23	E.S.E.	1	S.C.S.	......	Cloudy.	
" 4	5 p.m.	28.71	32	34	......	E.S.E.	1	S.C.S.	......	"	
" 5	9 a.m.	28 88	27	......	25	W.	Light.	S.	......	Overcast.	
" 5	5 p.m.	29.08	22	24	......	W.	3	S.	......	"	
" 6	9 a.m.	29 37	3	......	0	N.N.W.	1	C.S.	......	Cloudy.	Overcast to cloudy.
" 6	5 p.m.	29.16	12	13	......	N.N.E.	1	S.	......	Overcast.	Overcast all day.
" 7	9 a.m.	28.92	16	......	12	S.	3	C.S.	......	Cloudy.	Cloudy ; breaking up.
" 7	5 p.m.	29.06	10	12	......	S.W.	2	....	......	Clear.	Clear.
" 8	9 a.m.	29.30	—1	......	—1	W.S.W.	....	....	......	"	
" 8	5 p.m.	29.33	—1	5	......	N.N.E.	....	....	......	"	Clear, bright day.
" 9	9 a.m.	29.04	18	......	—4	N.E.	3	S.	......	Overcast.	
" 9	5 p.m.	28.70	22	22	......	N.E.	2	N.	......	Snowing.	Heavy snow storm.
" 10	9 a.m.	29.05	7	......	7	S.S.W.	2	....	......	Clear.	Clearing up.
" 10	5 p.m.	29.27	10	14	......	S.S.W.	2	....	......	"	Clear day.
" 11	9 a.m.	29.38	0	......	0	S.S.W.	1	C.C.S.	......	Cloudy.	
" 11	5 p.m.	29.35	28	23	......	S.	2	S.	......	Overcast.	Clouding up.
" 12	9 a.m.	29.50	1	......	—1	N.	1	S.	......	"	

Nov.	12	5 p.m.	29.34	4	5	......	N.N.W.	2	S.	......	Overcast.	Overcast all day.
"	13	9 a.m.	29.15	4	......	3	S.	1	S.	......	"	Two inches of snow during night.
"	13	5 p.m.	28.85	7	7	......	N.W.	1	S.	......	"	
"	14	9 a.m.	28.74	15	......	7	W.N.W.	2	N.	......	Snowing.	Three inches of snow during night.
"	14	5 p.m.	29.00	6	15	......	S.S.W.	3	N.	......	"	Flurries of snow all day.
"	15	9 a.m.	29.12	1	......	—1	S.W.	2	N.	......	"	Still snowing.
"	15	5 p.m.	29.27	3	6	......	N.W.	4	C.S.	......	Cloudy.	Clearing up.
"	16	9 a.m.	29.52	—5	......	—7	S.W.	1	......	......	Clear.	River frozen over during night.
"	16	5 p.m.	29.55	—3	—1	......	W.S.W.	1	......	......	"	Clear.
"	17	9 a.m.	29 32	—12	......	—17	N.N.E.	1	S.	......	Overcast.	
"	17	5 p.m.	29.30	—2	—1	......	N.N.E.	3	N.	......	Snowing.	Light fall of snow.
"	18	9 a.m.	29.70	—17	......	—17	Calm.	......	......	......	Clear.	
"	18	5 p.m.	29.70	—14	—5	......	"	......	......	......	"	Beautiful day.
"	19	9 a.m.	29.45	4	......	—14	"	......	S.	......	Overcast.	
"	19	5 p.m.	29 20	15	16	......	"	......	N.	......	Snowing.	Light fall of snow.
"	20	9 a.m.	29 00	—2	......	—2	S.S.W.	2	S.C.S.	......	Cloudy.	
"	20	5 p.m.	29.30	10	12	......	N.N.E.	1	S.	......	Overcast.	Dull day.
"	21	9 a.m.	29.63	—2	......	—2	S.S.W.	1	C.S.	......	Cloudy.	
"	21	5 p.m.	29.70	0	0	......	S.S.W.	Light.	......	......	Clear.	Cloudy to clear.
"	22	9 a.m.	29.41	—1	......	—14	N.E.	1	C S.	......	Cloudy.	
"	22	5 p.m.	29.32	0	1	......	......	......	......	......	Clear.	
"	23	9 a.m.	29 48	—4	......	—7	S.W.	Light.	C.S.	......	Cloudy.	
"	23	5 p.m.	29.50	5	5	......	W.N.W.	1	N.	......	Snowing.	Light fall of snow.
"	24	9 a.m.	30.12	—15	......	—15	W.N.W.	Light.	......	......	Clear.	
"	24	5 p m.	30.25	—15	—11	......	W.N.W.	1	......	......	"	Clear cold weather.
"	25	9 a.m.	30.35	—22	......	—22	W.N.W.	Very light.	......	......	"	"
"	25	5 p.m.	30.24	—20	—19	......	......	"	......	......	"	"
"	26	9 a.m.	30.00	—34	......	—35	......	"	......	......	"	"
"	26	5 p.m.	30.02	—28	—26	......	N.W.	"	......	......	"	"
"	27	9 a.m.	29.95	—33	......	—35	N.W.	"	......	......	"	"
"	27	5 p.m.	29.90	—30	—27	......	N.W.	"	......	......	"	"
"	28	9 a.m.	29.88	—38	......	—47	......	"	......	......	"	"
"	28	5 p.m.	29.82	—30	—28	......	......	"	......	......	"	"
"	29	9 a.m.	29.75	—20	......	—34	N.E.	1	C.S.	......	Cloudy.	Changeable.
"	29	5 p.m.	29.75	—14	—14	......	......	......	......	......	Clear.	
"	30	9 a.m.	29.85	—10	......	—14	S.S.W.	1	N.	......	Snowing.	
"	30	5 p.m.	29 82	—16	—9	......	S.S.W.	Very light.	C.C.S.	......	Cloudy.	Two inches of snow.
Dec.	1	9 a.m.	29 70	—14	......	—20	E.N.E.	"	S.C.S.	......	"	
"	1	5 p.m.	29.55	—9	—6	......	N.N.E.	1	S.C.S.	......	Cloudy.	Cloudy all day.
"	2	9 a.m.	29.72	—5	......	—9	N W.	......	S.	......	Overcast.	
"	2	5 p.m.	29.90	—7	—5	......	N.W.	3	S.	......	"	Dull weather.
"	3	9 a.m.	30 13	—22	......	—22	N.W.	1	S.C.S.	......	Cloudy.	
"	3	5 p.m.	30.15	—25	—20	......	N.W.	1	S.C.S.	......	"	Cold raw day.
"	4	9 a.m.	29.99	—34	......	—35	......	......	......	......	Clear.	
"	4	5 p.m.	29 95	—32	—31	......	......	......	......	......	"	Clear and cold.
"	5	9 a.m.	30.15	—31	......	—36	W.N.W.	1	S.	......	Overcast.	
"	5	5 p.m.	30.20	—33	—30	......	......	......	......	......	Clear.	Overcast to clear.
"	6	9 a.m.	29.90	—32	......	—34	......	......	S.C.S.	......	Cloudy.	
"	6	5 p.m.	29 70	—28	—28	......	......	......	......	......	Clear.	Cloudy to clear.
"	7	9 a.m.	29.45	—22	......	—28	......	......	N.	......	Snowing.	

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE—*Continued.*

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.		Weather at time.	REMARKS.
			Air.	Max.	Min.	Direction.	Force.	Kind.	Amt.		
1887. Dec. 7	5 p.m.	29.40	—17	—16	......	N. W.	1	N.	......	Snowing.	Snowing all day.
" 8	9 a.m.	29.55	—18	......	—22	N. W.	3	N.	......	"	
" 8	5 p.m.	29.80	—20	—17	......	N. W.	3	N.	......	"	Very stormy. [fell.
" 9	9 a.m.	29.95	—32	......	—34	......	......	......	......	Clear.	Cleared up during night; six inches of snow
" 9	5 p.m.	29.85	—32	—31	......	......	......	......	......	"	
" 10	9 a.m.	29.50	—35	......	—38	......	......	......	......	"	
" 10	5 p.m.	29.24	—26	—22	......	N. W.	Very light.	N.	......	Snowing.	Flurries of snow.
" 11	9 a.m.	29.09	—17	......	—26	......	......	......	......	Clear.	
" 11	5 p.m.	29.00	—22	—17	......	N.E.	2	S.	......	Overcast.	
" 12	9 a.m.	29.10	—15	......	—17	S.W.	3	N.	......	Snowing.	
" 12	5 p.m.	29.33	—16	—14	......	S.W.	1	S.	......	Cloudy.	Snowing 10 p.m. to 11 a.m.
" 13	9 a.m.	29.69	—26	......	—27	S.W.	1	S.C.S.	9	"	
" 13	5 p.m.	29.56	—25	—14	......	N.E.	1	S. Haze.	7	"	
" 14	9 a.m.	29.10	—21	......	—21	Variable.	Light.	S.	2	"	
" 14	5 p.m.	29.07	—15	—15	......	N.E.	2	S.	......	"	
" 15	9 a.m.	28.90	—16	......	—16	......	......	S.	......	"	
" 15	5 p.m.	29.02	—24	—16	......	S.S.W.	3	S.C.S.	8	"	Bright aurora.
" 16	9 a.m.	29.30	—29	......	—29	S.W.	1	......	......	Clear.	
" 16	5 p.m.	29.45	—26	—25	......	S.W.	1	......	......	"	
" 17	9 a.m.	29.52	—23	......	—37	S.	Light.	N.	10	Snowing.	Aurora.
" 17	5 p.m.	29.57	—30	—21	......	......	......	......	......	Clear.	Snowing 4 a.m. to 10 a.m.
" 18	9 a.m.	29.65	—32	......	—40	S.	1	......	......	"	
" 18	5 p.m.	30.07	—33	—29	......	S.	2	......	......	"	
" 19	9 a.m.	29.85	—32	......	—35	E.	1	......	......	"	
" 19	5 p.m,	29.775	—32	—31	......	......	......	......	......	"	
" 20	9 a.m.	29.20	—5	......	—34	N.E.	1	S.C.S.	10	Overcast.	
" 20	5 p.m.	29.23	—1	0	......	N.E.	Light.	......	......	Clear.	
" 21	9 a.m.	29.15	2	......	—6	N.E.	3	N.	10	Snowing.	
" 21	5 p.m.	29.05	10	10	......	N.W.	3	S.	10	Overcast.	Snowing 3 a.m. to 10 a.m.
" 22	9 a.m.	29.70	—9	......	—10	......	......	......	......	Clear.	
" 22	5 p.m.	29.75	—15	10	......	......	......	......	......	"	
" 23	9 a.m	29 45	—8	......	—20	N.N.W.	3	S.	10	Overcast.	Aurora.
" 23	5 p.m.	29.52	—10	—7	......	N.	3	S.	10	"	
" 24	9 a.m,	29 82	—15	......	—17	......	......	S.	3	Cloudy.	
" 24	5 p.m.	29 92	—13	—10	......	......	......	......	......	Mist.	Misty.
" 25	9 a.m.	29.99	—25	......	—27	......	......	S.C.S.	3	Cloudy.	
" 25	5 p.m	29.99	—29	—10	......	......	......	S.	1	"	Aurora.
" 26	9 a.m.	30.00	—25	......	—30	N.N.E.	1	C.S.	6	"	
" 26	5 p.m.	30.00	—24	—23	......	......	......	......	......	Clear.	

Dec. 27	9 a.m.	30.02	—25	...	—31	N.N.E.	1	C.S.	3	Cloudy.	
" 27	5 p.m.	30.30	—27	—24	...	N.N.E.	2	S.	...	Overcast.	
" 28	9 a.m.	30.35	—33	...	—35	N.E.	2	C.C.S.	4	Cloudy.	
" 28	5 p.m.	30 40	—31	—26	...	N.	1	...	...	Misty.	
" 29	9 a.m.	30.35	—28	...	—37	...	...	...	...	"	
" 29	5 p.m.	30.25	—30	—26	...	...	...	...	...	Clear.	Clear calm day.
" 30	9 a.m.	30.10	—37	...	—45	...	...	...	...	Misty.	
" 30	5 p.m.	29.98	—33	—31	...	N.E.	Very light.	S.	2	Cloudy.	
" 31	9 a.m.	29 60	—36	...	—36	E.	1	...	...	Clear.	Clear cold weather.
" 31	5 p.m.	29.50	—23	—20	...	N.	Light.	...	...	"	
1888.											
Jan. 1	9 a.m.	29.25	—22	...	—25	N.E.	2	S.	10	Overcast.	
" 1	5 p.m.	29.10	—23	—21	...	N.E.	1	...	...	Clear.	
" 2	9 a.m.	29.55	—26	...	—28	Variable.	Light.	...	...	Cloudy.	
" 2	5 p.m.	29.55	—27	—22	...	Variable.	Light.	...	...	Clear.	Light snow fall.
" 3	9 a.m.	29.85	—20	...	—30	N N.W.	2	N.	10	Overcast.	Record until 15th January kept by S. Scott, H. B. Co.
" 3	5 p.m.	...	—26	—28	...	N.N.W.	2	C.	...	Cloudy.	
" 4	9 a.m.	...	—28	...	—38	E.	2	C.	...	"	
" 4	5 p.m.	...	—32	—24	...	E.	1	...	...	Clear.	
" 5	9 a.m.	...	—22	...	—31	S.E.	1	...	...	"	
" 5	5 p.m.	...	—23	—19	...	S.E.	1	...	...	"	
" 6	9 a.m.	...	—32	...	—33	W.	2	C. & S.	...	Cloudy.	
" 6	5 p.m.	...	—36	—24	...	S.W.	1	...	...	"	
" 7	9 a.m.	...	—24	...	—29	S.E.	1	S.	...	"	
" 7	5 p.m.	...	—27	—22	...	S.E.	1	...	...	Clear.	
" 8	9 a.m.	...	—18	...	—23	W.	Light.	...	...	Misty.	
" 8	5 p.m.	...	—22	—10	...	W.	Light.	S.	...	Cloudy.	
" 9	9 a.m.	...	—33	...	—35	S.E.	Light.	C.S.	...	"	
" 9	5 p.m.	...	—31	—30	...	...	...	...	...	Clear.	
" 10	9 a.m.	...	—27	...	—40	S.E.	1	C.K.S.	...	Cloudy.	
" 10	5 p.m.	...	—32	—24	...	S.E.	1	C.S.	...	"	
" 11	9 a.m.	...	—32	...	—39	W.	2	...	...	Clear.	
" 11	5 p.m.	...	—34	—29	...	S.W.	1	...	...	"	Clear bright day.
" 12	9 a.m.	...	—35	...	—38	W.	1	S.	2	Cloudy.	
" 12	5 p.m.	...	—31	—24	...	W.	1	...	...	Clear.	
" 13	9 a.m.	...	—28	...	—3	W.	1	C.S.	...	Cloudy.	
" 13	5 p.m.	...	—20	—16	...	...	...	C.S.	...	"	
" 14	9 a.m.	...	—15	...	—31	W.	Light.	S.	10	Overcast.	
" 14	5 p.m.	...	6	6	...	W.	2	S.	10	"	
" 15	9 a.m.	...	20	...	0	N.N.W.	Light.	N.	10	Snowing.	
" 15	5 p.m.	29.50	8	20	...	N.W.	1	S.	10	Overcast.	Snowing 5 a.m. to 10 a.m.
" 16	9 a.m.	29.34	5	...	2	N.W.	4	S.	7	Cloudy.	
" 16	5 p.m.	29 60	—19	8	...	N.W.	3	S.C.S.	3	"	Snow two feet deep.
" 17	9 a.m.	29.98	—32	...	—33	N.	1	...	...	Clear.	
" 17	5 p.m.	30.41	—29	—5	...	N.E.	1	...	...	"	
" 18	9 a.m.	29.64	—17	...	—37	N.W.	1	S.	2	Cloudy.	
" 18	5 p.m.	30.20	—13	—13	...	S.W.	2	S.	10	Overcast.	
" 19	9 a.m.	30.02	—18	...	—20	...	...	S.C.S.	3	Cloudy.	
" 19	5 p.m.	29.83	—6	—5	...	S.W.	2	C.S.	9	"	
" 20	9 a.m.	29.53	—1	...	—6	S.W.	2	S.C.S.	10	Overcast.	

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE—*Continued.*

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.		Weather at time.	REMARKS.
			Air.	Max.	Min.	Direction.	Force.	Kind.	Amt.		
1888. Jan. 20	5 p.m.	29.50	3	5	......	S.W.	1	N.	10	Snowing.	
“ 21	9 a.m.	....	—20	......	—21	N.N.W.	2	C.S.	4	Cloudy.	Snowing 4 p.m. to 1 a.m.
“ 21	5 p.m.	....	—26	3	......	N.N.W.	1	C.S.	6	“	Record kept by S. Scott Jan. 21st to Feb. 4th.
“ 22	9 a.m.	....	—24	......	—38	....	....	....	......	“	
“ 22	5 p.m.	....	—22	—22	......	....	....	....	......	“	
“ 23	9 a.m.	....	—17	......	—26	W.	1	....	......	“	
“ 23	5 p.m.	....	—28	—16	......	W.	1	....	......	“	Dull cloudy weather.
“ 24	9 a.m.	....	—24	......	—29	....	....	....	......	“	
“ 24	5 p.m.	....	—21	—17	......	....	....	....	......	“	
“ 25	9 a.m.	....	—37	......	—37	S.E.	1	....	......	Clear.	
“ 25	5 p.m.	....	—26	—21	......	E.	1	....	......	“	
“ 26	9 a.m.	....	—23	......	—37	E.	1	....	......	Cloudy.	
“ 26	5 p.m.	....	—16	—15	......	N.	1	....	......	“	
“ 27	9 a.m.	....	—9	......	—27	S.E.	1	....	......	“	
“ 27	5 p.m.	....	5	5	......	E.	2	C.C.S.	5	“	
“ 28	9 a.m.	....	—6	......	—6	....	....	C.S.	7	“	
“ 28	5 p.m.	....	—9	5	......	W.	1	C.S.	3	“	
“ 29	9 a.m.	....	—10	......	—12	N.	1	N.	10	Snowing.	
“ 29	5 p.m.	....	—8	—6	......	....	....	N.	10	“	Snowing at intervals all day.
“ 30	9 a.m.	....	—10	......	—10	N.	2	N.	10	“	
“ 30	5 p.m.	....	—12	—8	......	N.	2	N.	10	“	Flurries of snow.
“ 31	9 a.m.	....	—8	......	—12	W.	1	N.	10	“	
“ 31	5 p.m.	....	—10	—8	......	W.	3	S.	10	Overcast.	Stopped snowing 2 p.m.
Feb. 1	9 a.m.	....	—32	......	—34	W.	2	S.C.S.	3	Cloudy.	Clearing.
“ 1	5 p.m.	....	—32	—10	......	W.	1	....	......	Clear.	
“ 2	9 a.m.	....	—23	......	—38	E.	2	....	......	“	Clear bright weather.
“ 2	5 p.m.	....	—21	—18	......	E.	1	....	......	“	
“ 3	9 a.m.	....	—20	......	—26	W.	2	C.S.	4	Cloudy.	Changeable.
“ 3	5 p.m.	....	—21	—17	......	W.	1	....	......	Clear.	
“ 4	9 a.m.	....	—23	......	—30	E.	1	C.C.S.	3	Cloudy.	
“ 4	5 p.m.	....	—21	—17	......	....	....	S.C.S.	5	“	
“ 5	9 a.m.	....	—25	......	—29	N.W.	1	S.C.S.	4	“	
“ 5	5 p.m.	....	—19	—18	......	N.W.	1	S.C.C.S.	7	“	
“ 6	9 a.m.	29.79	—21	......	—26	....	....	S.C.C.S.	4	“	Dull cloudy weather.
“ 6	5 p.m.	29.75	—17	—15	......	S.W.	Light.	S.C.C.S.	4	“	
“ 7	9 a.m.	29.72	—29	......	—34	....	....	S.C.C.S.	5	“	
“ 7	5 p.m.	29.78	—30	—17	......	....	....	S.C.S.	3	“	
“ 8	9 a.m.	29.79	—34	......	—40	E.	1	S.	10	Overcast.	
“ 8	5 p.m.	29.69	—21	—19	......	E.	2	S.	10	“	

Feb. 9	9 a.m.	29.70	—25	......	—27	......	......	S.C.S.	3	Cloudy.	Snowing 6 p.m. to 11 p m.
" 9	5 p.m.	29.75	—22	—17	......	......	......	S.	2	"	
" 10	9 a.m.	29.80	—28	......	—41	......	......	S.	1	"	
" 10	5 p.m.	29.67	—35	—22	......	......	......	......	......	Clear.	
" 11	9 a.m.	29.16	—30	......	—35	S.	1	......	......	"	
" 11	5 p.m.	29.73	—15	—14	......	S.W.	4	S.	10	Overcast.	Stormy day.
" 12	9 a.m.	29.80	—35	......	—35	N.W.	3	S.	2	Cloudy.	
" 12	5 p.m.	30.00	—35	15	......	N.W.	2	......	......	Clear.	
" 13	9 a.m.	30.47	—47	......	—48	S.W.	2	......	......	"	Coldest day of the season.
" 13	5 p.m.	30.35	—35	—35	......	......	......	......	......	"	
" 14	9 a.m.	29.87	—42	......	—42	......	......	......	......	"	
" 14	5 p.m.	29.59	—23	—20	......	N.N.E.	1	......	......	"	Clear cold weather.
" 15	9 a.m	29.28	—22	......	—39	N.N.E.	1	S.	10	"	
" 15	5 p.m.	29.30	—17	—16	......	N.N.E.	Light.	S.	10	Overcast.	
" 16	9 a.m.	29.37	—18	......	—23	......	......	S.	10	"	
" 16	5 p.m.	29.67	—14	—12	......	......	......	N.	10	Snowing.	
" 17	9 a.m.	29.46	—22	......	—25	N.N.E.	Light.	S.	10	Overcast.	Snowing 4 p.m. to 10 p.m.
" 17	5 p.m.	29.37	—15	—10	......	N.	Light.	S.	10	"	
" 18	9 a.m.	29.50	—10	......	—16	......	......	S.C.S.	7	Cloudy.	Snowing 10 a.m. to 3 p.m.
" 18	5 p.m.	29.51	—7	—5	......	......	......	......	......	Clear.	
" 19	9 a.m.	29.02	—4	......	—15	E.N.E.	1	S.C.S.	9	Cloudy.	
" 19	5 p.m.	29.00	—1	10	......	E.	2	......	......	Clear.	
" 20	9 a.m.	29.00	—5	......	—8	E.	1	S.	10	Overcast.	
" 20	5 p.m.	29.21	—3	0	......	N.	2	S.	10	"	
" 21	9 a.m.	29.55	—5	......	—18	E.	1	S.	10	"	
" 21	5 p.m.	29.65	—10	—3	......	N.	1	S.C.S.	3	Cloudy.	Snowing 10 a.m. to 2 p.m.
" 22	9 a.m.	29.60	—13	......	—16	N.	Light.	N.	10	Snowing.	
" 22	5 p.m.	29.61	—7	—2	......	N.	Light.	S.	10	Overcast.	Snowing 7 a.m. to 2 p.m.
" 23	9 a.m.	29.80	—11	......	—14	......	......	S.	10	"	
" 23	5 p.m.	29.98	—8	—5	......	N.	Light.	C.S.	5	Cloudy.	
" 24	9 a.m.	30.10	—22	......	—27	N.E.	1	S.C.S.	8	"	
" 24	5 p.m.	30.06	—15	—8	......	N.	Light.	S.C.S.	3	"	
" 25	9 a.m.	30.02	—18	......	—27	N.N.E.	2	S.	10	Overcast.	
" 25	5 p.m.	29.88	—12	—4	......	N.E.	2	S.	10	"	
" 26	9 a.m.	29.25	—5	......	—13	E.	2	N.	10	Snowing.	
" 26	5 p.m.	29.31	—3	—1	......	N.	2	N.	10	"	Snowing 2 p.m. to midnight.
" 27	9 a.m.	29.73	—12	......	—17	N.N.W.	2	......	......	Clear.	
" 27	5 p.m.	30.00	—6	—3	......	N.W.	2	......	......	"	
" 28	9 a.m.	30.20	—30	......	—37	E.	1	......	......	"	
" 28	5 p.m.	30.15	—22	—6	......	E.	1	......	......	"	Clear and cold.
" 29	9 a.m.	30.12	—30	......	—36	E.	1	......	......	"	
" 29	5 p.m.	30.12	—12	—8	......	E.	1	......	......	"	
Mar. 1	9 a.m.	30.20	—30	......	—32	E.	Light.	......	......	"	
" 1	5 p.m.	30.09	—2	3	......	S.E.	Light.	......	......	"	
" 2	9 a.m.	29.85	—7	......	—17	......	......	S.C.S.	4	Cloudy.	
" 2	5 p.m.	29.82	9	15	......	S.E.	1	......	......	Clear.	
" 3	9 a.m.	29.70	2	......	—7	S.E.	1	C.S.S.	7	Cloudy.	
" 3	5 p.m.	29.85	12	17	......	N.W.	1	S.C.S.	6	"	
" 4	9 a.m.	29.98	7	......	6	N.W.	1	S.C.S.	3	"	
" 4	5 p.m.	29.90	9	15	......	N.E.	1	S.C.S.	6	"	

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE—*Continued.*

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.		Weather at time.	REMARKS.
			Air.	Max.	Min.	Direction.	Force.	Kind.	Amt.		
1889. Mar. 5	9 a.m.	29.75	4	......	—2	N.E.	1	S.	8	Cloudy.	
" 5	5 p.m.	29.57	9	17	......	N.E.	1	N.	10	Snowing.	
" 6	9 a.m.	29.80	9	......	7	N.	3	S.C.	5	Cloudy.	Snowing 4 p.m. to 2. a.m.
" 6	5 p.m.	29.99	3	10	......	N.	2	S.C.S.	6	"	
" 7	9 a.m.	30.09	—2	......	—7	N.	1	C.S.	8	"	
" 7	5 p.m.	29.95	—1	8	......	....	....	S.C.S.	9	"	
" 8	9 a.m.	29.95	—13	......	—15	N.	2	C.S.	3	"	Dull cloudy weather.
" 8	5 p.m.	30.04	—17	0	......	N.E.	Light.	S.C.S.	4	"	
" 9	9 a.m.	30.10	—31	......	—35	N.E.	Light.	S.C.S.C.	6	"	
" 9	5 p.m.	30.08	—22	—15	......	E.	1	S.C.	3	"	
" 10	9 a.m.	30.16	—41	.....	—45	....	....	....	.....	Clear.	
" 10	5 p.m.	30.10	—26	—20	......	N.E.	1	....	.....	"	
" 11	9 a.m.	29.95	—30	......	—40	E.N.E.	2	S.C.	8	Cloudy.	
" 11	5 p.m.	29.90	—17	—15	......	E.N.E.	3	S.	10	Overcast.	
" 12	9 a.m.	29.75	—22	......	—25	E.N.E.	2	S.C.S.	8	Cloudy.	
" 12	5 p.m.	29.85	—12	—10	......	E.N.E.	1	N.	10	Snowing.	
" 13	9 a.m.	29.87	—12	......	—14	E.N.E.	2	S.	10	Overcast.	Snowing 4 p.m. to 6 p.m.
" 13	5 p.m.	29.90	—5	—4	......	N.E.	1	S.	10	"	
" 14	9 a.m.	29.85	—7	......	—9	E.N.E.	1	S.	10	"	
" 14	5 p.m.	29.75	4	5	......	E.	2	S.	10	"	
" 15	9 a.m.	29.55	4	......	3	E.	1	N.	10	Snowing.	
" 15	5 p.m.	29.25	8	10	......	N.	1	N.	10	"	Snowing 7 a.m. to 10 a.m.
" 16	9 a.m.	29.23	5	......	4	....	....	....	.....	Clear.	Snowing 4 p.m. to 10 p.m.
" 16	5 p.m.	29.30	16	16	......	E.	Light.	C.S.	3	Cloudy.	
" 17	9 a.m.	29.28	3	......	—7	N.E.	1	S.	13	Overcast.	
" 17	5 p.m.	29.40	0	16	......	N.	1	S.	9	Cloudy.	
" 18	9 a.m.	29.56	5	......	—10	N.	1	S.	10	Overcast.	
" 18	5 p.m.	29.58	4	6	......	N.	2	S.	10	"	
" 19	9 a.m.	29.60	2	......	4	N.	3	N.	10	Snowing.	
" 19	5 p.m.	29.68	—7	2	......	N.W.	2	....	.....	Clear.	Snowing 4 a.m. to 10 p.m.
" 20	9 a.m.	30.02	—30	......	—35	S.W.	1	....	.....	"	
" 20	5 p.m.	29.98	—18	—7	......	S.W.	1	....	.....	"	
" 21	9 a.m.	29 67	—20	......	—30	N.E.	2	S.	9	Cloudy.	
" 21	5 p.m.	29.57	2	5	......	N.E.	1	S.C.S.	5	"	
" 22	9 a.m.	29.50	—4	......	—8	N.E.	1	S.C.S.	9	"	
" 22	5 p.m.	29.52	7	10	......	N.E.	1	S. haze.	8	"	
" 23	9 a.m.	29.60	3	......	—3	E.	1	C.S.	3	"	
" 23	5 p.m.	29.68	10	15	......	E.	Light.	C.S.	4	"	
" 24	9 a.m.	29.70	8	......	4	....	....	S.C.S.	2	"	

Mar. 24	5 p.m.	29.75	15	20	.....	.....	.....	.....	.....	Clear.	
" 25	9 a.m.	29.80	12	.....	3	N.E.	Light.	C.S.	2	Cloudy.	
" 25	5 p.m.	29.78	20	26	.....	.....	.....	S C.S.	4	"	
" 26	9 a.m.	29.80	10	.....	—4	.....	.....	.....	.....	Clear.	
" 26	5 p.m.	29.48	20	24	.....	E.	2	S.	9	Cloudy.	
" 27	9 a.m.	29 51	8	.....	2	N.N.E.	1	N.	10	Snowing.	Snowing 8 a.m. to 10 p.m.
" 27	5 p.m.	29.63	15	20	.....	N.NE.	1	N.	10	"	Snowing 4 p.m. to 10 p.m.
" 28	9 a.m.	29.90	—1	.....	—6	W.	2	S.	10	Overcast.	
" 28	5 p.m.	29.84	6	8	.....	W.S.W.	3	S.	10	"	
" 29	9 a.m.	29.60	—1	.....	—5	N.W.	2	S.C.S.	7	Cloudy.	
" 29	5 p.m.	29.45	7	12	.....	N.W.	1	S.	8	"	About three feet of snow in woods.
" 30	9 a.m.	29.65	—5	.....	—15	N.W.	1	S.C.S.	3	"	
" 30	5 p.m.	29.80	6	8	.....	N.W.	1	.....	.....	Clear.	
" 31	9 a.m.	29.45	8	.....	—5	N.W.	1	C.S.	8	Cloudy.	
" 31	5 p.m.	29.40	23	27	.....	N.W.	1	S.C.S.	7	"	
April 1	9 a.m.	29.40	22	.....	6	.....	.....	S.C.S.	8	"	Snowing 4 p.m. to midnight.
" 1	5 p.m.	29.55	2	27	.....	N.	3	N.	10	Snowing.	Stormy during night.
" 2	9 a.m.	29.78	- 8	.....	—15	N.	2	.....	.....	Clear.	
" 2	5 p.m.	29.83	—4	2	.....	N.	1	.....	.....	"	Bright and clear.
" 3	9 a.m.	29.83	—10	.....	—23	N.W.	1	.....	.....	"	
" 3	5 p.m.	29.70	—4	—2	.....	N.E.	1	.....	.....	"	
" 4	9 a.m.	29.65	—8	.....	—23	N.E.	1	Haze.	.....	Hazy.	
" 4	5 p.m.	29.60	—5	5	.....	S.E.	1	S.	6	Cloudy.	
" 5	9 a.m.	29.55	—9	.....	—31	S.E.	2	.....	.....	Clear.	
" 5	5 p.m.	29.37	0	2	.....	S.E.	2	S.	10	Overcast.	
" 6	9 a.m.	29.37	—2	.....	—16	.....	.....	.....	.....	Clear	
" 6	5 p.m.	29.35	15	23	.....	S.E.	Light.	.....	.....	"	
" 7	9 a.m.	29.13	8	.....	1	S.	1	S.C.S.	3	Cloudy.	
" 7	5 p.m.	28.85	28	30	.....	S.W.	3	S.	2	"	Light hail storms 10 p.m.
" 8	9 a.m.	28.91	24	.....	7	S.W.	1	.....	.....	Clear.	Flurries of snow.
" 8	5 p.m.	29.00	29	30	.....	W.	2	S.	9	Cloudy.	
" 9	9 a.m.	29.45	8	.....	—3	W.N.W.	3	K C.S.	3	"	
" 9	5 p.m.	29.65	18	29	.....	W.N.W.	2	S.C.S.	6	"	
" 10	9 a.m.	29.80	—1	.....	—17	.....	.....	S.C.S.	3	"	
" 10	5 p.m.	29.77	8	20	.....	.....	.....	.....	.....	Clear.	
" 11	9 a.m.	29.57	4	.....	—13	N.E.	3	S.	8	Cloudy.	
" 11	5 p.m.	29.30	9	12	.....	E.	3	N.	10	Snowing.	Snowing 4 p.m. to 2 a.m.
" 12	9 a.m.	29.40	15	.....	8	.....	.....	C.S.	5	Cloudy.	
" 12	5 p.m.	29.47	22	24	.....	S.W.	1	K.S.	2	"	
" 13	9 a.m.	29.48	14	.....	2	S.	Light.	.....	.....	Clear.	
" 13	5 p.m.	29.72	17	23	.....	.....	.....	.....	.....	"	Weather becoming much warmer, but no thaw
" 14	9 a.m.	29.80	10	.....	—6	.....	.....	.....	.....	"	has taken place yet.
" 14	5 p.m.	29.81	13	20	.....	E.	1	S.	10	Overcast.	
" 15	9 a.m.	29.95	16	.....	3	S.E.	1	C.S.	7	Cloudy.	
" 15	5 p.m.	30.00	20	24	.....	S.	1	S.C.S.	5	"	
" 16	9 a.m.	30.10	16	.....	—6	S.W.	Light.	.....	.....	Clear.	
" 16	5 p.m.	30.14	21	25	.....	N.N.W.	Light.	C.S.	2	Cloudy.	
" 17	9 a.m.	30.20	15	.....	—9	N. W.	Light.	.....	.....	Clear.	
" 17	5 p.m.	30.10	17	20	.....	N.E.	2	.....	.....	"	
" 18	9 a.m.	29.95	12	.....	3	N.E.	2	S.	10	Overcast.	

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE—*Continued.*

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.		Weather at time.	REMARKS.
			Air.	Max.	Min.	Direction.	Force.	Kind.	Amt.		
1888. April 18	5 p.m.	30.00	20	24	......	N.E.	2	S.C.S.	7	Cloudy.	
" 19	9 a.m.	29.98	8	......	—7	N.E.	1	S.C.S.	8	"	Crane seen.
" 19	5 p.m.	29.87	24	27	......	N.E.	1	S.C.S.	5	"	
" 20	9 a.m.	29.72	14	......	—2	....	....	S.	2	"	Barking Crow (*Corvus Americanus*) seen.
" 20	5 p.m.	29.65	29	33	......	N.E.	2	S.	10	Overcast.	Above freezing point for first time since Nov. 4.
" 21	9 a.m.	29.70	16	......	10	S.W.	1	....	......	Clear.	
" 21	5 p.m.	29.78	33	34	......	N.	2	K.S.	6	Cloudy.	
" 22	9 a.m.	29.95	24	......	6	S.E.	1	S.C.S.	9	"	Heavy white frost last night.
" 22	5 p.m.	29.91	29	33	......	E.	3	S.	10	Overcast.	
" 23	9 a.m.	29.85	18	......	14	N.	3	S.	10	"	
" 23	5 p.m.	29.85	21	29	......	N.N.E.	2	S.	10	"	A few flakes of snow.
" 24	9 a.m.	29.90	6	......	—1	N.N.E.	1	S.C.S.	2	Cloudy.	
" 24	5 p.m.	29.89	19	21	......	N.N.E.	1	C.S.	1	"	
" 25	9 a.m.	29.88	20	......	8	N.E.	1	S.	10	Overcast.	
" 25	5 p.m.	29.78	23	29	......	E.S.E.	1	S.	10	"	
" 26	9 a.m.	29.97	18	......	14	N.	3	N.	10	Snowing.	
" 26	5 p.m.	30.20	15	22	......	N.	3	S.C.S.	8	Cloudy.	Snowing 8 a.m. to 10 a.m.
" 27	9 a.m.	30.35	8	......	1	N.	1	S.C.S.	7	"	
" 27	5 p.m.	30 37	12	21	......	N.E.	1	S C.S.	8	"	
" 28	9 a.m.	30.25	10	......	8	E.N.E.	1	S.	10	Overcast.	
" 28	5 p.m.	30.01	20	23	......	E.	1	N.	10	Snowing.	Light snowfall.
" 29	9 a.m.	29.90	19	......	12	E.	1	S.	10	Overcast.	

METEOROLOGICAL OBSERVATIONS ON MACKENZIE RIVER, SUMMER 1888.

LOCALITY.	Date.	Hour.	Bar.	Thermometer. Air.	Thermometer. Max.	Thermometer. Min.	Wind. Direction.	Wind. Force.	Clouds.	Weather at time.	REMARKS.
Fort Simpson	1888. May 6	9 a.m.	......	43	......	39	S.	1	C.K.S.	Cloudy.	Canada goose arrived on the 2nd, ducks followed on the 3rd, and wavies on the 5th.
"	" 6	5 p.m.	......	53	56	......	S.W.	2	C.S.K.	"	
"	" 7	9 a.m.	......	40	......	38	S.S.E.	1	C.S.	"	
"	" 7	5 p.m.	......	57	60	......	E.	1	S.C.S.	"	Beautiful spring weather.
"	" 8	9 a.m.	......	33	......	32	W.	1	S.C.S.	"	
"	" 8	5 p.m.	......	56	58	......	S.E.	2	C.S.	"	
"	" 9	9 a.m.	......	38	......	34	S.S.E.	2	K.S.	"	
"	" 9	5 p.m.	......	46	50	......	S.E.	Light.	K.C.S.	"	
"	" 10	9 a.m.	......	34	......	32	E.	Light.	C.C.S.	"	
"	" 10	5 p.m.	......	39	48	......	S.S.E.	Light.	K.S.	"	
"	" 11	9 a.m.	......	36	......	34	S.E.	Light.	K.	"	
"	" 11	5 p.m.	......	54	56	......	S.E.	1	....	Clear.	Snow disappearing rapidly.
"	" 12	9 a.m.	......	38	......	34	N. W.	1	C.S.	Cloudy.	
"	" 12	5 p.m.	......	52	59	......	N.N.W.	1	....	Clear.	
"	" 13	9 a.m.	......	40	......	36	E.	1	C.S.K.	Cloudy.	Liard ice came down.
"	" 13	5 p.m.	......	54	56	......	E.	1	N.	Raining.	
"	" 14	9 a.m.	......	42	......	38	S.E.	1	N.	"	Light rain.
"	" 14	5 p.m.	......	50	52	......	N. W.	1	S.	Overcast.	Mackenzie clear of ice below the [fort.
"	" 15	9 a.m.	......	42	......	......	N.	1	S.C.	Cloudy.	
"	" 15	5 p.m.	......	54	......	......	N.	1	....	Clear.	
"	" 16	9 a.m.	......	40	......	......	N.	1	....	"	
"	" 16	5 p.m.	......	48	......	......	N.	1	....	"	Bright spring weather.
"	" 17	9 a.m.	29.95	41	......	34	W.N.W.	2	C.S.	Cloudy.	
"	" 17	5 p.m.	......	43	44	......	N.N.W.	1	....	Clear.	
"	" 18	9 a.m.	......	40	......	28	N.N.W.	1	C.S.	Cloudy.	
"	" 18	5 p.m.	......	46	53	......	N.	Light.	C.S.K.	"	
"	" 19	9 a.m.	29.80	38	......	29	N.E.	Light.	S.C.S.K.	"	
"	" 19	5 p.m.	29.75	48	51	......	E.N.E.	Light.	S.	Overcast.	
"	" 20	9 a.m.	29.87	32	......	28	N.E.	3	S.	"	Two inches of snow during night.
"	" 20	5 p.m.	29.87	34	34	......	N.E.	3	S.	"	
"	" 21	9 a.m.	29.82	32	......	25	....	....	S.	"	
"	" 21	5 p.m.	29.78	37	42	......	N.	2	C.S.K.	Cloudy.	Clearing.
"	" 22	9 a.m.	29.70	33	......	29	N.	3	S.C.S.K.	"	
"	" 22	5 p.m.	29.65	40	44	......	N.N.E.	3	C.S.K.	"	
"	" 28	9 a.m.	29.75	30	......	26	E.	2	S.	Overcast.	Snow gone, with the exception of a few patches in sheltered spots.
"	" 23	5 p.m.	29.56	35	40	......	E.S.E.	3	S.	"	
"	" 24	9 a.m.	29.50	30	......	28	E.S.E.	2	N.	Snowing.	
"	" 24	5 p.m.	29.48	40	42	......	E.S.E.	Light.	C.S.K.	Cloudy.	Three inches of snow.
"	" 25	9 a.m.	29.52	33	......	30	E.	Light.	S.C.S.K.	"	

LOCALITY.	Date.		Hour.	Bar.	Thermometer.			Wind.		Clouds.	Weather at time.	REMARKS.
					Air.	Max.	Min.	Direction.	Force.			
					°	°	°					
Fort Simpson	May	25	5 p.m.	29.55	42	46	......	E.	Light.	C.S.K.	Cloudy.	
"	"	26	9 a.m.	29.70	49	....	33	W.	2	S.C.C.S.	"	Cliff swallow (*Petrochelidon luni-*
"	"	26	5 p.m.	29.85	53	57	......	N.	2	S.C.S.	"	*frons*) arrived.
"	"	27	9 a.m.	29.99	40	......	39	N.N.E.	2	S.C.S.	Overcast.	Light showers.
"	"	27	5 p.m.	29.98	49	53	......	N.E.	1	C.S.K.	Cloudy.	
"	"	28	9 a.m.	29.94	45	......	40	N.	1	N.	Raining.	Very light rain.
Twenty-five miles below Fort Simpson	"	28	5 p.m.	29.95	42	......	......	N.E.	1	S.C.S.	Cloudy.	
" "	"	29	9 a.m.	29.99	39	......	38	....	....	S.	Overcast.	
Mouth Nahanni River	"	29	5 p.m.	29 85	43	......	......	N.N.E.	1	K.S.C.S.	Cloudy.	Ice piled up in high cliffs along [shore.
" "	"	30	6 a.m.	29.75	38	......	37	N.N.E.	3	N.	Raining.	A few drops of rain.
" "	"	30	9 p.m.	29.91	39	......	......	N.	1	C.S.	Cloudy.	
" "	"	31	5 a.m.	29.90	37	......	30	E.	1	C.C.S.	"	*Anemone patens* in bloom.
" "	"	31	9 p.m.	29.65	44	......	......	E.	1	S.C.S.	"	
" "	June	1	6 a.m.	29.60	40	......	35	E.	1	C.S.	"	Fine weather.
Twenty miles below Nahanni River	"	1	7 p.m	29.71	50	......	......	S.S.W.	3	S.C.S.	"	
" "	"	2	6 a.m.	29.73	44	......	......	....	....	C.S.	"	
Fort Wrigley	"	2	7 p.m.	29.58	55	......	......	S.E.	1	C.S.K.	"	
"	"	3	6 a.m.	29.55	38	......	......	N.	1	S.	Overcast.	Three inches of snow.
"	"	3	6 p.m.	29.99	49	......	......	S.E.	1	K.C.S.	Cloudy.	
"	"	4	6 a.m.	29.91	37	......	......	....	....	S.	Overcast.	
Hill by River Side	"	4	6 p.m.	30.04	41	......	......	E.	1	N.	Raining.	Light rain.
"	"	5	6 a.m.	30.16	34	......	28	....	....	K.S.C.S.	Cloudy.	
Twenty miles below Hill by River Side	"	5	6 p.m.	30.24	37	......	......	N.	3	S.C.S.	Overcast.	Cold disagreeable day.
" "	"	6	6 a.m.	30.20	43	......	37	N.	2	K.S.	Cloudy.	
Lat 63° 54′, Mackenzie River	"	6	6 p.m.	30.20	60	......	......	E.	1	S.C.S.	"	Mosquitoes getting thick.
" "	"	7	6 a.m.	30.04	36	......	31	E.	3	....	Clear.	
Opposite Roché Clark	"	7	6 p.m.	29 85	54	......	......	E.	3	....	"	
" "	"	8	6 a.m.	29.90	39	......	36	E.	1	....	"	
Twenty miles above Fort Norman	"	8	6 p.m.	30 01	60	......	......	N.	3	C.C.S.	Cloudy.	Vegetation scarcely begun.
" "	"	9	6 a.m.	30.05	43	......	40	....	....	K.C.S.	"	
Fort Norman	"	9	6 p.m.	30 15	65	......	......	N.	1	K.C.S.	"	
"	"	10	6 a.m.	29.90	54	......	40	N.E.	1	K.S.	"	
"	"	10	6 p.m.	29.85	65	......	......	N.E.	1	K.S.	"	
"	"	11	6 a.m.	29 76	47	......	43	N.	2	S.C.S.	"	
"	"	11	6 p.m.	29 72	53	......	......	N.	3	K.C.S.	"	Some flakes of snow.
"	"	12	6 a.m.	29.76	40	......	38	N.	3	S.	Overcast.	
Five miles below Fort Norman	"	12	6 p.m.	29 80	45	......	......	N.	3	C.S.	"	Alders and willows in flower.
" "	"	13	6 a.m.	29.95	42	......	35	E.	3	S.C S.	Cloudy.	
Fifty " "	"	13	6 p.m.	29 90	40	......	......	E.	2	C.S.K.	"	
" "	"	14	6 a.m.	29.78	48	......	40	E.	3	C.S.K.	"	
Seventy "	"	14	6 p.m.	29.63	49	......	......	E.	3	S.C.K.	"	

Seventy miles below Fort Norman....	June 15	6 a.m.	29.50	50	......	45	E.	3	S.	Overcast.	
120 " "	" 15	7 p.m.	29.49	54	......	......	E.	1	K.C.S.	"	
" "	" 16	6 a.m.	29.53	52	......	50	E.	2	S.C.S.	"	
Ramparts	" 16	7 p.m.	29.51	60	......	......	E.	1	K.C.S.	"	
"	" 17	6 a.m.	29 54	48	......	47	N.	2	S.	"	Passing showers.
Fort Good Hope	" 17	7 p.m.	29.55	50	......	......	N.	1	N.	Raining.	
"	" 18	6 a.m.	29.85	54	......	50	......	......	......	Clear.	Cross the arctic circle.
Forty miles below Fort Good Hope....	" 18	7 p.m.	29.90	60	......	......	N.	Light.	S.	Cloudy.	Clear to cloudy weather.
" "	" 19	6 a.m.	30.04	53	......	45	N.	Light.	Hazy.	Haze.	
Hundred "	" 19	8 p.m.	30.10	59	......	......	N.	1	S.C.S.	Cloudy.	Trees still bare of leaves.
" "	" 20	7 a.m.	30.14	47	......	46	Var.	Light.	......	Clear.	
Traveller River, Mouth of	" 20	9 p.m.	30.22	65	......	......	E.	1	S.	Cloudy.	
" "	" 21	7 a.m.	30.22	48	......	44	E.	1	......	Clear.	Ice along river nearly gone.
Twenty miles above Little Red River.	" 21	9 p.m.	30.05	66	......	......	E.	2	......	"	
" "	" 22	7 a.m.	30 10	49	......	46	E.	2	S.	Cloudy.	
Seven miles below Little Red River...	" 22	9 p.m.	30.06	60	......	......	E.	1	S.C.S.	"	
" "	" 23	6 a.m.	30.05	45	......	44	N.	3	C.C.S.	"	Weather fine, but windy in day [time.
Peel River, Ten miles above Mouth...	" 23	9 p.m.	30.07	45	......	......	N.	3	S.C.S.	"	
" "	" 24	6 a.m.	30.22	47	......	43	N.	3	S.C.S.	"	
" "	" 24	8 p.m.	30.25	56	......	......	N.	3	S.C.S.	"	
" "	" 25	7 a.m.	30.30	49	......	44	N.	3	S.C.S.	"	Leaves appearing on aspens.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

See also 910.97127 U67
by W. Upham.

REPORT

OF EXPLORATION OF THE

GLACIAL LAKE AGASSIZ IN MANITOBA.

BY

WARREN UPHAM.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
WILLIAM FOSTER BROWN & CO.
1890.

To A. R. C. Selwyn, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

Sir,—I herewith submit to you my report of observations on the area of the glacial Lake Agassiz in Manitoba. This exploration was performed in May, June and July, 1887, for the Geological Survey of Canada and for that of the United States, under which latter, in accordance with instructions from President T. C. Chamberlin in charge of the Glacial Division of that Survey, the southern portion of this lacustrine area, lying in Minnesota and North Dakota, had been examined by me during the two preceding summers. It was deemed very desirable to continue the exact mapping and levelling along its beaches northward into Manitoba for the purpose of making the final report on this subject for the United States Geological Survey as complete as possible; and arrangements providing for this were made by the Director of that Survey and yourself, enabling me to include within my examination all the prairie region that was occupied by Lake Agassiz.

Besides the prairie district thus examined, this glacial lake is believed to have included a much larger wooded region on the north and east, together with the present lakes Winnipeg, Manitoba, and Winnipegosis, its whole area being probably somewhat more than the combined areas of the five great Laurentian lakes. One of the two maps accompanying this report shows this probable extent of Lake Agassiz; and the other shows its portion examined in Manitoba, with the course of its beaches, marking the successive stages of the lake, and the Pembina and Assiniboine deltas.

Elevations determined by railway surveys have been taken as the basis of my levelling along the beaches. For opportunity to examine railway profiles and for manuscript notes of them, my grateful acknowledgments are due to Mr. P. A. Peterson of Montreal and Mr. R. M. Pratt of Winnipeg, engineers of the Canadian Pacific Railway, to Mr. George H. Webster of Portage la Prairie, engineer of the Manitoba and Northwestern Railway, to Mr. Collingwood Schreiber of Ottawa, in charge of government railways, and to Dr. George M. Dawson and Dr. Robert Bell, your associates in this survey.

I have the honor to be,

Sir,

Your obedient servant,

WARREN UPHAM.

Somerville, Mass., June, 1889.

REPORT

OF EXPLORATION OF THE

GLACIAL LAKE AGASSIZ IN MANITOBA.

INTRODUCTION.

Among the most important geologic records of the Quaternary period in America are the sediments and shore lines of former lakes of great extent, which are now represented by lakes that occupy, excepting within the basin of the Saint Lawrence, only a small part of their ancient area. Lake Bonneville in the basin of Great Salt Lake, Utah, and Lake Lahontan in the basin of the Humboldt River and Pyramid Lake, Nevada, are conspicuous examples of one class of these Quaternary lakes, formed by increased rain-fall where now an arid climate limits the lakes to small areas, with their surface far below the water-sheds across which they would outflow to the sea. These are south of the glaciated area of the continent, but they appear to have owed their existence to the changes of climate by which the supposed ice-sheets of the glacial epochs were formed. Lake Agassiz, which occupied the basin of the Red River of the North and Lake Winnipeg, belongs to another class of these lakes, caused directly by the supposed barrier of the ice-sheet where this was accumulated on a northwardly sloping land surface. Such glacial lakes were developed on a vast scale in the basins of Lake Winnipeg and the Laurentian lakes during the recession of the ice-border, when it was being gradually melted away by a warmer climate; and it is also evident that many small lakes of the same kind then flowed southward over the lowest points of the present water-sheds. Examples of this class now existing are the little Merjelen See, pent up in a tributary valley on the east side of the Great Aletsch glacier in the Alps, and similar ice-dammed lakelets in Greenland.

Two classes of Quaternary lakes.

On the western boundary of Minnesota a remarkable valley is eroded in the glacial drift to the depth of 125 to 150 feet with a width of about one mile and a half, extending from north to south across the lowest part of the water-shed that divides the basin of the Red River of the North from that of the Mississippi. This channel has been evidently the course of a great river since the drift was deposited. After the river ceased to flow here, portions of the bottom of the valley have become filled to the slight depths of ten or twenty feet by alluvial beds brought in by tributary streams, and the intervening portions of the old valley are occupied by the long, narrow and shallow Lakes Traverse and Big Stone, the former outflowing northward by the Bois des Sioux to the Red River, and the latter southward by the Minnesota River to the Mississippi. The general level of the land on each side of this water-course is about 1,100 feet above the sea; the heights of Lakes Traverse and Big Stone are respectively 971 and 963 feet above the sea; and the lowest point of the divide between them, in Brown's Valley, is only three feet above Lake Traverse. A valley of similar size extends all along the course of the Minnesota River; but toward the north the broad water-course, with the adjoining highland on each side, ends within a few miles.

Channel of outlet from Lake Agassiz.

The country north of Lake Traverse sinks gradually to a level not much above the small Bois des Sioux River, which flows north 35 miles, emptying into the Red River of the North at Breckenridge and Wahpeton. The Red River, here turning abruptly from its western course, flows thence north to Lake Winnipeg, 285 miles. These streams occupy the axial depression of a vast plain of glacial drift and lacustrine and fluvial deposits, forty to fifty miles wide and more than 300 miles long, stretching from Lake Traverse to Lake Winnipeg. This expanse, widely famed for the large harvests and superior quality of its wheat, is commonly called the Red River Valley. It has a very uniform continuous descent northward, averaging a little less than one foot per mile. So slight an inclination is imperceptible to the eye, as is also the more considerable ascent, usually two or three feet per mile, for the first ten or fifteen miles to the east and west from the Red River. This river flows along the lowest portion of the plain, somewhat east of its central line, in a quite direct general course from south to north, but meanders almost everywhere with minor bends which carry it alternately a half mile or one mile to each side of its main course. It has cut a channel twenty to fifty feet deep and is bordered by only few and narrow areas of bottomland, instead of which its banks usually rise steeply on one side and by moderate slopes on the other, to the lacustrine plain which thence reaches nearly level ten to thirty miles from the river.

The Red River Valley.

Where the surface rises on each side of this expanse, definite and continuous beach deposits are found marking the shore lines of a vast lake which formerly covered the Red River Valley and by its outflow eroded the deep channel extending thence southward as already described. This lake is believed by the writer to have owed its existence to glacial conditions during the final melting and gradual recession of an ice-sheet which overspread the northern half of North America. When this continental glacier, subdued by a more temperate climate, was yielding its ground between Lake Traverse and Hudson Bay, free drainage from its south side could not take place, because the descent of the land is northward. As soon as the border of the ice had receded beyond the water-shed dividing the basins of the Minnesota and Red Rivers, it is evident that a lake, fed by the glacial melting, stood at the foot of the ice fields and extended northward as they withdrew along the Red River Valley to Lake Winnipeg, filling this valley to the height of the lowest point over which an outlet could be found. Until the ice barrier was so far melted upon the area between Lake Winnipeg and Hudson Bay that this glacial lake began to be discharged northward, its outlet was along the present course of the Minnesota River. Because of its relation to the retreating continental ice-sheet, this lake has been named in memory of Professor Louis Agassiz, the first prominent advocate of the theory that the drift was produced by land ice.[1] Within the past fifteen years the truth of this explanation of the drift has been demonstrated by the recognition and detailed study of the morainic deposits that were accumulated along the southern boundary of the ice-sheet, extending from Nantucket, Martha's Vineyard, Cape Cod, and Long Island, across New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, and South and North Dakota. The characters of other drift deposits, as the till and the kames and eskers, also the glacial striæ, point with equal certainty to a vast sheet of land ice as their cause; and the explanation accounts for this lake in the Red River Valley, for similar lakes that were tributary to it from the basins of the Souris and South Saskatchewan Rivers, and for the contemporaneous higher levels of the great lakes now discharged by the River St. Lawrence.

Lake Agassiz caused by the receding ice-sheet.

The evidences of the former existence of a great lake in the Red River Valley were observed in 1823 by Keating, the geologist of the first scientific expedition to this district,[2] in 1848 by Owen,[3] in 1857 by Palliser,[4] in 1858 by Hind,[5] and in 1873 by Dr. G. M. Dawson.[6] The

Earlier observers.

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1 Geological and Natural History Survey of Minnesota, Eighth annual report, for the year 1879, pp. 84, 85.

2 Narrative of an Expedition to the source of St. Peter's River, Lake Winnepeek, Lake of the Woods, &c., performed in the year 1823, ... under the command of Stephen H. Long, U. S. Topographical Engineer. London, 1825. Vol. ii, p. 3.

3 Report of a Geological Survey of Wisconsin, Iowa, and Minnesota. Philadelphia, 1852. p. 178.

4 Journals, detailed reports, &c., presented to Parliament, 19th May, 1863, p. 41.

5 Report of the Assiniboine and Saskatchewan Exploring Expedition. Toronto, 1859. pp. 39, 40, 167, 168.

6 Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel, from the Lake of the Woods, to the Rocky Mountains. Montreal, 1875. p. 248.

excavation of the valley occupied by Lakes Traverse and Big Stone and the Minnesota river was first explained in 1868 by Gen. G. K. Warren, who attributed it to the outflow from this ancient lake. He made a careful survey of this valley, and his maps and descriptions, with the accompanying discussion of geologic questions, are most valuable contributions to science.[1] After his death, in commemoration of this work, the glacial river that was the outlet of Lake Agassiz was named River Warren.[2] That this lake existed because of the barrier of the receding ice-sheet was first pointed out in 1872 by Prof. N. H. Winchell.[3]

Previous work in the United States.

The part of the area of Lake Agassiz which lies in Minnesota, so far as it is prairie, was explored by the writer in 1879 and 1881, under the direction of Prof. N. H. Winchell, State Geologist, with the assistance in 1881 of Horace V. Winchell as rod-man in levelling.[4] Further exploration of this lake was carried forward in 1885 and 1886 for the United States Geological Survey by the writer, under the direction of Pres. T. C. Chamberlin, with Robert H. Young as assistant, mapping the upper or Herman beaches in North Dakota from Lake Traverse to the international boundary, besides portions of the lower shore lines both in North Dakota and Minnesota, with exact determinations of their elevation by levelling. A preliminary report of part of these observations was published in 1887.[5]

Continuation in Manitoba.

By co-operation of the Geological Surveys of the United States and Canada, a portion of my field-work in 1887 was devoted to the examination of the northward extension of the beaches of Lake Agassiz in Manitoba. Travelling with horse and wagon, and assisted by Mr. Young as in the two preceding years, a somewhat detailed exploration of this lacustrine area was continued about a hundred miles north from the international boundary, the most northern points reached being

[1] "On certain physical features of the Upper Mississippi River," American Naturalist, vol. ii, pp. 497-502, November, 1868. Annual Report of the Chief of Engineers, United States Army, for 1868, pp. 307-314. "An essay concerning important physical features exhibited in the valley of the Minnesota River, and upon their signification," with maps, Report of Chief of Engineers, 1875. "Valley of the Minnesota River and of the Mississippi River to the junction of the Ohio. Its origin considered—depth of the bed rock," with maps, Report of Chief of Engineers, 1878, and American Journal of Science, III, vol. xvi, pp. 417-431, December, 1878. (General Warren died August 8, 1882.)

[2] Proceedings of the American Association for the Advancement of Science, vol. xxxii, for 1883, pp. 213-231; also in American Journal of Science, III, vol. xxvii, Jan. and Feb., 1884; and Geology of Minnesota, vol. i, p. 622.

[3] First Annual Report of the Geological and Natural History Survey of Minnesota, for 1872, p. 63; and Sixth Annual Report, for 1877, p. 31. Professor Winchell also explained in like manner the formerly higher levels of the Laurentian lakes, Popular Science Monthly, June, 1873; and the same view is stated by Prof. J. S. Newberry in the Report of the Geological Survey of Ohio, vol. ii, 1874, pp. 6, 8, and 51.

[4] Geological and Natural History Survey of Minnesota, Eighth Annual Report, for 1879, pp. 84-87; Eleventh Annual Report, for 1882, pp. 137-153, with map; and Final Report, vols. i and ii.

[5] United States Geological Survey, Bulletin No. 39. The Upper Beaches and Deltas of the Glacial Lake Agassiz. pp. 84, with map.

Shoal Lake, between Lakes Winnipeg and Manitoba, and Orange Ridge post-office, near the southeast end of Riding Mountain. The wooded character of the country farther north makes continuous levelling and tracing the beaches of this lake impracticable; and the same condition limited my examination on the east to a narrow belt adjoining the Red River. The western border of this portion of Lake Agassiz is formed by the Pembina Mountain, the Tiger Hills, the Brandon Hills, and Riding Mountain; and the mouth of the Assiniboine was at Brandon during the highest stage of the lake. In this direction my observations were extended west of the shore line of Lake Agassiz to include the vicinity of the Assiniboine and the Canadian Pacific Railway to Griswold, the course of the Souris River below Plum Creek, Lang's Valley, a glacial water-course extending from the Elbow of the Souris southeast to Pelican Lake and the Pembina River, and the lower course of that river, by which a large delta was deposited in the west margin of Lake Agassiz a few miles south of the international boundary. The breadth of the country thus traversed from east to west is about a hundred and fifty miles.

The upper or Herman beach of Lake Agassiz was traced and its height determined in Minnesota by continuous levelling from Lake Traverse east to Herman and thence north to Maple Lake, twenty miles east-southeast of Crookston, a total distance of about 175 miles, including an extent of 140 miles from south to north. Through North Dakota this shore was thus followed continuously along the west side of the Red River Valley about 250 miles, extending northwesterly from Lake Traverse to the vicinity of Wyndmere, Milnor, and Sheldon, and thence in a nearly direct course slightly west of north to the international boundary. Profiles of the numerous railway lines crossing this district supplied reliable elevations above the sea level at their stations; and in many instances they also show distinctly their intersections of the beaches of this lake. These elevations were taken as the data and reference points of my levelling, which was proved throughout its entire extent to be accurate within close approximation by its agreement with the railway surveys, the comparisons being made at intervals varying from twenty to forty or fifty miles apart. The same methods were employed in this survey in Manitoba, where the profiles of the Canadian Pacific Railway and its branches and of the Manitoba & Northwestern Railway, kindly supplied for my examination by the engineers of these roads, were similarly the basis of my determinations of the elevations of the beaches. All these heights, as stated in this report and in the annexed notes of railway profiles, are referred to the sea level at mean tide; and the close agreements of several independent surveys from the sea to this district and of the profiles of the many

Methods of survey.

Reference of elevations to the sea level.

intersecting lines of railway in Minnesota, South and North Dakota and Manitoba, give complete assurance that these heights are not only consistent together but also absolutely true within limits of error probably nowhere exceeding five feet. Such exact determinations of the elevations of the beaches of this lake seem very important because these deposits which were formed along the level shores of the lake in its successive stages are found at the present time to have a gradual ascent from south to north, amounting to about a foot per mile in the highest and oldest beach and gradually diminishing to a quarter or even an eighth part of this amount in the lowest and latest of the beaches. The general topographic features of the region traversed, the character of the drift deposits, its underlying geologic formations, and numerous records of the sections passed through by wells, were also noted.

Plan of this report.

In this report are successively presented a brief description of the topography of the basin of Lake Agassiz, an account of the drift formations in Manitoba, and the history of this glacial lake in its relationship to the recession of the ice-sheet as shown by terminal moraines. The beaches and delta deposits of Lake Agassiz observed in Manitoba are described in detail, including their changes of levels from the time of the highest and earliest to that of the lowest and latest beaches. Next follow notes of wells, and remarks on the soil, the agricultural capabilities of the district, and its economic geology. Finally, in Appendices I and II the courses of glacial striæ in and about the area of Lake Agassiz, and tables of altitudes in Manitoba, Assiniboia and Alberta, are given.

Accompanying maps.

A map showing the whole extent of Lake Agassiz and for comparison with it the upper great lakes that outflow by the Saint Lawrence, and another map showing the beaches of this lake in Manitoba and its deltas brought in by the Assiniboine and Pembina Rivers, accompany this report. The courses of glacial striæ and the terminal moraines of the ice-sheet are noted on each. It should be remarked, however, respecting the first of these maps, that the northern and northeastern boundaries of this glacial lake probably can never be exactly determined, and must be laid down in any attempt of this kind, by estimation; for they were formed by the receding ice-sheet instead of a land surface on which beaches would be discoverable. During the formation of its highest continuous and well marked beach, this lake extended north in Minnesota at least to Maple Lake, and in Manitoba to Thornhill. The continued recession of the ice-sheet during the time of formation of the sixteen beaches made at lower levels while the lake outflowed southward probably caused it to attain nearly the area shown on this map before it began to be discharged into Hudson Bay. Afterward,


MAP OF THE
GLACIAL LAKE AGASSIZ
and adjoining portions of
NORTH AMERICA.
BY WARREN UPHAM.
Shores of Glacial Lakes.
The blue tint shows approximately the areas covered by Lake Agassiz and other glacial lakes.
Glacial Striæ.
Terminal Moraines.
SCALE OF MILES.
HUDSON BAY
JAMES BAY
KEEWATIN
SASKATCHEWAN
ASSINIBOIA
MANITOBA
LAKE AGASSIZ
ONTARIO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
WISCONSIN
MICHIGAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
REINDEER LAKE
Methy Portage
Frog Portage
Nelson R.
Hayes R.
Severn R.
Equan R.
Attawapiskat R.
Albany R.
Kenogami R.
Missinaibi R.
Moose R.
Mattagami R.
Abitibi R.
Big R.
Battle R.
Pasqua Hills
Porcupine Hills
Touchwood Hills
Beaver Hills
Moose Mountain
Wood Mountain
International Boundary
Milk R.
Souris R.
Mouse R.
Lake Souris
Coteau du Missouri
Missouri River
Margin of the Glacial Drift
Receding Ice-Sheet
Driftless Area
Elbow
Lake Saskatchewan

eleven beaches were formed while the lake stood nearly stationary at various stages, interrupting the further descent of its surface to its present representative, Lake Winnipeg, its northward outflow having passed during a considerable time along the southern border of the waning ice-sheet before it was melted from the present course of the Nelson River. The lacustrine area therefore was not wholly covered by water at any one time; for when the lake reached its maximum extent on the north and northeast, it had receded below that portion of its earlier area which lies above the beaches marking its stages tributary to Hudson Bay.

TOPOGRAPHY OF THE BASIN OF LAKE AGASSIZ.

Area of Lake Agassiz.

The area that was covered by Lake Agassiz occupies the geographic center of the North American continent. Its extent is approximately from 45° 30′ to 55° of north latitude, and from 92° 30′ to 100° at Brandon, and to 106° on the Saskatchewan, of west longitude. It thus measures from south to north, and likewise from east to west, nearly seven hundred miles, or about twice the length of Lake Superior. The central and deepest portion of Lake Agassiz covered the broad, flat expanse of the Red River Valley and of the lake region farther north; and in its highest stage it reached on the international boundary from Rainy Lake to the Pembina Mountain. It was separated from Lake Superior, Lake Nipigon, and James Bay by a moderately undulating or in part hilly plateau, which rises 300 to 500 feet above the highest shore of Lake Agassiz and holds nearly this elevation southward to its termination in the highlands bordering Lake Superior, but from which toward the east and northeast a gradual slope descends to the sea level of James and Hudson Bays. On the west this glacial lake washed the base of the great range of highlands named in its successive portions from south to north the Coteau des Prairies, Pembina Mountain, Riding and Duck Mountains, and the Porcupine Mountain, and Pasquia Hills; and on the northwest it extended beyond the fork of the South and North Saskatchewan. Northward it reached beyond Lake Winnipeg and covered the upper part of the course of the Nelson. When finally the receding ice-sheet gave place for this river, the glacial lake, no longer ice-dammed, was reduced to Lake Winnipeg.

Comparison with the areas of the Laurentian lakes and the lakes of Manitoba.

Measured on the accompanying map, the probable area of Lake Agassiz is about 110,000 square miles. It thus exceeded the total area of the five great lakes, namely, Superior, 31,200 square miles; Michigan, 22,450; Huron, with Georgian Bay, 23,800; Erie, 9,960; and Ontario, 7,240; amounting together to 94,650 square miles.[1] The

[1] According to measurements on the U. S. Lake Survey charts, as stated in "Physical Characteristics of the Northern and Northwestern Lakes," by L. Y. Schermerhorn, Am. Jour. of Science, III, vol. xxxiii, p. 279, April, 1887.

areas of the three great lakes of Manitoba, remaining where shallow depressions prevented the complete drainage of Lake Agassiz, are approximately as follows: Lake Winnipeg, 8,500 square miles; and Lakes Manitoba and Winnipegosis, each 2,000 square miles.

Depth of Lake Agassiz.

At the time of the formation of its highest beach the depth of Lake Agassiz above Fargo and Moorhead was nearly 200 feet; above Grand Forks and Crookston, a little more than 300 feet; above Pembina, Saint Vincent, and Emerson, on the international boundary, about 450 feet; and above Lakes Manitoba and Winnipeg, respectively about 500 and 600 feet. The northward ascent of the beaches of this glacial lake as compared with the level of the present time, and its successive stages during its fall to Lake Winnipeg, will be considered in a later part of this report.

Shore Lines, Deltas, and Dunes.

Beach ridges.

Viewed in their relation to the general topography, the shore lines of Lake Agassiz are inconspicuous, though they are very distinctly traceable. They are usually marked by a deposit of beach gravel and sand, forming a continuous, smoothly rounded ridge, such as is found along the shores of the ocean or of our great lakes wherever the land sinks in a gently descending slope beneath the water-level. The beaches of Lake Agassiz commonly rise three to ten feet above the adjoining land on the side that was away from the lake, and ten to twenty feet above the adjoining land on the side where the lake lay. In breadth these beach ridges vary from ten to twenty-five or thirty rods. In some places they have been cut through and carried away by streams; and occasionally they are interrupted for a quarter or a half of a mile or even two or three miles, where the outline of the lake shore and the direction of the shore currents prevented such accumulation.

Eroded shores.

Another type of shore lines is developed where the lake has formed a terrace in the till, with no definite beach deposit, the work of the waves having been to erode and carry away rather than to accumulate. The height of these steep, wave-cut slopes varies from ten to thirty feet, which is indeed a very slight elevation in comparison with the cliffs of till of similar origin on some parts of the shores of Lake Michigan and others of the Laurentain lakes. No portions of the beach ridges nor of these low eroded escarpments, marking the margin of Lake Agassiz, are noteworthy objects in the view from points so far away as two or three miles; but nearer at hand they appear sufficiently impressive, when the mind reverts to the receding ice-sheet and this great glacial lake by which they were made.

Delta deposits of sand and gravel, so extensive as to be important features in the topography, were formed in the edge of Lake Agassiz by several of its tributary streams. Such deltas were brought into the east side of the lake by the Buffalo and Sand Hill Rivers; and into the west side by the Sheyenne, Pembina, and Assiniboine Rivers. The Deltas. Pembina formed a delta that reaches twelve miles from north to south and has a maximum width of seven miles. The "First Pembina Mountain," which rises very conspicuously near Walhalla, North Dakota, a few miles south of the international boundary, as a steep wooded escarpment about 175 feet above the flat prairie of the Red River Valley at its base, with its crest 1,150 to 1,200 feet above the sea, is the eroded front of this Pembina delta. The sand and gravel beds brought into Lake Agassiz by the Sheyenne River reach fifty miles from northwest to southeast, and their maximum width is nearly thirty miles. But the largest of all these deltas is that of the Assiniboine in Manitoba, which extends from Brandon seventy-five miles east to Portage la Prairie, and from Treherne, Glenboro and Milford forty miles north to Gladstone and Neepawa. Its area is fully 2,000 square miles, and its depth probably averages 50 feet, with a maximum of about 200 feet.

Extensive tracts of the deltas formed by the Sand Hill, Sheyenne, and Assiniboine Rivers have been heaped up by the wind in dunes, or drifting sand hills, which vary in height from twenty-five to one hundred feet. Their extremely uneven contour, and their singular aspect, being partly covered by small trees and bushes but in many places wholly destitute of vegetation where they are now gullied and drifted by the wind, make these hills a unique element in the topography of the Red River basin. The worthlessness of the dunes for Dunes. agriculture is also in marked contrast with the fertility of the surrounding prairie, but they frequently include patches of good pasturage in the intervening hollows. The time of formation of these dunes was probably soon after the withdrawal of Lake Agassiz, before vegetation had spread over the surface. The winds could then erode more rapidly than now, and heaped up these hills of sand in nearly their present size and height; but it is evident also that their forms have been constantly undergoing slight changes since that time.

Country adjoining Lake Agassiz.

East from the flat prairie of the Red River Valley is the undulating and in part rolling and hilly wooded region of northern Minnesota and eastern Manitoba. Through this district the outline of Lake Agassiz is mapped approximately. It extends farthest east on the international boundary, where it reaches beyond Rainy Lake. The general level of Wooded region of eastern Manitoba. the country adjoining Rainy Lake and the Lake of the Woods is 50 to

150 feet below the highest stage of Lake Agassiz; but the northern and eastern part of this district may have been still covered by the waning ice-sheet when the lake stood at that height. On account of the impracticability of tracing the shores of Lake Agassiz through this wooded and uninhabited region, the northeastern limits of this glacial lake, where the shore in its successive stages passed from the land surface to the barrier of the receding ice-sheet, remain undetermined.

Plain sloping from Lake Winnipeg to Hudson Bay, described by Dr. Bell.

The country north and northeast of Lake Winnipeg presents no considerable elevations, but is mainly a broad, nearly flat expanse, similar to the Red River Valley and the lake district of Manitoba, slowly declining to the sea level. Dr. Robert Bell writes of it as follows:—"The region through which the upper two thirds of the Nelson River flows may be described as a tolerably even Laurentian plain, sloping towards the sea at the rate of about two feet in the mile. The river, for the first hundred miles from Great Playgreen Lake, does not flow in a valley, but spreads itself by many channels over a considerable breadth of country. This tendency to give off 'stray' channels is characteristic of numerous rivers throughout the northern and comparatively level Laurentian regions, but it is perhaps more strongly marked in the Nelson than in any other. In the above section of this stream the straggling channels are of all sizes, from mere brooks up to large rivers. . . . The general aspect of the country is even, or slightly undulating, the highest points seldom rising more than thirty or forty feet above the general level." The country adjoining the lower part of this river, according to the same explorer, has a similar contour, only moderately uneven; but the channel of the river, excepting in the ten miles next to its mouth, is deeply eroded. Its enclosing bluffs vary in height from one hundred to two hundred feet between Broad Rapid, where the river is approximately 125 feet above the sea, and Gillam's or Lower Seal Island, which is at the head of the tide, about twenty miles from Hudson Bay.[1]

Ascent westward from Lake Agassiz.

Along the west side of the basin of the Minnesota River, of the Red River Valley, and of Lakes Manitoba and Winnipegosis, the surface rises from two or three hundred to one thousand feet above their slightly undulating or quite flat belt of lowland. No other feature in the contour of the Northwestern States and adjoining British territory is more noteworthy, extended and prominent, than this, excepting perhaps the ascent along the similar and parallel Coteau du Missouri. The latter, however, lacks the accompaniment of such a continuous broad depression beside it. This wide valley, occupied by Lakes Winnipeg, Manitoba and others, and by the Red and Minnesota Rivers,

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[1] Geological Survey, Reports of Progress for 1877 to 1879.

varying in elevation from 710 to 1,100 feet above the sea, is the base of the slowly ascending expanse of the great plains which rise thence westward to a height somewhat exceeding 4,000 feet above sea level at the foot of the Rocky Mountains on the international boundary. Most of this elevation is attained by a gradual slope, averaging four or five feet per mile throughout the distance of 730 miles from the Red River to the Rocky Mountains; but at two lines, extending approximately from south to north, first on the west side of this valley, and again in the Coteau du Missouri, 100 to 200 miles farther west, the surface rises more rapidly several hundred feet within a few miles by a terrace-like ascent. The first was the western shore of Lake Agassiz, and continuing south and southeast held the same relation to an earlier glacial lake which occupied the basin of the Minnesota and Blue Earth Rivers.

The southern portion of this line of elevation is the massive and high Coteau des Prairies of southwestern Minnesota and the east part of South Dakota. Its lower continuation from the Head of the Coteau des Prairies, west of Lake Traverse, for the next one hundred and seventy-five miles northward, bears no name, and is scarcely more conspicuous, or in some parts even less so, than the moderate ascent that forms the opposite border of the Red River Valley in Minnesota. Farther north this line of higher land rises abruptly 300 to 500 feet in Pembina Mountain, and from 500 to 1,000 feet in Riding and Duck Mountains and the Porcupine and Pasquia Hills. All of these are successive parts of a very remarkable terrace-like escarpment, stretching from North Dakota by the west side of Lakes Manitoba and Winnipegosis to the Saskatchewan River. Its portions thus differently named are divided by deep and broad valleys eroded by intersecting streams.

Coteau des Prairies, and highland continuing thence north.

Pembina Mountain is a distinct and conspicuous topographic feature for a distance of about seventy-five miles, of which two thirds lie north of the international boundary. Its southern end is in the southwest part of T. 158, R. 56, in Walsh county, North Dakota, between the South and Middle branches of Park River; and its northern end is about six miles east-southeast from Treherne, where the course of this highland turns to the west and its more uneven continuation takes the name Tiger Hills. It is a prominent, wooded escarpment, mostly 300 to 400 feet high, extending in a very direct course from south to north or a few degrees west of north. The width occupied by its slope varies from a half of a mile to two or three miles, and from its crest a plateau, having a moderately rolling surface, stretches nearly level or with slow ascent westward. Its crest north of the international boundary averages about 400 feet above its base, or 1,400 feet above

Pembina Mountain.

the sea; but within a few miles farther west the rolling surface of the highland rises 100 to 200 feet higher.

Assiniboine Valley.

Northwestward from Treherne the plateau of which Pembina Mountain forms the eastern edge, is interrupted across a distance of sixty-five miles, to Riding Mountain. This broad depression is occupied by the Assiniboine and its tributaries, and by small streams on the northeast which send their waters to Lake Manitoba. The plateau, indeed, loses its regularity of surface upon all the country farther north and west, because it has been eroded to the depth of several hundred feet on the greater part of the basin of the Assiniboine.

Tiger Hills.

The border of the plateau south of this river, reaching from close south of Treherne westerly fifty miles to the Elbow of the Souris River, is called the Tiger Hills.[1] It is irregularly sculptured in steep, rounded, massive hills, and is overspread by drift deposits consisting partly of morainic accumulations. For a distance of forty miles west from the Pembina Mountain this belt occupies a width of five to eight miles, upon which the surface falls from south to north 300 to 400 feet. The country on the south has an average elevation nearly the same as the summits of the hills, which yet rise very prominently as seen from the lower region on the north. The western part of the Tiger Hills, extending ten or twelve miles east and an equal distance west from the gorge that is cut through the range by the Souris, rises considerably above the adjoining nearly flat surface on each side. The foot of the belt of hills there is 100 to 150 feet lower on the north than on the south; and the Souris flows through it in a gorge 350 feet deep. From this vicinity Hind applied the name Blue Hills of the Souris to this belt, but that name is not used by the people of the district.

Riding and Duck Mountains.

North of the Assiniboine the eastern outline of the continuation of this plateau is preserved in the prominent elevations of Riding and Duck Mountains, two remarkable wooded highlands, much alike in their general features and extent. The steep eastern escarpment of each is about fifty miles long, that of Riding Mountain trending from southeast to northwest, and that of Duck Mountain having a course a few degrees west of north. These elevations rise above the country adjoining the Assiniboine by a somewhat gradual slope, but they are abruptly cut off on their northeast side by a precipitous descent. This takes place on a line approximately parallel with Lakes Manitoba and Winnipegosis, the former of these lakes being about forty miles east of Riding Mountain, while the south end of the latter is twenty-five miles east of Duck Mountain. The crests of these highlands, according to Mr. J. B. Tyrrell's measurements, are respectively about 2,000 and

[1] From the aboriginal name, which doubtless refers to the cougar or American Panther (Felis concolor, L.).

2,300 to 2,700 feet above the sea, the latter being the highest land in Manitoba; and the bases of their escarpments are about 1,200 to 1,500 feet above the sea, being four hundred to seven hundred feet above the lakes on the east, whose height slightly exceeds 800 feet.

The reader is referred to Mr. Tyrrell's maps and descriptions of the district of Riding and Duck Mountains, to be published in the annual reports of this Survey, for details of its topography and geology and of the shore lines of Lake Agassiz north of the limit of my exploration. Maps and reports of Mr. Tyrrell.

Beyond Duck Mountain, after an interruption of about thirty miles across the basins of Swan and Woody Rivers, this line of highlands is continued in the Porcupine Mountain or Hills, which reach about twenty-five miles from south to north. These form a somewhat broken plateau, similar with the preceding in its general features of steep acclivity on the east and gentle descent westward. On their north side another gap about twenty miles wide is occupied by the Red Deer and Overflowing Rivers. Porcupine Hills.

Next are the Pasquia Hills, whose eastern end is in line with Pembina, Riding and Duck Mountains, and the Porcupine Hills, being about a hundred miles west from the mouth of the Saskatchewan. The Pasquia Hills extend thence a hundred and fifty miles westward, where they formed the southern shore of the northwestern arm of Lake Agassiz, lying about twenty-five miles south of the Saskatchewan River and parallel with it, to the Birch Hills and the South Saskatchewan River. They are the northern escarpment limiting the irregularly eroded country which is here considered as an extension of the great plateau of North Dakota and southern Manitoba and Assiniboia, thus holding the same relation to the valley of the Saskatchewan that the Tiger Hills sustain to the Assiniboine Valley. Pasquia Hills.

Existing Lakes within the area of Lake Agassiz.

The glacial Lake Agassiz was gradually reduced in size, first by the erosion and lowering of its southward outlet, and afterward by finding successively lower outlets to the northeast, until with the complete departure of the ice-sheet it sank to its present representatives, the great lakes of Manitoba. These are three in number, Lakes Winnipeg, Manitoba, and Winnipegosis. With them are associated several others, comparatively small, as Cedar Lake, through which the Saskatchewan flows near its mouth, Lake Dauphin, south of Lake Winnipegosis and tributary to it, and Lake Saint Martin on the Fairford or Little Saskatchewan River, the outlet of Lakes Manitoba and Winnipegosis. The great lakes of Manitoba.

Lake Winnipeg is two hundred and fifty miles long, trending from south-southeast to north-northwest. The maximum width of its southern part is about twenty-five miles, and of its northern part sixty miles. Its area is approximately 8,500 square miles, being intermediate in extent between Lakes Ontario and Erie. Eighty-five miles from its south end, Lake Winnipeg is reduced to a strait two to four miles wide, which extends northwesterly twelve miles, terminating at the cape called Dog's Head. The narrowest part of the strait, scarcely exceeding a mile in width, is at this cape. Here the strait opens into the northern and main portion of the lake, which includes five-sixths of its area. The elevation of Lake Winnipeg, determined by the surveys for the Canadian Pacific Railway, is 710 feet above the sea. Its depth, according to Mr. J. Hoyes Panton, nowhere exceeds sixty-five feet. "The shallowness of this comparatively large body of water," as Mr. Panton writes, "accounts for its treacherous nature and explains how on many occasions it has proved a disastrous water-way to the freighting boats of by-gone days. As you sit upon the deck of the steamer, threading its way among the islands, you are surprised at the tortuous course made, when water seems on every side and no shore near. So shallow is the lake that many places miles from land are not covered with more than six or seven feet of water. It is only safe to experienced captains, thoroughly acquainted with the concealed channels that afford a safe course at a distance from the shore."[1] On account of this slight depth, the mud brought in by the Red River is held in suspension, being almost constantly stirred up from the bottom by the waves of the lake, throughout its southern half; but in the broad northern half of its length, beyond Beren's River and Island, the water is comparatively clear.[2] Low land borders this lake along nearly its whole extent, and the highest points on the shore or visible from it rarely attain an elevation of fifty feet.

Lake Winnipeg.

Lake Manitoba,[3] from which comes the name of the province of Manitoba, lies about forty miles west of the south half of Lake Winnipeg; and Lake Winnipegosis,[4] separated only about two miles from the north end of Lake Manitoba, lies mostly forty to fifty miles west of the north half of Lake Winnipeg, but its most northeast part is only twenty miles southwest from that lake. The length of each of these lakes,

Lakes Manitoba and Winnipegosis.

[1] "Notes on the Geology of some islands in Lake Winnipeg," Transactions of the Historical and Scientific Society of Manitoba, Jan. 28, 1886.

[2] "Lake Winnipeg receives its name from the muddy or sallow appearance of its waters; *We* signifies muddy, and *Nepe* water, in Chippewa."—Keating's Narrative of Long's Expedition, vol. ii, p. 77.

[3] Meaning the "Narrows or Strait of the Manitou or Great Spirit," as I am informed by letters from Prof. George Bryce and Mr. J. B. Tyrrell. This name was originally pronounced by white inhabitants, nearly as by the Indians, with accents on the initial and final syllables; but during the past ten years or more its almost universal pronunciation in English has been with only one accent, which is laid on the next to the last syllable.

[4] Meaning "Little Winnipeg."—Hind's Narative of the Canadian Exploring Expeditions, vol. ii, p. 42.

measured in a straight line, is about a hundred and twenty miles, trending in parallelism with Lake Winnipeg; and each of them covers an area of nearly 2,000 square miles. Both are shallow in proportion to their size, and are surrounded by low shores. The maximum width of Lake Manitoba, about twenty-eight miles, is at its south end. Near its middle, it is narrowed to a strait about half a mile wide and two miles long. Its northern part is of quite irregular form, and is nearly intersected from the north by a long peninsula. This lake, according to levelling by Mr. H. S. Treherne, is 809 feet above the sea, being thus almost exactly a hundred feet higher than Lake Winnipeg. The country between these lakes and from Lake Manitoba west to Lake Dauphin and to Riding and Duck Mountains is low and approximately level, but has a general westward ascent, averaging a few feet per mile. The width of Lake Winnipegosis varies from five to fifteen miles. Its northern portion is bent to the west, so that its length, following this curve, is nearly a hundred and fifty miles. Its outlines, moreover, are very irregular, presenting a constantly varying succession of bays, capes, and islands. This lake outflows by the Water Hen Lake and River to Lake Manitoba, and has n elevation of nineteen feet above the latter, as determined by surveys for the Canadian Pacific Railway, or 828 feet above the sea.

Rainy Lake and the Lake of the Woods, on the international boundary, are bodies of water of considerable size, lying within the eastern part of the area of Lake Agassiz. The length of Rainy Lake is nearly fifty miles, trending from east-southeast to west-northwest, and its average width is about five miles, giving it an area of 250 square miles, approximately. It is much diversified by projecting points, numerous bays and narrow arms, and plentiful islands. Its height above the sea is about 1,117 feet; and its maximum depth, according to soundings by Dr. A. C. Lawson, is a hundred and ten feet.

Rainy Lake.

The Lake of the Woods has a very irregular form, nearly surrounding a large peninsula in its northern part, and including many bays on the north and east, some of them connected with the main lake only by narrow channels. A multitude of islands, large and small, dot its surface, excepting in its southwest part, called Sand Hill Lake, where it adjoins Minnesota. Measured from north to south or from east to west, its maximum extent in either direction is sixty miles, approximately; and its area is about 1,500 square miles. Its elevation, determined by the Canadian Pacific Railway survey, is 1,060 feet above the sea; and the maximum depth of its northern part, called Clear Water Lake, is stated by Dr. Dawson to be eighty-four feet.

Lake of the Woods.

Rivers tributary to Lake Agassiz and draining its area.

Present drainage of the area of Lake Agassiz.

The area of Lake Agassiz is drained to Lake Winnipeg, chiefly by the Winnipeg, Red, and Little Saskatchewan or Fairford Rivers. On the northwest this glacial lake also included the region crossed by the lower part of the Saskatchewan. Flowing out from Lake Winnipeg, the united waters of all these river systems are carried by the Nelson to Hudson Bay.

Rainy River.

It seems probable that the recession of the ice-sheet uncovered the entire course of the Rainy and Winnipeg Rivers before Lake Agassiz had fallen below the level of Rainy Lake. These are upper and lower portions of the main trunk of the same river system. East of Rainy Lake a large tract tributary to it reaches nearly a hundred miles on the international boundary, including almost countless lakes and small streams. The Rainy River, about eighty miles long, connecting Rainy Lake and the Lake of the Woods, is a broad and majestic, deep stream, with an average width of a sixth of a mile, flowing in general in a somewhat direct west-northwest course. At the mouth of Rainy Lake it has rapids that fall about three feet. Its principal falls are at Fort Francis, a little more than two miles from Rainy Lake, where it descends twenty-three feet in about a tenth of a mile. Manitou Rapids, about thirty-five miles from Rainy Lake, are a short descent of about two feet, with outcropping rock in the channel and banks. Six miles below these is the Long Sault, a mile in length, estimated by Major Long to have "an aggregate descent of about ten feet." Excepting these rapids, Rainy River has an average descent of only about three inches per mile, giving to the ordinary low stage of water a very gentle current. It is navigable for large steamboats from the Lake of the Woods to the foot of the Long Sault; and thence to Rainy Lake it is navigated by a tug or propeller, towing Mackinaw boats. The banks of the river are only ten to twenty feet high, and are fertile and heavily wooded, having commonly a clayey soil.

Winnipeg River.

Winnipeg River, the outlet of the Lake of the Woods, has a length of about a hundred and sixty miles, flowing in a winding course to the northwest. Its total descent is 350 feet, four-fifths of this being in the many falls and rapids which occur along nearly its entire extent. These falls are divided by portions with only a strong or gentle current, or by lake-like expansions of the river where no current is perceptible. On each side the country rises to a moderate elevation in low hills and ridges, with frequent outcrops of the bed-rocks. The highest land crossed by the Canadian Pacific Railway south of the Winnipeg River, from eighteen to twenty-eight miles west of Rat Portage, is about 200 feet above the Lake of the Woods and about 550 feet above Lake Winnipeg, rising thus nearly to the highest level of Lake Agassiz. English River, which flows through Lac Seul or Lonely Lake, is a large tributary of the Winnipeg from the east. The only important affluent from the south is the Whitemouth, draining a considerable area west of the Lake of the Woods. The water of Winnipeg River is very clear, and is strongly contrasted with the muddy water of Lake Winnipeg with which it mingles at its mouth.

The Red River of the North, so named to distinguish it from the Red River of Louisiana, has its source in a small lake about 1,600 feet above the sea, thirteen miles west of Lake Itasca. It first flows south about sixty miles, measured in a direct line, passing through Elbow, Many Point, Round, Height of Land, Little Pine, Pine, and Rush Lakes, to Otter Tail Lake, this portion being commonly called Otter Tail River. In this distance it descends to 1,315 feet above the sea. **Red River of the North.** The contour of the adjoining country is rolling or hilly northward and undulating or flat southward. Below Otter Tail Lake this stream is called the Red River by this report, following the example of Owen and the prevailing popular usage; but it is still occasionally spoken of as Otter Tail River to its junction with the Bois des Sioux, forty-two miles west of Otter Tail Lake. The descent in this distance is 372 feet, or about five feet per mile, following the course of the stream. Because of the numerous large lakes on the upper part of its course, its volume along this descent to Breckenridge is not greatly affected by either heavy rains and snow-melting or dry seasons. From its bend at Breckenridge and Wahpeton the Red River flows north 285 miles, measured in a direct line, to Lake Winnipeg. The entire length of the Red River, measured thus in straight lines successively to the south, west, and north, is about 390 miles; **Length, and descent.** but in its meanderings, nowhere diverging far from these lines, it flows nearly seven hundred miles. Its descent below Breckenridge is 233 feet, and in total from its source to its mouth approximately 900 feet. All the way below McCauleyville and Fort Abercrombie, fifteen miles north of Breckenridge, it is navigated by steamboats, barges, and flat-boats; **Navigation.** but along the Goose Rapids, extending about twelve miles next below the mouth of Goose River as measured in the meandering course of the stream, the channel is obstructed by boulders which forbid navigation during low stages of water. The width of this river in the United States varies from six to twenty rods, being in some places less than the length of the steamboats; but north of the international boundary it is commonly twenty rods wide. The range between its lowest and highest stages increases rapidly north of Breckenridge, becoming thirty-two feet at Moorhead and Fargo, and attaining its maximum of fifty feet at Belmont. It continues nearly at forty feet from Grand

Forks to the international boundary and to Winnipeg. At Lower Fort Garry, sixteen miles north of Winnipeg and about twenty miles from the mouth of the river, it is thirty-five feet; but beyond that point it rapidly diminishes in approaching Lake Winnipeg. Floods rising nearly or quite to the high water line thus noted have been rare, occurring in 1826, 1852, 1860, 1861, and 1882. They are caused in the spring by the melting of unusual supplies of snow and by accompanying heavy rains, and often are increased by gorges of ice. These floods attain a height only a few feet below the level of the adjoining prairie where that is highest, and along the greater part of the distance between Grand Forks and Lower Fort Garry the banks are overflowed and the flat land on each side of the river to a distance of two to four or five miles from it is covered with water one to five feet or more in depth.

Highest floods.

Excepting the Red Lake River and the Sheyenne, Pembina, and Assiniboine, all the tributaries of the Red River are small, the length of their areas of drainage varying from forty to seventy-five miles. In summer droughts several of them, including the Bois des Sioux, are dried up along the greater part of their course, containing only here and there pools in the deeper hollows of their channels.

Tributaries of Red River.

Sheyenne River, having its sources near the great southeastern bend of the Souris River in North Dakota, first flows to the east nearly a hundred miles, passing ten miles south of Devil's Lake; next it flows south about a hundred miles, to where it enters the area of Lake Agassiz; and thence its course is eastward and northward, uniting with the Red River ten miles north of Fargo and Moorhead. The large valley of the upper part of this river, and its extensive delta deposited in Lake Agassiz, are probably attributable to a stream much larger than the present Sheyenne, formed by drainage from the ice-sheet when it terminated near Devil's Lake. At that time, also, a glacial lake in the basin of the Souris outflowed southeastward to the Sheyenne and James Rivers.

Sheyenne River.

During a later stage in the recession of the ice-sheet, this glacial lake in the Souris basin was extended west and north of Turtle Mountain and finally found a lower outlet in southern Manitoba. Its outflowing river ran southeasterly from the Elbow of the Souris, eighteen miles southwest of its mouth, to the Pembina River. Pelican Lake, eleven miles long from northwest to southeast and about a mile wide, occupies a part of the channel of this stream; and a distinct water-course of similar width, called Lang's Valley,[1] eroded 110 to 150 feet below the general level, extends eleven miles between this lake and

Lang's Valley.

[1] Named for James Lang, who was the first immigrant here, coming in 1880.

the Souris. The highest portion of Lang's Valley is 1,364 feet above the sea and about 100 feet above the Souris at its Elbow, and it is enclosed by bluffs 110 feet high. It is a channel similar to that of Lakes Traverse and Big Stone and Brown's Valley, eroded by the River Warren outflowing from Lake Agassiz.

Pembina River.

Pembina River[1] flows from the northern part of Turtle Mountain in a rather crooked easterly course through southern Manitoba and the edge of North Dakota about one hundred and thirty miles, measured in a direct line, to its mouth at Pembina and Saint Vincent. From its junction with the outlet of Pelican Lake to Walhalla at the base of the First Pembina Mountain, its valley varies from 175 to 450 feet in depth. Rock Lake and Swan Lake on this part of the river, each several miles long and from a half mile to one mile wide, are due to deposits brought into this valley by tributaries after it ceased to be the avenue of drainage from the Souris basin. In crossing the Red River Valley the Pembina runs in a channel only twenty to forty feet deep. Its descent from the northern base of Turtle Mountain to Walhalla is about 700 feet, and thence to its mouth 186 feet, its junction with the Red River being 748 feet above the sea. Long or White Mud River, Clearwater or Cypress River, and Tongue River, are its chief tributaries, all from the south side.

Assiniboine River.

The Assiniboine, the largest tributary of the Red River, drains a basin three hundred miles wide from south to north and four hundred miles long from west to east. From its sources, fifty miles southwest of the Porcupine Hills, the Assiniboine flows south-southeasterly two hundred miles, to a point about fifty miles below the mouth of the Qu'Appelle and forty miles west of Brandon; thence it flows easterly about a hundred and fifty miles to its mouth. Its height above sea level at the mouth of the Qu'Appelle is 1,264 feet; at the bridge of the Canadian Pacific Railway near Brandon, 1,161 feet; at the mouth of the Souris, about 1,100 feet; at Portage la Prairie, 842 feet; and at its junction with the Red River in Winnipeg, 724 feet. During its high stages of water, the Assiniboine has been navigated by steamboats to Fort Ellice at the mouth of the Qu'Appelle. Along this portion it varies from ten to twenty-five rods in width.

Overflow from the Assiniboine to Lake Manitoba.

The highest floods of the Assiniboine at Portage la Prairie and along a considerable distance eastward rise only twelve to fifteen feet above its lowest stage, but they then attain a height only a few feet below the highest portions of the adjoining country, much of which is submerged. At this extreme height, which the river reached and main-

[1] This name is stated by Keating to be from the Ojibway word "*anepeminan*, which name has been shortened and corrupted into Pembina," meaning the fruit of the bush cranberry (Viburnum Opulus, L.).—Narrative of Long's Expedition, vol. ii, p. 38.

tained from the 3rd to the 15th of May, 1882, the only time of such high water since 1860 or 1861, it overflowed near the former site of the fort of the Hudson's Bay Company two miles southwest of Portage la Prairie, and a portion of its flood passed north in shallow, winding water-courses to Lake Manitoba, making a descent of about forty feet in the distance of fifteen miles between the river and the lake. Near the same time Lake Manitoba also reached its highest stage, about eight feet above its lowest level, rising until it overflowed southward across the east part of T. 13, R. 6, and thence eastward through the southern row of sections in T. 13, R. 5, falling ten feet in fifteen miles to Long Lake, through which old channel of the Assiniboine its waters were discharged into this river twenty miles east of Portage la Prairie.[1]

Overflow from Lake Manitoba to Long Lake and the Assiniboine.

Qu'Appelle or Calling River and the Souris or Mouse River are the largest tributaries of the Assiniboine. Each of these streams has an interesting glacial history, which is recorded in the topographic features of their valleys and areas of drainage. The Qu'Appelle valley was the outlet of a glacial lake in the basin of the South Saskatchewan. The description, map and sections given by Hind,[2] show that this valley is quite uniformly about one mile wide, and is from 110 to 350 feet below the general level of the region through which it lies, this height being reached by steep bluffs on each side. Its length, from the Elbow of the South Saskatchewan to its junction with the Assiniboine is about two hundred and seventy miles, the general course being a little to the south of east. Of this extent the west end of the valley for about twelve miles is occupied by the River that Turns, and the remainder by the Qu'Appelle, the summit or height of land in this channel at the divide between these rivers being approximately 85 feet above the South Saskatchewan, 440 feet above the mouth of the Qu'Appelle, and 1,700 feet above the sea. The enclosing bluffs are composed mainly of glacial drift, with only a few exposures of the underlying Cretaceous rocks. The alluvial bottomland of the Qu'Appelle is generally from a half mile to one mile wide, and through it the river flows in a winding course, here and there passing through long lakes. Like the similar lakes of the Pembina and Minnesota Rivers, these owe their existence to the recent deposits of tributaries, and show that the bed of the glacial river was considerably lower than that of the present stream. The outflow of the Saskatchewan glacial lake, fed by the melting ice-fields of an immense area reaching west to

Qu'Appelle Valley, the outlet of the Saskatchewan glacial lake.

[1] Compare H. S. Treherne's description of this vicinity, "An ancient outlet of Lake Manitoba," Ninth Annual Report of the Geological and Natural History Survey of Minnesota (for the year 1880), pp. 388-392.

[2] Report of the Assiniboine and Saskatchewan Exploring Expedition, Toronto, 1859, by Henry Youle Hind.

the Rocky Mountains, took its course east by this trough-like channel or valley, entering the Assiniboine at Fort Ellice and reaching the border of Lake Agassiz at Brandon.

Long or Last Mountain Lake, about fifty miles long from south to north and one or two miles wide, lying north of the upper part of the Qu'Appelle and tributary to it, occupies a similar glacial water-course. The elevation of Long Lake is 1,598 feet, being about a hundred feet lower than the divide in the channel from the Elbow of the South Saskatchewan to the Qu'Appelle. It seems probable that when the ice-sheet had receded so far north as to allow the Saskatchewan lake to extend to the district northwest and north of Long Lake, it there obtained some lower point of discharge and outflowed along the course of this lake, forsaking its former outlet.[1] Owing to the changes in relative elevation which have taken place in the region of Lake Agassiz since that time, this new outlet, or the earliest and highest one of several successive outlets, across the water-shed between the Saskatchewan basin and Long Lake may now be found fifty or perhaps even a hundred feet higher than the old channel to the head of the Qu'Appelle, that is, 1,750 or 1,800 feet above the sea, the possible difference being probably as much as a foot to each mile of the distance between the old and new outlets.

Long Lake, probably the later glacial outlet from the Saskatchewan basin.

Souris River, flowing circuitously southwestward from Assiniboia into North Dakota and thence northeastward into Manitoba, became tributary to the Assiniboine after the waters of the glacial lake in its own basin, at first flowing to the James and Sheyenne, had been wholly drained away by its outlet through Lang's Valley and the Pembina River. The length of the Souris is nearly four hundred miles, but it is only five to ten rods wide along its lower portion. In North Dakota its descent is approximately from 1,650 to 1,400 feet above the sea, and thence to its mouth it falls about three hundred feet.

Souris River

Little Saskatchewan or Fairford River drains an area that extends more than two hundred miles west from Lake Winnipeg and includes an equal distance in latitude, from the most northern part of Lake Winnipegosis to the south end of Lake Manitoba. The latter lake receives several small streams at its south end; and the Water Hen River, the outlet of Lake Winnipegosis, flows into its north end. Four considerable streams are tributary to Lake Winnipegosis, namely, the Mossy River, the outlet of Lake Dauphin, flowing into its south end, and the Swan, Red Deer, and Overflowing Rivers at its northwest end. Riding and Duck Mountains form the southwestern boundary of

Little Saskatchewan River.

[1] Report of the Assiniboine and Saskatchewan Exploring Expedition, 1859, pp. 28 and 35.

this basin; but the Porcupine Hills are entirely enclosed between the Swan and Red Deer Rivers, and the latter drains much of the plateau bordered by the Pasquia Hills.

Saskatchewan River.

The lower part of the basin of the Saskatchewan, next to its mouth, was latest occupied by the ice-sheet; but that area was relinquished by it, allowing this great river to take its present course, long before Lake Agassiz began to be drained northward. From the most western sources of the Saskatchewan in the Rocky Mountains to its mouth is a distance of more than seven hundred miles; and the maximum width of its basin is about three hundred and fifty miles. Its two branches of nearly equal size, the North and South Saskatchewan Rivers, unite two hundred and thirty miles west of Lake Winnipeg. The elevation of the South Saskatchewan at Medicine Hat, where it is crossed by the Canadian Pacific Railway, is 2,137 feet; at its Elbow, 1,619 feet, approximately; and at its junction with the North Saskatchewan, about 1,200 feet. Cedar and Cross Lakes, through which the Saskatchewan flows near its mouth, are approximately 114 and 108 feet above Lake Winnipeg, or 824 and 818 feet above the sea. Hind informs us that the name Saskatchewan means "the river that runs swiftly;" and he states that in the Grand Rapids, between Cross Lake and its mouth, it falls forty-three feet in two and a half miles.[1] Its average descent per mile from Medicine Hat eastward is about two feet. The Saskatchewan and both its North and South branches for several hundred miles above their junction vary commonly from a sixth to a third of a mile in width, and during favorable stages of water are navigable by steamboats from Cedar Lake to the Rocky Mountain House on the North Saskatchewan, about 3,000 feet above the sea, and beyond the confluence of the Bow and Belly Rivers, which form the South Saskatchewan, fifty miles west of Medicine Hat, at an elevation exceeding 2,200 feet. The chief hindrances to their navigation in low stages are shifting sand-bars, over which they expand in some places to widths of a half mile to one mile, being very shallow and divided by low sandy islands. The adjoining country rises within a few miles from these rivers, or at the farthest ten or twenty miles, to an elevation three hundred to six hundred feet or more above them, excepting along the last hundred miles of the Saskatchewan, where it flows through a broad lowland region. There the highest parts of the country are only fifty to a hundred feet above the river, and its shores are generally low and in many portions swampy.

Grand Rapids.

Navigation.

Adjoining country.

Besides the great tributaries of Lake Winnipeg, namely, the Winnipeg, Red, Little Saskatchewan and Saskatchewan Rivers, about a dozen

[1] Report of the Assiniboine and Saskatchewan Exploring Expedition, 1859.

streams varying in length from ten to forty miles enter its west side, and twenty or more of similar or somewhat greater length enter its east side. Of the latter the largest are Beren's and Poplar Rivers, each about a hundred miles long. The recession of the ice-sheet from southwest to northeast uncovered the entire region west of Lake Winnipeg, and probably the whole of the country traversed by these streams on the east, before its melting finally permitted the waters of the glacial Lake Agassiz to be drained to the level of this lake. Smaller tributaries of Lake Winnipeg.

The Nelson, as before noted, is bordered by no areas of highland along its course of about four hundred miles from Lake Winnipeg to Hudson Bay. The upper half of this river flows in a general direction only a few degrees east of north, passing through Great and Little Playgreen, Pipestone, Cross and Sipi-wesk Lakes, to Split Lake; thence it turns to the east for about a hundred miles, passing through Gull Lake; and finally takes a northeastward course along its lower one hundred miles. According to Dr. Bell's observations, Sipi-wesk Lake is approximately 570 feet above the sea, or a hundred and forty feet below Lake Winnipeg; Split and Gull Lakes are respectively about 440 and 420 feet above the sea; and the descent in the next forty-eight miles, to the foot of Broad Rapid, is nearly three hundred feet. The Nelson is navigable from the sea about ninety miles to the First Limestone Rapid, where the elevation is probably about fifty feet above the sea level. Nelson River.

About four fifths of the area drained by the Nelson, including the basins of the Red River of the North, the Little Saskatchewan and the Saskatchewan, and the greater part or possibly all of the basin of the Rainy and Winnipeg river system, were uncovered from the ice-sheet and were tributary to Lake Agassiz while it still had its southward outlet. The waters of a large part of British America were thus carried along the course of the Minnesota and the Mississippi to the Gulf of Mexico. The basin of Lake Agassiz then included approximately 350,000 square miles, of which nearly a third was covered by the lake itself. In the later stages of this glacial lake, when it flowed northeastward by outlets higher than the Nelson, its basin probably extended north beyond the present water-shed of Lake Winnipeg and the Nelson to include the upper portion of the basins of the Churchill and the Mackenzie, the lower course of these rivers being obstructed by the waning ice-sheet. It seems probable that with this addition the area of the glacial lake basin was not less than 500,000 square miles. Area of the basin of Lake Agassiz.

DRIFT FORMATIONS IN MANITOBA.

Thickness of the drift in Manitoba.

The thickness of the sheet of superficial deposits overlying the bed-rock in West Selkirk is 65 feet; in Winnipeg and Saint Boniface it varies from 30 to 80 feet; near Niverville it is from 65 to 100 feet; in Dominion City, near Letellier, and on the Low farm west of Morris, it is at least 170 to 250 feet, and in West Lynne at least 108 feet; at Rosenfeld it is 143 feet; near Carman it is about 100 feet; and seven miles west of Portage la Prairie, 158 feet. From these records it seems probable that the thickness of these deposits upon the flat plain of the Red River Valley in Manitoba averages about a hundred feet, considerably exceeding this, to a maximum of 150 to 250 feet, along the central part of this area south of the Assiniboine, but not probably averaging more than 50 feet in the lower part of the valley between Winnipeg and Lake Winnipeg, where the higher portions of the bed-rock rise to the surface. On the Archæan area of the east part of Lake Agassiz, plentiful rock-outcrops occur about Rainy Lake and the Lake of the Woods, westward along the Canadian Pacific Railway nearly to the Whitemouth River, and in the country east of Lake Winnipeg; and it is probable that the average thickness of the superficial deposits in that extensive district is not more than 30 to 50 feet. West of Lake Agassiz, many portions of the plateau bordered by the Pembina Mountain and the Tiger Hills have only a small depth of drift, ranging from a few feet to 20 or 30 feet, but in some places the drift appears to extend deeper, as shown by stream valleys, and its average thickness may be 40 feet or more.

Distribution of the till.

Till, also called boulder-clay, constitutes the greater part of the entire sheet of superficial deposits, both within the area of Lake Agassiz and upon the adjoining country. It usually lies on the striated bed-rock, and upon large areas it reaches thence upward to the surface; but elsewhere this unmodified glacial drift is covered by modified drift, the stratified gravel, sand and clay deposited by streams which flowed down from the ice-sheet during its melting, or by lacustrine and fluvial sediments. Fully half of the area of Lake Agassiz in Minnesota and North Dakota has a surface of till; but in the part of this lake area examined in Manitoba its proportion is less, because much of this district is covered by the Assiniboine delta and its associated lacustrine beds. Extensive tracts of till, however, occupy the surface on the north and east portions of this area, as north of Neepawa, on the east side of the Big Grass Marsh, from the south end of Lake Manitoba eastward by Shoal Lake nearly to the Red River and Winnipeg and south to the Canadian Pacific Railway, from East Selkirk eastward along this railway, and ten miles east of Emerson, where the flat plain

Tracts of till forming the surface within the area of Lake Agassiz.

of the Red River Valley is bordered by slightly higher land. Till also forms the surface of the terrace along the foot of the Pembina Mountain escarpment between the international boundary and Thornhill. Beneath the delta deposits of gravel and sand, and on the central portion of the flat plain of the Red River Valley, where the surface is commonly fine silt or clay, a sheet of till lies between these sediments and the bed-rock.

The till is the direct deposit of the ice-sheet, as is shown by its consisting of clay, sand, gravel, and boulders, mingled indiscriminately in an unstratified mass, without assortment or transportation by water. Very finely pulverized rock, forming a stiff, compact, unctuous clay, is its principal ingredient, whether at great depths or near the surface. It has a dark bluish gray color, except in its upper portion, which is yellowish to a depth that varies from five to fifty feet, but is most commonly between fifteen and thirty feet. This difference in color is due to the influence of air and water upon the iron contained in this deposit, changing it in the upper part of the till from protoxide combinations to hydrous sesquioxide. Another important difference in the till is that its upper portion is commonly softer and easily dug, while below there is a sudden change to a hard and compact deposit, which must be picked and is far more expensive in excavating. The probable cause of this difference in hardness was the pressure of the vast weight of the ice-sheet upon the lower and older till, while the upper till was contained in the ice and dropped loosely at its melting. Upon each side of Lake Agassiz the till has a moderately undulating and rolling surface. Within the area that was covered by this lake it has a much smoother and more even contour, and its upper portion, owing to its manner of deposition in this body of water, sometimes shows an imperfect stratification, with a scantier intermixture of boulders and gravel. Yet even where it has distinct lamination, it usually is more like till than like ordinary modified drift, and contains stones and gravel through its entire mass.

Characters of the till.

Boulders are frequent or plentiful in the till throughout Manitoba, their abundance being nearly the same as in northeastern Minnesota and in the least rocky parts of New England. Their usual range in size extends up to a diameter of four or five feet; but in a few localities, especially in the course of morainic belts, they were observed of all sizes up to ten or twelve feet cubes. Generally as large a proportion as ninety-nine per cent. of the boulders exceeding one foot in diameter consists of Archæan granite, gneiss and schists, being derived from the Archæan area on the northeast and north. With these are occasional limestone blocks, derived from the belt of Palæozoic limestones, constituting on the average perhaps nearly one per cent. of the

Boulders and gravel from Archæan and Palæozoic formations.

large rock fragments of the drift. The bedded and jointed character of the limestones has prevented their supplying many large boulders in comparison with the more massive crystalline Archæan rocks, while yet usually about half of the smaller cobbles and pebbles in the till and in gravel and sand deposits are from these Palæozoic limestones. But east of Lake Winnipeg and northeast of a line drawn from this lake southeastward across the Lake of the Woods to the west end of Rainy Lake, both boulders and gravel of limestone are absent or exceedingly rare. This line probably marks the eastern limit of the glacial currents that moved south-southeast in the vicinity of Winnipeg and at Black Bear Island near the Narrows of Lake Winnipeg, carrying débris from the limestone region of the Manitoba lakes. Upon the Cretaceous area a considerable proportion of the gravel and cobbles is derived from the Fort Pierre shale, but this formation supplies no large boulders.

Northeastern limit of limestone drift.

Localities of abundant and large boulders.

The following localities may be mentioned as having especially abundant boulders. On the slope of the Pembina Mountain, in T. 3, R. 6, between Morden and Thornhill, very plentiful and large boulders are spread upon an area of several square miles, as noted in the description of the Tintah beaches. The sides of Star Mound, especially those facing the north and northeast, are strewn with a multitude of boulders, nearly all granitic, of all sizes up to five feet in diameter or rarely larger. These were probably combed out of the ice-sheet in its passage over this hill. Comparatively few boulders occur on the small flat area at its top. Pilot Mound, an equally prominent hill seen from this looking toward the northwest, is like Star Mound a knob of Cretaceous shale with thin covering of drift, but it has no such unusual profusion of boulders on its slopes. Rock Lake, through which the Pembina flows, derives its name from the remarkable abundance of boulders, mostly granitic, up to six feet or more in diameter, bordering its shores; and along a distance of one or two miles west from this lake the Pembina Valley is much encumbered with boulders, which in some places are accumulated upon small morainic ridges and knolls. The largest boulder noted in this exploration, having nearly twice the size of any other observed, is a block of dark gray granitoid gneiss, 22 feet long, 8 to 14 feet wide, and projecting 2 to 5 feet above the surface, in the N. W. ¼ of sec. 9, T. 1, R. 4 E., on the low ridge ten miles east of Emerson. Among the other plentiful boulders of that vicinity, none were seen exceeding seven or eight feet in dimension. Like many of the smaller boulders throughout this prairie region, this block is surrounded by a slight depression, one to three feet below the adjoining ground; and a careful examination shows that some of its projecting corners and edges are smoothly polished. These depressions were formed by the trampling and pawing of buffaloes in rubbing upon the

Star Mound.

Pilot Mound.

Rock Lake.

East of Emerson.

boulders, which were thereby sometimes worn and polished as perfectly as could be done by art.

Boulders polished by buffaloes.

A belt of morainic drift deposits, accumulated along the border of the ice-sheet during one or more pauses or times of re-advance interrupting its retreat, was observed upon the country that adjoins Lake Agassiz on the west and is crossed by the Assiniboine, Souris and Pembina Rivers. Though sufficient time was not available in this exploration for tracing the entire course of this recessional moraine, I have attempted to correlate it provisionally with the moraines of North Dakota and of Minnesota, thus indicating the probable course of the boundary of the ice-sheet at the time of the formation of the highest or Herman beach of Lake Agassiz.

Recessional moraine in southwestern Manitoba.

Evidence which is more fully detailed in the ensuing parts of this report, in treating of the modified drift and the history of this glacial lake, leads me to believe that the Red River Valley was uncovered by the recession of the ice-sheet and was occupied by this lake as far north as the latitude of Winnipeg and the south end of Lakes Winnipeg and Manitoba, while the ice still extended south on the west side of this valley to Devil's Lake and Turtle Mountain. The very abundant boulders noted on the east slope of the Pembina Mountain between Morden and Thornhill were probably deposited at this time on the east margin of this ice-lobe that reached south to Devil's Lake; and remarkable crescent-shaped moraines observed on the highest shore of Lake Agassiz in the southwest part of Walsh County, North Dakota, seem referable to the same time and manner of deposition.[1]

On the east slope of Pembina Mountain and southward.

The west side of this Dakota lobe of the ice-sheet during this and two or three earlier stages of its recession rested on Turtle Mountain, of which Dr. G. M. Dawson writes:—"It is a broken, hilly, wooded region, with an area of perhaps about twenty miles square, and slopes gradually upward from the plain around it, above which it is elevated, at its highest points, about 500 feet. . . . . Nearly all the abrupt slopes and ridges—of which there are many—show boulders in abundance, and these appear to be chiefly of Laurentian rocks. . . . The western is more abruptly hilly than the eastern side, and the more prominent ridges have a general northerly and southerly direction, with the intervening valleys characterized by swamps and lakes. Large areas of comparatively level or only gently undulated ground are however found in some places. The surface of the 'mountain' appears to be that of the drift, as deposited, and has been but little modified by subsequent sub-aerial action. The lakes lie in basin-like

Morainic drift on Turtle Mountain described by Dr. Dawson.

[1] Bulletin No. 39, U. S. Geological Survey, p. 61.

hollows, and notwithstanding their great number, drainage valleys and stream courses are few and unimportant."[1]

Stages in the recession of the ice-sheet west and north of Turtle Mountain.

The outermost moraine marking the farthest advance of the ice-sheet in the last glacial epoch passes along the Coteau du Missouri, crossing the international boundary in its northwestward course about a hundred and fifty miles west of Turtle Mountain. Between this Altamont moraine and the Fergus Falls and Leaf Hills moraines, which are probably contemporaneous with the great moraines close south of Devil's Lake and on Turtle Mountain, several distinct stages in the recession of the ice-sheet are recognizable by morainic deposits in Iowa, Minnesota, and South and North Dakota. The morainic drift of Turtle Mountain apparently represents two or three stages in the glacial recession, and in the country lying on the west and northwest numerous morainic belts will doubtless be found beyond the limits of my exploration.

Moraine of the Tiger, Brandon and Arrow Hills.

The moraine observed by me in southwestern Manitoba belongs to a time somewhat later than the great moraines of the Leaf Hills, the south side of Devil's Lake and Turtle Mountain; but it is believed to be contemporaneous with the accumulation of the boulders east of Thornhill and the moraines of southwestern Walsh County before mentioned, and with morainic hills on the north side of Devil's Lake. The most southern part of its observed course extends northerly from the east end of Turtle Mountain by Killarney to the northern part of Pelican Lake, a distance of about twenty-five miles. Thence it extends west-northwest twenty miles, forming the west part of the Tiger Hills in their extent along the north side of Lang's Valley and the Souris to T. 7, R. 19, where it again bends to the north and holds that course ten or twelve miles to the prominent Brandon Hills. Here again it turns to the west, making a sharp angle, but within a few miles it sinks to the general level of the adjoining country and loses its distinctive character. Proceeding onward to the west about twenty miles, this moraine is next found on the north side of the Assiniboine a few miles northwest of Griswold, and thence it takes a northwest course, lying mostly from five to eight or ten miles northeast of the Assiniboine and approximately parallel with it to the Arrow River and Bird Tail Creek, beyond which I have no definite information of its farther course. On both sides of the Arrow River it rises in prominent elevations, with characteristically rough contour and plentiful boulders, and this portion is called the Arrow Hills. The ascertained extent of this moraine, known in successive parts as the Tiger, Brandon and Arrow Hills, is about a hundred and twenty-five miles. Its general course is

[1] Report on the Geology and Resources of the region in the vicinity of the Forty-ninth Parallel, pp. 223, 224.

northwest, but within the Souris basin and that of the head streams of the Pembina, on the north side of Turtle Mountain, it is deflected about twenty-five miles to the northeast. The ice-sheet was there indented by two re-entrant angles, one having its apex in the range of the Tiger Hills near Poor's Lake, a few miles north of the north end of Pelican Lake, and the other in the Brandon Hills. A glacial lake, dammed by the ice-sheet and probably causing its indentations along the course of this moraine, then filled the Souris basin and outflowed around the south side of Turtle Mountain and Devil's Lake, being tributary to Lake Agassiz by the Sheyenne.

A conspicuous portion of this moraine was examined in sec. 19, T. 4, R. 16, two to three miles west of the middle of Pelican Lake. Here morainic hills rise 40 to 60 feet above the general level, their tops being 1,550 to 1,575 feet above the sea. A beautiful lakelet, about a quarter of a mile long and said to have a depth of fourteen feet, is enclosed by these hills near the center of the section. Their material is very gravelly till, not water-worn, about half of the small rock fragments being granite and half limestone. It also contains frequent, but nowhere abundant, granitic boulders up to two or three feet in diameter. This till, like that of the flat country north and northwest to Lang's Valley, and of the Tiger Hills beyond, includes only a very small proportion of gravel from the Fort Pierre shale. These roughly irregular hills and hillocks occupy a width of a half mile from east to west in sec. 19, and extend more or less noticeable in a narrower belt to the south-southwest at least five miles. Toward the north-northeast, beyond an interval of one mile of the plain like that on each side, consisting of a slightly undulating sheet of till, the moraine re-appears in hillocks and short ridges 20 to 40 feet high, becoming most prominent in sec. 32 of this township, near the verge of the southwestern bluff of Pelican Lake.

Sec. 19, T. 4, R. 16, west of Pelican Lake.

Within five miles northward from the north end of Pelican Lake, this moraine is typically developed around Poor's Lake, consisting of irregularly grouped hills, knolls and ridges of till, rising 50 to 100 feet above the intervening hollows, to 1,550 and 1,600 feet above the sea. Notman's Hill in sec. 15, T. 6, R. 16, is one of its outlying knobs on the north. On the southwest side of this morainic belt, Lookout Hill in sec. 2, T. 6, R. 17, affords a fine prospect of Pelican and other lakes, Lang's Valley, and the flat plain that rises thence slowly toward the Turtle Mountain. The morainic drift here spread over the western part of the Tiger Hills gives to this range more knolly and broken outlines than along most of its extent farther east, where its rounded massive hills of Cretaceous shale are only covered by a somewhat smooth sheet of till that commonly varies from a few feet to

West part of the Tiger Hills.

twenty feet in thickness. In contrast with this, along the western morainic portion of the range, extending from Notman's Hill and Poor's Lake west-northwest across the Souris, the thickness of the drift probably averages 100 to 150 feet.

Between Lang's Valley and Gregory's mill.

The road from Langvale post office, in Lang's Valley, to Gregory's mill on the Souris, five miles to the north, crosses this morainic belt of the Tiger Hills, which there is three to four miles wide and has a surface of many hills and short ridges, with typical morainic contour, rising in elevations mostly 20 to 50 feet above the intervening depressions. It is a half mile east from this road to the top of the Big Tiger Hill, which is the highest point of the entire range, about 1,640 feet above the sea, being nearly 300 feet above Lang's Valley. The elevation of the road on the west is about 1,525 feet, and of its highest place one and a half miles north-northwest of this hill, about 1,570 feet. All this portion of the range is till, but it has fewer boulders than are usually found on morainic areas, though they are probably twenty times as abundant as on the plain southward. Small rock fragments, rarely water-worn, are very abundant, nearly all Archæan granitoid gneiss and Palæozoic limestone in about equal proportions, with little or no shale. Looking west-northwest from the Big Tiger Hill, this belt of rolling morainic hills is seen extending ten miles along the northeast side of the Souris at an elevation of about 1,575 feet. South of the Souris and thence southeast to the moraine west of Pelican Lake, a vast flat expanse is seen rising slowly from an elevation of about 1,475 feet at its verge bordering the Souris and Lang's Valley to about 1,700 feet at the northern base of Turtle Mountain, which rises to 2,000 feet or more in the blue distance thirty miles south-southwest.

Big Tiger Hill.

Gorge cut by the Souris through the Tiger Hills.

In the central part of T. 6, R. 18, two miles west of the Big Tiger Hill, the Souris cuts through this moraine by a very picturesque gorge that extends four miles north from its Elbow. The stream in this distance descends approximately from 1,265 to 1,210 feet above the sea, its channel being in many places obstructed by boulders but having no considerable abrupt fall. The width of the gorge is a half mile to one mile between the tops of its steep sides, which rise in their highest portion 350 feet from the river to the crest of the morainic belt. In some places along the southern part of the gorge the Fort Pierre shale is exposed by recent erosion to a height of 100 feet or more above the river; but it has only low outcrops near Gregory's mill at the northern boundary of the moraine. The Souris there and through its next five or six miles northeast to Souris City has eroded its channel to a depth of about 140 feet in a smooth sheet of till, only reaching the underlying shale in a few places, without cutting deeply into it. This expanse of till has a descent of several feet to the mile, nearly the same as that of the Souris itself, toward the Assiniboine. Where its southern margin adjoins the moraine, in the vicinity of Gregory's mill, at an elevation of 1,350 to 1,360 feet above the sea, or 150 feet above the Souris, it is strewn with multitudes of granitic boulders up to eight or ten feet in diameter. Vicinity of Gregory's Mill.

From the west end of the Tiger Hills in the south part of T. 7, R. 19, this morainic belt curves to the north and is called the Brandon Hills, having through this township a characteristically knolly contour upon a width of four or five miles, with an elevation 1,450 to 1,500 feet above the sea. In the southeast part of T. 8, R. 19, the moraine rises to 1,550 and 1,600 feet, attaining about the same height as the most prominent cluster of these Brandon Hills, which lies a few miles farther north and northeast, in the northern part of secs. 31, 32, and 33, T. 8, R. 18. Viewed from the Souris and Assiniboine on the east and from Brandon on the north, this cluster of hills stands forth very conspicuously, having a steep ascent of about 250 feet from base to crest, which is 1,575 to 1,610 feet, approximately, above the sea. The most eastern ridge, running to the apex of the angle which the moraine makes here from a northern to a western course, is narrow and bounded by very steep slopes, having an osar-like form, with undulations of 20 to 30 feet along its crest, which extends about three fourths of a mile in a slightly crooked course to the N. or N. 10° E., having a height approximately 1,550 to 1,575 feet. The surface of this ridge consists of gravelly drift, principally not water-worn, with frequent but not very plentiful boulders up to five feet in diameter. About half of the small rock fragments are Archæan and half limestone, but nearly all the large boulders belong to the former. The highest portion of this hill cluster lies one to two miles west-northwest from the highest point of this ridge, and seen at that distance it appears as a similar ridge but with trend from east to west. Within the angle between these ridges the prospect to the southwest overlooks a very uneven tract of morainic knolls and small ridges irregularly grouped, having an elevation of 1,450 to 1,550 feet. In the northern part of T. 8, R. 19 and 20, the east to west morainic belt sinks and becomes indistinct from the adjoining country of undulating till which rises westward; and farther west, from Plum Creek to Griswold and the Assiniboine, it is concealed beneath delta deposits of sand. Brandon Hills.

On the north side of the Assiniboine this moraine again rises prominently in the west half of T. 10, R. 23, three to six miles west of Griswold. The channel eroded by the river here is about 200 feet deep, mainly or wholly in drift, the river being about 1,200 feet and the general surface on each side about 1,400 feet above the sea. In the first six miles north from the Assiniboine the moraine attains a North of the Assiniboine.

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height 50 to 100 feet or more above the adjoining country, the tops of its irregular hills and ridges being 1,450 to 1,550 feet above the sea. Thence this belt of drift hills, having an average width of three or four miles, continues northwest diagonally across T. 11, R. 24, the west half of T. 12, R. 24, and the northeast part of T. 12, R. 25, the south and west parts of T. 13, R. 25, and the east half of T. 13, R. 26. In the two townships last named its hills rise 100 to 150 feet above the country on the east and west; and from the name of the river which intersects it in the north edge of T. 13, this part of the moraine is known as the Arrow Hills. Farther northwest, where its continuation crosses Bird Tail and Snake Creeks, the surface, though not prominently hilly, is rough and unusually strewn with boulders.

Arrow Hills.

Extent of the glacial recession to this moraine.

Enough of this moraine is thus known to show that at the time of its formation the ice-sheet had so far retreated from its former western boundary on the Missouri Coteau as to uncover the entire length of the Qu'Appelle and the Assiniboine for nearly sixty miles below the mouth of that river, to Oak Lake. The significance of this will appear more fully on subsequent pages relating to the Saskatchewan and Souris glacial lakes, the latter of which extended at this time from the southern bend of the Souris in North Dakota to the Assiniboine and the lower Qu'Appelle.

Modified drift bordering Rainy River and the southwest part of the Lake of the Woods.

Modified drift, consisting of stratified gravel and sand, overlies the bed-rocks and the till, and generally forms the surface on an extensive area about the southwest part of the Lake of the Woods and along the Rainy River. Southward similar deposits cover large tracts in Minnesota, reaching to the lakes at the sources of the Mississippi and to the Leaf Hills, and thence southeastward to Minneapolis and Saint Paul. The contour of the greater part of these deposits is flat or moderately undulating, and their surface varies in height from a few feet to fifty feet or rarely more above the adjoining lakes and streams. In central Minnesota these tracts of gravel and sand have an elevation that increases from south to north, being 825 to 950 feet in the vicinity of Minneapolis and Saint Paul, rising gradually to 1,200 feet in the distance of about a hundred miles northwest to Brainerd, and ranging from 1,350 to 1,500 feet between the Leaf Hills and Itasca Lake. Thence their surface sinks to 1,150 and 1,075 feet in the vicinity of Rainy River and the Lake of the Woods. West of this lake gravel and sand cover most of the country for nearly seventy-five miles to the upper part of the Roseau, Rat, and Seine Rivers, declining in this direction to about 900 feet above the sea. Northwestward these deposits continue to a remarkable group of osars and small plateaus of gravel and sand, between 750 and 875 feet above the sea, seven to fifteen miles east-northeast of Winnipeg, of which Bird's Hill, beside

Its continuation south into Minnesota, and northwest to Bird's Hill, near Winnipeg.

the Canadian Pacific Railway, is the most western and one of the most conspicuous.

This broad belt of country, characterized by extensive gravel and sand deposits overlying the till, reaches from south-southeast to north-northwest about four hundred miles. From Red Lake in Minnesota north to the Rainy River, the Lake of the Woods, and the vicinity of Winnipeg, it lies within the area of Lake Agassiz. On each side this belt is bordered by areas of nearly the same general elevation which have mostly a surface of till; and it is to be remarked that the height of the tracts of modified drift and till are alike determined by that of the underlying rocks on which these superficial deposits are spread as a sheet of slight depth in comparison with the gradual change in their elevation. The drift sheet on this belt, including both the sand and gravel and underlying deposits of till, probably varies in its average thickness from 50 to 150 feet, while its central portion rises 400 to 600 feet above its south and north ends. Though the greater part of both the modified drift and till have only slight undulations, the former being often nearly flat and the latter moderately uneven, other portions are crossed by moraines which have a prominently knolly and hilly contour, rising usually 25 to 75 feet, or occasionally 100 to 200 feet, and in the Leaf Hills 100 to 350 feet, above the adjoining country. In some places the belts of morainic hills, consisting chiefly of till with abundant boulders, are bordered on one side by tracts of stratified gravel and sand which slope slowly downward from them and are merged in the extensive plains or moderately undulating areas of this modified drift, showing that a part of the gravel and sand was brought by streams that descended from the ice-sheet during the time of accumulation of its moraines. Besides these overwash slopes of modified drift, the morainic belts often include knolls, hillocks, and short ridges of sand and gravel, called *kames*, which seem to have been heaped up where such streams left their ice-walled channels and were spread out more widely, thereby losing their velocity and carrying power, upon the adjoining land surface. These deposits show that the lower part of the ice-sheet enclosed much drift material, denominated by Chamberlin *englacial drift*, from which the glacial streams gathered clay, sand, and gravel, and spread them beyond the border of the ice.

Adjoining areas of till and associated moraines.

Kames.

During the rapid melting of the ice in its times of retreat between successive moraines, the glacial streams attained their greatest extent and volume, and brought proportionately extensive deposits of modified drift, spreading it mainly in plains or moderately undulating tracts beyond the ice-margin, but here and there leaving prolonged ridges of gravel and sand, called *osars*, which were formed in their channels

Osars.

Deposition of the modified drift attributed to rivers flowing convergingly to this belt from the melting ice-sheet.

between walls of ice.* The distribution of the modified drift, thus found upon large tracts along a broad belt from Saint Paul to Winnipeg, while it is very scantily developed on a still wider region of Minnesota, North Dakota, and Manitoba southwest of this belt, and likewise is scanty or wanting on its northeast side in northern Minnesota and about the northeast and north portions of the Lake of the Woods, seems to be attributable to converging slopes of the surface of the ice-sheet and the consequent convergence of its currents, which brought an unusual amount of englacial drift into the ice along this belt, and by which also the streams produced in its melting were caused to flow thither from extensive areas of the ice on the east and west. The glacial striæ of these adjoining areas show that on the east the course of the motion, and the descent of the surface, of the ice-sheet were from northeast to southwest, but that on the west the glacial current moved, and the ice surface sloped, toward the southeast. On the east drift limestone is absent or very rare, because no limestone formations were crossed within several hundred miles by that part of the ice-sheet; but on the west the drift contains much fine limestone detritus, sand and gravel, and frequent boulders of limestone, borne southeastward from Manitoba over the Archæan area of the southwest part of the Lake of the Woods, of Rainy River, and of northern and central Minnesota. In the same directions with the slopes of the ice surface, which are known from the courses of the glacial striæ and the transportation of the drift, the streams of the glacial melting flowed convergently from the east and west, from the ice over northern Minnesota and eastern Manitoba on one side, and from that over the Red River Valley and western Manitoba on the other, toward this belt of plentiful superficial deposits of gravel and sand.

Group of osars northeast of Winnipeg.

Prominent osars begin at Bird's Hill, the first station of the Canadian Pacific Railway northeast of Winnipeg, from which it is seven miles distant, and extend thence seven or eight miles east-northeast and an equal distance southeast. The southern and southeastern portion of this group comprises many low ridges of gravel and sand five to fifteen feet high, trending from northwest to southeast; also somewhat rounded mounds, as Oak Hummock in the S. E. ¼ of sec. 12, T. 11, R. 4 E., which rises about thirty feet above the adjoining country, with its top approximately 810 feet above the sea; and occasionally a massive and conspicuous hill, as Moose Nose in secs. 29 and 30, T. 11,

* The discrimination of the two classes of gravel and sand deposits named thus *kames* and *osars* was advocated by W. J. McGee in the Report of the International Geological Congress, second session, Boulogne, 1881, p. 621; and by T. C. Chamberlin, in the Third Annual Report of the U. S. Geological Survey, for 1881-82, p. 299, and Am. Jour. of Science, III, vol. xxvii, May, 1884, p. 389. President Chamberlin shows that the latter term, in this Anglicized form, has long been in common use by Jackson, Hitchcock, Desor, Murchison, and other writers.

SECTIONS

ILLUSTRATING THE REPORT ON THE

GLACIAL LAKE AGASSIZ IN SOUTHERN MANITOBA.

BY WARREN UPHAM.

Fig. 1. Typical Section across a Beach Ridge of Lake Agassiz.

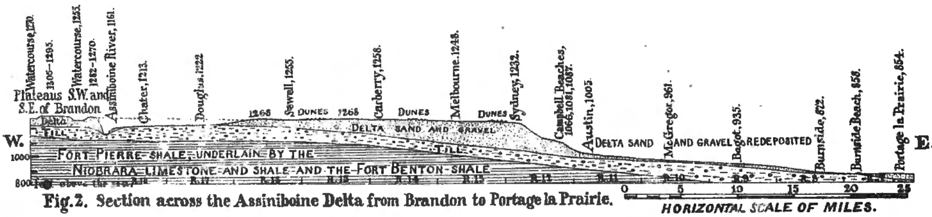


Fig. 2. Section across the Assiniboine Delta from Brandon to Portage la Prairie.

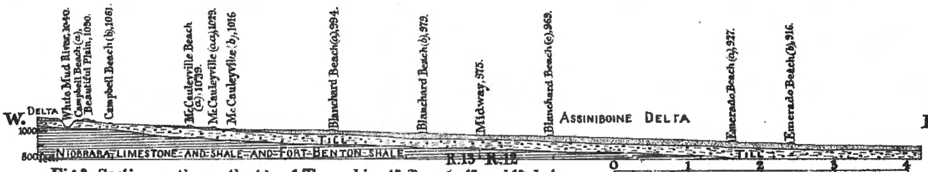


Fig. 3. Section on the south side of Townships 15, Ranges 13 and 12, between Arden and Gladstone.

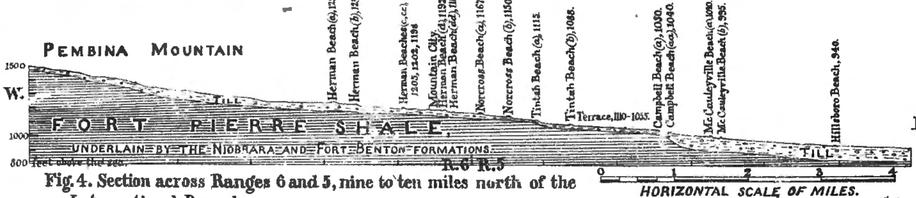


Fig. 4. Section across Ranges 6 and 5, nine to ten miles north of the International Boundary.

Fig. 5. Section on the International Boundary, Ranges 6 and 5.

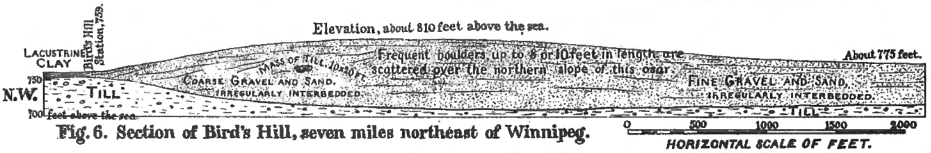


Fig. 6. Section of Bird's Hill, seven miles northeast of Winnipeg.

R. 5 E., which projects sixty feet above the average of the nearly flat country around it, rising to about 840 feet above the sea. Toward the north, in secs. 35 and 36, T. 11, R. 4 E., and again from sec. 2, T. 12, R. 4 E., through a distance of four miles east-northeast to sec. 9, T. 12, R. 5 E., these deposits of gravel and sand form plateaus a half mile to one mile wide, trending from west to east, elevated 820 to 850 feet above the sea and 40 to 60 or 75 feet above the adjoining low land, which on the north is a spruce and tamarack swamp about a mile wide and four miles long from east to west. Next to the north, these osars again rise in plateaus, ridges, and hills in secs. 19 to 22, T. 12, R. 5 E., culminating in Griffith's Hill in the N. E. ¼ of sec. 19, about 875 feet above the sea, or a little more than a hundred feet above the railway two miles distant on the west. This whole group of elevations is composed of gravel and sand, irregularly bedded, which appear to be deposits formed near the mouths of glacial rivers where they flowed between walls of ice and were here and there divided by ice islands, whose melting left these hills, ridges and plateaus bounded by moderately steep slopes and separated by intervening depressions. With the completion of the melting of the ice about and beneath these deposits, they sank to the bottom of Lake Agassiz, here about 500 feet deep; and the infrequent boulders that are found scattered upon their surface were dropped from floating ice. Toward the north, west, and southwest, they are bounded by the flat plain of the Red River Valley, 750 to 760 feet above the sea; while toward the east and southeast they are connected with plains and undulating tracts of gravel and sand which reach with slow and gradual ascent to the Lake of the Woods and into Minnesota. Submergence in Lake Agassiz.

An instructive section of Bird's Hill has been made in the excavation of its gravel and sand for railway ballast. This massive osar extends from the railway station about one mile east-southeast and thence a half mile southeast, beyond which it is connected by a low ridge with the plateau of secs. 35 and 36, T. 11, R. 4 E. Its width is a quarter to a half of a mile; and its maximum height, one third to two thirds of a mile from the station, is 45 to 50 feet above the railway and the flat plain that extends thence west. The elevation of Bird's Hill station is 759 feet, and of the crest of this hill 805 to 810 feet above the sea. It has a broadly rounded top, with gentle slopes on all sides. Along its northern slope an excavation reaches three fourths of a mile, varying in width from ten to twenty-five rods and in depth from ten to thirty feet. The top of the excavation is about twenty feet below the crest of the hill. As thus exposed to view, the greater part of this deposit is seen to be gravel, much of which is very coarse, containing pebbles and rock fragments of all sizes up to one and a half feet in Bird's Hill.

diameter, many of the smaller being well rounded, but the larger mostly angular with only slight marks of water-wearing. In some portions near the west end of this section no interbedding of coarser and finer layers of the torrential osar gravel is noticeable for ten feet or more vertically, the spaces between the large stones and cobbles being filled with finer gravel and sand. Imbedded in this coarse gravel on the south side of the excavation I noted a mass of ordinary till, unstratified boulder-clay enclosing gravel and boulders in a solid matrix of somewhat sandy clay, wholly bounded by definite but irregular outlines, its dimension vertically being about ten feet and its length twenty feet. No other mass of till, either of small or large size, was observed in this entire section. It probably was derived from the drift that was contained within the ice-sheet and finally overspread its surface when the greater part of the thickness of the ice was melted. From a sheet of drift thus deposited on the ice that formed the bank of the glacial river, this mass may have fallen into its channel. The eastern half of the section includes much fine gravel and sand irregularly interbedded, and along a considerable extent there the south side of the excavation from ten to twenty feet below its top is clear sand. Palæozoic limestones make up about three quarters of the gravel, the remainder being Archæan granites, gneiss and schists. Some two hundred boulders were found scattered upon the area of the excavation; and they occur with nearly the same frequency on other portions of this northern slope of the hill, but are rarely found on its top and southern slope. They vary in size from two to eight or ten feet in length; nearly all are Archæan, but a few of Palæozoic limestone, up to five feet in length, were observed. None were seen enclosed within the gravel and sand of the osar; and the workmen informed me that they occur only on or near the surface. This hill was covered by Lake Agassiz, and its boulders were doubtless dropped or stranded from bergs and floes on this lake, before the border of the ice-sheet had retreated from the vicinity. Indeed, the occurrence of the boulders chiefly on the northern slope seems to indicate that they were mostly stranded there while ice yet remained beneath this deposit and prevented its entire submergence in the lake. The thickness of this osar is at least nearly 100 feet; for a well 45 feet deep, dug at the bottom of the excavation was wholly in the same formation of gravel and sand. It is thus known to extend considerably below the level of the Red River Valley plain, which consists of fluvial and lacustrine clay underlain at a slight depth by till. A section across the osar and plain would show till abutting upon the edge of the gravel and sand, indicating that both the stratified osar and the upper part of the till were formed from englacial drift.

Mass of till imbedded in torrential gravel.

Boulders dropped or stranded from floating ice.

Thickness of this osar and its relation to the upper part of the till.

Smaller osar deposits were observed in Ts. 12 and 13, R. 1 E., ten to twenty miles northwest of Winnipeg. Beginning about three miles east of Rosser, a narrow and occasionally interrupted belt of osar gravel and sand, with frequent boulders scattered on the surface, extends northwest diagonally across secs. 10, 16, and 20, the northeast corner of sec. 19, and the southwest part of sec. 30, T. 12, and thence westward through sec. 25 of the next township. Its highest portions rise ten to twenty-five feet above the depressions of the moderately undulating surface of till on each side, and are 800 to 810 feet above the sea. Along a distance of about a third of a mile in sec. 30 it has the form and character of an ordinary beach ridge and is destitute of boulders. A similar low osar crosses secs. 12 and 14, T. 13, trending from southeast to northwest; and others occur in the vicinity of the Grosse Isle, a name applied to poplar groves in secs. 17 and 18 of this township and in secs. 12 and 13 of the next west. Osars north-west of Winnipeg.

From the east part of the Grosse Isle a notable osar, known as Burns's Ridge, runs north-northwestward across secs. 30 and 31, T. 13, R. 1 E, Five miles west of Stonewall a section of this little beach-like ridge was made in sec. 30 by the original line of the Canadian Pacific Railway, which was abandoned for the more southern route by way of Winnipeg. The osar is cut to a depth of eight feet by the railway and to twelve feet in an excavation on the south side of the railway grade. A well in the lowest part of this excavation goes four feet deeper, that is, sixteen feet below the crest of the ridge. The entire section consists of stratified gravel and sand, extending eight feet above and at least as far below the general level of the adjoining surface, and the visible width of the deposit is about thirty rods. How much deeper i tmay extend, perhaps with increasing width, is undetermined. Its gravel, which is nearly all limestone, contains pebbles up to six inches in diameter. No boulders occur in this excavation, and they are rare upon the surface of this and other such comparatively broad and high portions of this osar, none being sometimes seen along a distance of several rods; but in its narrower and slightly lower portions, as traced in its somewhat crooked course northward through the next one and a half miles, it often is found to be sprinkled with frequent boulders up to three or four feet in diameter, mostly Archæan. They appear to have been stranded as at Bird's Hill, immediately after the ice-walls enclosing the osar were melted or even during that process, and before the melting of the ice under this gravel and sand allowed the water of Lake Agassiz to submerge the more massive portions of the ridge. Only a small depth of water, probably not more than thirty or fifty feet at the most, would be required for this; and afterward the melting of the underlying ice gave to the lake here a depth of fully 500 feet. Burns's Ridge. Stranded boulders.

Farther to the north the osar sinks or is merged in the moderately undulating till which there forms the surface. The crest of this peculiar ridge, approximately 800 to 805 feet above the sea, undulates three to five feet within short distances, not showing so much uniformity in elevation and directness in its course as are characteristic of beach ridges; and it is the only instance observed in all my exploration of Lake Agassiz where a gravel formation nearly resembling a beach bears boulders on its surface. Not a single boulder has been anywhere found on or within the beaches of this lake; nor have osars like the Bird's Hill group or like these of smaller size and more stream-like courses been observed by me in any other part of this lacustrine area, excepting the vicinity of Red Lake in Minnesota. But osars doubtless exist here and there throughout the belt of modified drift that extends upon this area from Red Lake by the Lake of the Woods to Bird's Hill and Burns's Ridge; and probably they continue north-northwesterly upon the country between Lake Winnipeg and Shoal Lake.

HISTORY OF LAKE AGASSIZ.

Drainage from the receding ice-sheet.

During the recession of the ice-sheets of both the earlier and later epochs of glaciation, drainage from the ice-border in many places flowed in channels from which the streams became turned by the slopes of the land into more northern courses when this was permitted by the farther retreat of the ice. Where the slope is southward, free drainage from the melting ice took place along the present valleys, and these were partially filled with modified drift, remnants of which form terraces and plains on each side of the present streams. But on areas that sloped more or less directly toward the receding ice-border, the streams of that time eroded channels which were abandoned when lower outlets were uncovered. Because of the large supply of water from the glacial melting, some of these river-courses became conspicuous topographic features, as noted by Dawson,* McConnell,† and Tyrrell‡ in various parts of the region between Lake Agassiz and the Rocky Mountains. On a slope nearly parallel with the retiring ice-border, the deserted river-courses were seldom the outlets of lakes of considerable size; but where a large area was inclined toward the ice-sheet, it was covered by an expanse of fresh water, formed by the streams that flowed down from the melting ice surface and overflowing across what is now a line of water-shed between great drainage basins,

Deserted river-courses.

* Report on the Geology and Resources of the region in the vicinity of the Forty-ninth Parallel, pp. 263-265; Geological Survey of Canada, Report of Progress for 1882-83-84, p. 150 C.

† Geological Survey of Canada, Annual Report, vol. i, for 1885, pp. 21 and 74 C.

‡ Do., Annual Report, vol. ii, for 1886, pp. 43, 45 E, and 145, 146 E.

until the continued recession of the ice allowed the lake to be discharged by the natural slope of the land. Lake Agassiz was the largest of these glacial lakes. Others existed in the basins of the James, Souris, and Saskatchewan Rivers, of which the two last named outflowed eastward into Lake Agassiz. The basins of the great Laurentian lakes, which are being studied by Mr. G. K. Gilbert of the United States Geological Survey, were also filled at this time to higher levels than now, determined by the elevations of the outlets through which they then flowed southward to the Mississippi and finally eastward to the Mohawk and Hudson.*

Glacial lakes contemporaneous with Lake Agassiz.

In tracing the history of Lake Agassiz it will be needful to review the recession of the ice-sheet which was its northern barrier, as the stages of that recession are shown by the successive terminal moraines of Iowa, Minnesota, South and North Dakota, and Manitoba; to observe the stages of the lake itself which are recorded in its successive beaches; and to note the contemporaneous history of the glacial lakes on the west, whose outflow by the Sheyenne, Pembina, and Assiniboine brought large deltas into the western edge of Lake Agassiz and spread deposits of fine silt over extensive areas of its bottom.

Summary of the history of Lake Agassiz.

When the latest North American ice-sheet attained its greatest area, its southern portion from Lake Erie to North Dakota consisted of vast lobes, one of which reached from central and western Minnesota south to central Iowa. This Minnesota lobe in its maximum extent ended near Des Moines, and its margin was marked by the Altamont moraine, the first and outermost in the series of eleven distinct marginal moraines of this epoch which are recognizable in Minnesota. When the second or Gary moraine was formed, it terminated on the south at Mineral Ridge in Boone County, Iowa. At the time of the third or Antelope moraine, it had farther retreated to Forest City and Pilot Mound in Hancock County, Iowa. The fourth or Kiester moraine was formed when the southern extremity of the ice-lobe had retreated across the south line of Minnesota and halted a few miles from it in Freeborn and Faribault Counties. The fifth or Elysian moraine, crossing southern Le Sueur County, Minnesota, marks the next halting-place of the ice. At the time of formation of the fifth moraine, the south end of the ice-lobe had been melted back a hundred and eighty miles from its farthest extent, and its southwest side, which at first rested on the crest of the Coteau des Prairies, had retired thirty to

Recession of the Minnesota lobe of the ice-sheet from Des Moines to the Leaf Hills.

* "Changes of Level of the Great Lakes," by G. K. Gilbert, in The Forum, vol. v, pp. 417-428, June, 1888. Geol. Sur. of Canada, Report of Progress to 1863, pp. 910-915. C. Whittlesey, "On the Fresh-water Glacial Drift of the Northwestern States," 1864, pp. 17-22, in Smithsonian Contributions, vol. xv. J. S. Newberry, in Report of the Geological Survey of Ohio, vol. ii, 1874, pp. 50-65, with three maps. "The Lake Age in Ohio," by E. W. Claypole, pp. 42, with four maps, Trans. of the Geol. Soc. of Edinburgh, 1887.

fifty miles to the east side of Big Stone Lake and the east part of Yellow Medicine County, Minn. During its next stage of retreat this ice-lobe was melted away from the whole of Le Sueur County, and its southeast extremity was withdrawn to Waconia in Carver County, where it again halted, forming its sixth or Waconia morine. The seventh or Dovre moraine marks a pause in its recession when its southeast end rested on Kandiyohi County. Probably nearly all of the southern half of Minnesota was at this time divested of its ice-mantle, while nearly all of the northern half was still ice-covered. By its next recessions the glacial border was withdrawn to the eighth or Fergus Falls moraine, and the ninth or Leaf Hills moraine. These are merged together in the prominent accumulations of the Leaf Hills, which lie in southern Otter Tail County, Minnesota, reaching in a semicircle from Fergus Falls to the southeast, east, and northeast, a distance of about fifty miles, and marking the southern limits of this ice-lobe when it terminated half-way between the south and north borders of Minnesota.* The south part of Lake Agassiz probably began to be uncovered by the retreating ice-sheet between its stages marked by the Waconia and Dovre moraines; and this lake reached northward from Lake Traverse 100 to 125 miles along the Red River Valley when the Fergus Falls and Leaf Hills moraines were accumulated.

On the west side of Lake Agassiz the Dakota lobe of the ice-sheet, from its junction with the Minnesota lobe near the head of the the Coteau des Prairies, twenty-five miles west of Lake Traverse and Brown's Valley, at first reached about 200 miles south along the valley of the James or Dakota River to Yankton and the Missouri; but it was gradually diminished in its extent until, at the times of formation of the Kiester, Elysian, Waconia, and Dovre moraines, it no longer retained its lobate outline. While these moraines were being formed in Minnesota, the southwestern boundary of the ice-sheet in South and North Dakota passed from the vicinity of Big Stone Lake and Lake Traverse northwesterly along moraine belts that have been traced through Sargent, Ransom, Barnes, and Griggs Counties, North Dakota, and by the sources of the James and Sheyenne Rivers. During the later stages represented by the Fergus Falls and Leaf Hills moraines, the Dakota ice-front appears to have become again lobate, extending from the west shore of Lake Agassiz southward and then westward and northward, between the lake area and the Sheyenne River, to the prominent and typical moraines that are found south of Stump and Devil's Lakes, on the Big Butte, about Broken Bone Lake and north-

Recession of the ice-sheet in South and North Dakota from Yankton to the south side of Devil's Lake.

* For detailed descriptions of these moraines, and of the recession of the ice-sheet in this State, see Geology of Minnesota, vols. i and ii.

ward, and on Turtle Mountain. In their remarkable development these moraines are similar to the massive Leaf Hills, with which they seem to have been contemporaneous.

Tract of till crossing the Red River Valley.

The course of the ice front where it formed the northern barrier of Lake Agassiz, at the time of its accumulation of these great moraines of the Leaf Hills and the south side of Devil's Lake, is marked by morainic deposits both east and west of the lake near the latitude of 47° 10′, which passes twenty miles north of Fargo; by an unusual abundance of boulders near this latitude and farther north on portions of the till forming each side of the lacustrine area; and by a tract of till which stretches across the Red River Valley at Caledonia, constituting the bed and banks of the river along the Goose Rapids. In the lake this morainic till was spread with a generally even surface, but it has many small inequalities, the higher portions being three to five feet or rarely ten feet above adjoining hollows. Boulders and gravel are plentiful on its surface, this being the only interruption of the lacustrine and alluvial clayey silt which elsewhere continuously occupies the central part of this valley plain from near Breckenridge to Winnipeg.

Eastward course of the ice-border at the time of the Leaf Hills moraine.

Toward the east the ice-sheet at this time had receded from the southwest part of Lake Superior, which was held about 500 feet higher than now and overflowed to the Saint Croix and Mississippi Rivers by the way of the Bois Brulé River and Upper Saint Croix Lake. It seems nearly certain also that the ice-border continued across Green Bay and the north part of Lake Michigan; and further east, I think that it probably crossed southwestern Ontario and the central or northern portions of New York, Vermont, New Hampshire, and Maine.. The Laurentian lakes were dammed by the retreating glacial barrier and overflowed at the lowest points on their southern water-shed.

The Itasca moraine correlated with that of the Tiger, Brandon, and Arrow Hills.

During the formation of the tenth or Itasca moraine, crossing the lake region at the head of the Mississippi, the ice-sheet bounding Lake Agassiz probably extended thence northward, passing not far west of Red Lake and the Lake of the Woods, to the vicinity of Winnipeg, the Bird's Hill group of osars being perhaps deposited at the angle where this boundary of the ice-sheet turned back southwestward. In that course it seems to have reached across the lake area to the boulder-strewn escarpment of the Pembina Mountain east of Thornhill, and beyond to have passed south along the west shore of Lake Agassiz into North Dakota, to Pilot Knob in sec. 5, T. 154, R. 56, thence westward to the north side of Devil's Lake, and thence north-northwestward by the east part of Turtle Mountain and along the moraine of the west part of the Tiger Hills and of the Brandon and Arrow Hills.

The eleventh or Mesabi moraine, well developed in northeastern

Minnesota, is probably represented by morainic accumulations north of Pokegama Falls of the Mississippi, about Bowstring Lake, the head of the Big Fork of Rainy River, east of the Narrows between the south and north parts of Red Lake, and on the east part of the Tiger Hills. Lake Agassiz had contemporaneously a length of more than 300 miles, from Lake Traverse to near the south end of Lake Winnipeg. Later moraines, formed at times of halt or re-advance, interrupting the recession of the ice-sheet between northern Minnesota and Hudson Bay, have not been determined; but I believe that they exist and await discovery when the glacial drift of that wooded and very scantily inhabited region shall be fully explored.

Glacial melting on the area of Lake Agassiz during the formation of the highest Herman beach.

The highest of the Herman beaches of Lake Agassiz extends in Minnesota, as traced in this survey, to the north side of Maple Lake, twenty miles east-southeast of Crookston, and probably it continues thence into the forest region on the east, where it is impracticable to follow its course, to the vicinity of Red Lake; and on the west side of Lake Agassiz it reaches through North Dakota and at least fourteen miles into Manitoba, terminating on the northern part of the Pembina escarpment somewhere between Thornhill and its northern end, that is, between fourteen and forty miles north of the international boundary. Before the formation of this beach was completed, the ice-sheet had retired from the lake area as far north as the beach extends. During pauses of this glacial recession the Dovre, Fergus Falls, Leaf Hills, and Itasca moraines were formed, showing a northward retreat of the ice-border across a distance of about 150 miles in central Minnesota and 150 to 200 miles in North Dakota and southern Manitoba, with a maximum of probably not less than 300 miles in the Red River Valley, where Lake Agassiz would doubtless cause a more rapid melting of the ice-margin. Through this time the River Warren eroded a channel about fifty feet deep, approximately from 1,100 to 1,050 feet above the sea, or perhaps it eroded only the lower half of that depth, in the moderately undulating sheet of till which reached across the present valley of Lakes Traverse and Big Stone. The shortness of the time probably occupied in the formation of the beaches of Lake Agassiz may well astonish us in what it implies concerning the rapidity of the recession of the ice-sheet, and the brevity, geologically speaking, of the stages of pause or re-advance when its moraines were accumulated.

Southwestern shore near Milnor first uncovered from the ice.

The retreat of the ice seems to have uncovered the southwest border of Lake Agassiz earlier than its shores farther north and on its east side, as is shown by the Milnor beach, a less distinct shore deposit than the Herman beach and 20 to 25 feet above it, which was observed near Milnor, North Dakota, and along a distance of about ten miles thence north-west to the Sheyenne, but was not recognized farther north nor in Minnesota. The formation of the Sheyenne delta had begun at this time of the Milnor beach, and continued through the time of the Herman beach, with which latter the Buffalo, Sand Hill, Pembina, and Assiniboine deltas were also contemporaneous. The departure of the ice from the Red River Valley seems to have been too rapid to permit the accumulation of definite shore deposits on the borders of Lake Agassiz, excepting the scanty Milnor beach derived from the Sheyenne delta, until its outlet was cut down to the level of the Herman beach, which probably represents a time of much slower erosion of the outlet, due to diminished glacial melting and smaller volume of the outflowing stream.

Compared with the level of the present time, the highest Herman beach has a gradual ascent from south to north which averages nearly a foot per mile, amounting to about 175 feet in the 224 miles from the mouth of the lake at its southern end to the international boundary. The mouth of the lake was then about 1,055 feet, and its surface on the international boundary about 1,230 feet, above the present sea level. It is further found that in the northern part of the explored area of Lake Agassiz this upper or Herman beach, which is single along the southern part of the lake, becomes divided into numerous parallel beaches that were formed at intervals of pause in a progressing elevation of that area. A portion of these relative changes of level, however, was due to a subsidence of the lake itself toward the north, on account of the diminution of its attraction by gravitation toward the ice-sheet, proportionate with the decrease of the ice in its final melting. As many as six other Herman stages below the highest are recognizable by beach deposits, which indicate a rise of the land combined with a sinking of the lake to the amount successively of about 8, 10, 7, 15, 10, and 5 feet, or in total 55 feet, on the line between North Dakota and Manitoba, while yet the relative elevations of the lake and the adjoining land along its southern part for some seventy-five miles northward from Lake Traverse remained with only slight changes, not sufficient for the formation of any secondary beach ridge.

Northward ascent of the Herman beaches.

In a later part of this report the discussion of the causes of these changes in the height of the land and of the lake is accompanied by a table of the present elevations of the successive beaches formed by the lake on its west side through its entire existence, until it was drained to the levels of Lakes Manitoba and Winnipeg. The two highest beaches (*a* and *aa*) in the Herman series of this table were not found north of the Pembina Mountain escarpment; but the next two (*b* and *bb*) are well developed at Brandon and near Neepawa, reaching thus to the northern limit of my exploration at the south end of Riding Mountain. During the interval between these Herman beaches *a* and *b*, the combined rise of the land and fall of the lake were only eighteen or twenty feet on the international boundary; but in this time the southern end of the ice-lobe west of the lake had been withdrawn from the east part of the Tiger Hills to Riding Mountain, and the Assiniboine delta was being rapidly deposited. The northward extent of Lake Agassiz in its subsequent Herman stages is not definitely determined, but evidently some of the upper beaches observed by Mr. Tyrrell on the foot slopes east of the escarpments of Riding and Duck Mountains belong to this series, the highest, according to information supplied by him, being in lat. 51°52′ or two hundred miles north of the international boundary, at an elevation of about 1,460 feet above the sea.

Extent of Lake Agassiz in its Herman stages north to Riding and Duck Mountains.

The foregoing observations show that the ice-sheet was melted away from at least half of the area of Lake Agassiz during its Herman stages. In the ensuing Norcross, Tintah, Campbell and McCauleyville stages, through which the lake continued to outflow southward by the River Warren, the recession of the ice doubtless permitted it to extend north and east beyond Lake Winnipeg and along the lower valley of the Saskatchewan. Each of these stages is represented by two or three beaches in northern Minnesota and North Dakota and in southern Manitoba, which, with the seven beaches of the Herman series, make seventeen shore lines recognizable in that part of the lacustrine area belonging to the time of its southern outlet. Between the Herman and Norcross beaches the channel of the River Warren was eroded about 25 feet; it was deepened 15 to 30 feet more at the time of the Tintah beaches; 10 to 20 feet farther down to the Campbell beaches; and again 10 to 20 feet to the McCauleyville beaches. In all, the mouth and southern end of the lake were lowered about 100 feet between the highest Herman beach and the lowest McCauleyville beach. Proceeding northward, the vertical distance between these beaches gradually increases to 240 feet on the international boundary, the difference of 140 feet more than the depression caused by erosion of the outlet being attributable to the northward rise of the land and subsidence of the water-level.

Later stages of the lake while it outflowed southward.

Before Lake Agassiz could obtain an outlet to the northeast, the thick ice-sheet that had filled the basin of Hudson Bay was so far melted as to admit the sea, which at first covered the land west of James Bay 350 to 500 feet above the present sea level. Eleven stages of Lake Agassiz are marked by beaches that lie below the beds of Lakes Traverse and Big Stone, which were the channel of the River Warren when the lake ceased to outflow to the south. These beaches are separated by vertical intervals that vary from 10 to 45 feet through the range of elevation between the lowest McCauleyville beach and Lake Winnipeg, which was originally twenty feet higher than now.

Stages of north-eastern outflow.

As soon as the ice upon Hudson and James Bays and the adjoining country had so receded as to give to Lake Agassiz an outlet lower than the River Warren, it began to be drained in that direction, perhaps flowing at first across the water-shed between the Poplar and Severn, and later along lower courses, including the canoe route by the Hill and Hayes Rivers. Each of its successive outlets was probably eroded to a considerable depth, being occupied by the outflowing river during the time of formation of two or more beaches, until the retreat of the southeastern border of the portion of the ice-sheet remaining west of Hudson Bay finally permitted drainage to take the course of the Nelson, the ice-dammed Lake Agassiz being thus changed to Lake Winnipeg. The northeastern outflow commenced when the lake at the latitude of the south end of Lake Winnipeg stood about 1,000 feet above the present sea level, and it was gradually lowered to 730 feet when the Nelson between its successive lakes began to erode the shallow channel of the upper part of its course.

Fossils have been found in the deposits of Lake Agassiz at two localities. They are all fresh-water shells of species now living in this district, occurring in beach ridges where excavations have been made to obtain sand for masons' use. The Campbell beach, about six miles southwest of Campbell, Minnesota, at an elevation approximately 985 feet above the sea, has thus yielded shells of *Unio ellipsis*, Lea, a common species of the upper Mississippi region. In the Gladstone beach, a half mile northeast of Gladstone, Manitoba, about 875 feet above the sea and 165 feet above Lake Winnipeg, four species occur in considerable abundance from two to four feet below the surface, namely, *Unio luteolus*, Lamarck, *Sphærium striatinum*, Lam., *Sphærium sulcatum*, Lam., and *Gyraulus parvus*, Say. These species from both localities were kindly determined by Prof. R. Ellsworth Call, who states that *Unio luteolus* is one of the most widely distributed representatives of the genus, its range being from Lake Winnipeg to Texas, east to New York, and west to Montana. It is generally abundant in Minnesota. Both these species of *Sphærium* are reported by Dr. Dawson from the Lake of the Woods and Pembina River; and the first is the most common species of its genus in Minnesota, while its range northward extends at least to Great Playgreen Lake and York Factory, where it has been collected by Dr. Bell. The Campbell beach was formed in the later part of the time of the lake's southward outflow; and the Gladstone beach belongs to the middle portion of the time of its outflow toward the northeast, its south end being then about 85 miles south of the international boundary.

Molluscan fauna of Lake Agassiz.

Evidences of man's presence in this region during the departure of the ice-sheet have been discovered by Miss Franc E. Babbitt at Little

Falls in central Minnesota. A stratum containing many artificially chipped fragments of quartz is enclosed there in the modified drift of the upper Mississippi Valley, which was deposited by the floods supplied from the melting ice-sheet in its retreat while it was being withdrawn from northern Minnesota and the Red River Valley.* It seems probable therefore that men lived on the shores of Lake Agassiz and witnessed the erosion of the channel of the River Warren, the gradual lowering of the lake level and reduction of its area, and its later northeastward outflow to Hudson Bay. But this is not left wholly to conjecture, for Mr. Tyrrell informs me that in northwestern Manitoba, at an elevation of 1,135 feet above the sea, he has found sharp-edged fragments of quartzite, chipped by human workmanship, interbedded with the rounded gravel of one of the Campbell beaches.†

Traces of men contemporaneous with the glacial recession and Lake Agassiz.

If the question be asked how many thousand years ago did the recession of the ice-sheet take place, causing Lake Agassiz to fill the Red River Valley and the basin of Lake Winnipeg, a reply is furnished by the computations of Prof. N. H. Winchell,‡ that approximately 8,000 years have elapsed during the erosion of the postglacial gorge of the Mississippi from Fort Snelling to the Falls of Saint Anthony; of Dr. Andrews,‖ that the erosion of the shores of Lake Michigan, and the resulting accumulation of dune sand drifted to the southern end of that lake, cannot have occupied more than 7,500 years; of Professor Wright,§ that streams tributary to Lake Erie have taken a similar length of time to cut their valleys and the gorges below their water-falls; of Mr. Gilbert,** that the gorge below Niagara Falls has required only 7,000 years or less; and of Prof. B. K. Emerson,†† on the rate of deposition of modified drift in the Connecticut Valley at Northampton, Massachusetts, from which he believes that not more than 10,000 years have elapsed since the glacial period. An equally small estimate is also

Measurements of time since the last glacial epoch.

* Proceedings of Am. Assoc. for Adv. of Science, vol. xxxii, 1883, pp. 385-390; American Naturalist, vol. xviii, pp. 594-605, and 697-708, June and July, 1884; and Proc., Boston Soc. of Natural History, vol. xxiii, 1888, pp. 421-449.

† Preliminary notes of this discovery, and of the northwestward continuation of the beaches of Lake Agassiz in the district of Riding and Duck Mountains, are included by Mr. Tyrrell in a paper, "On the Superficial Geology of the Central Plateau of Northwestern Canada," read before the Geological Society of London, Nov. 7, 1888, of which an abstract is given in the Geological Magazine, III, vol. vi, pp. 37-38, Jan., 1889.

‡ Geology of Minnesota, Fifth annual report, for 1876; and Final report, vol. ii, pp. 313-341. Quart. Jour. Geol. Soc., vol. xxxiv, 1878, pp. 886-901.

‖ Transactions of the Chicago Academy of Sciences, vol. ii. James C. Southall's Epoch of the Mammoth and the Apparition of Man upon the Earth, 1878, chapters xxii and xxiii.

§ Am. Jour. Sci., III., vol. xxi, pp. 120-123, Feb., 1881; The Ice Age in North America, 1889, chapter xx.

** Proceedings, Am. Assoc. for Adv. of Science, vol. xxxv., for 1886, p. 222. "The History of the Niagara River," Sixth An. Rep. of Commissioners of the State Reservation at Niagara, for 1889, pp. 61-84.

†† Am. Jour. Sci., III., vol. xxxiv, pp. 404-5, Nov., 1887.

indicated by the studies of Gilbert * and Russell † for the time since the last great rise of Lakes Bonneville and Lahontan. These measures of time, surprisingly short whether we compare them on the one hand with the period of authentic human history or on the other with the long record of geology, carry us back to the date when the ice-sheet of the last glacial epoch was melting away from the basins of the upper Mississippi, of the Red River of the North, and of the Laurentian lakes.

Duration of Lake Agassiz compared with that of Lake Michigan, as indicated by shore erosion and beach deposits.

The entire departure of this ice-sheet therefore probably occupied at the most not more than two or three thousand years; and half of this time may measure the duration of Lake Agassiz, with the formation of its beaches marking more than twenty-five successive stages in the concurrent subsidence of its surface and rise of the earth's crust, which amounted together to 700 feet on the latitude of the north part of Duck Mountain and the middle of Lake Winnipeg. But even these short estimates may be too long. The shores of Lake Michigan, similar with those of Lake Agassiz in the drift of which they are formed, in their north and south trends, and in the adjoining depths of water, have suffered an amount of erosion by the lake waves during postglacial time which very far exceeds the total erosion that was effected upon the shores of Lake Agassiz during all its stages, the proportion between them being surely not less than ten to one; and Lake Michigan has a similarly greater amount of beach deposits, which upon a large area about its south end are raised by the wind in conspicuous dunes. This contrast indeed suggests that the duration of Lake Agassiz, and the recession of the ice-sheet from Lake Traverse to the lower part of the Nelson River, may have been included within less than one thousand years.

Glacial lake in the basin of the Blue Earth and Minnesota Rivers.

Before Lake Agassiz began to exist, the receding Minnesota and Dakota ice-lobes had each given place to a large lake on the central part of the area from which they withdrew. By the barrier of the Minnesota ice-lobe a lake having an elevation of about 1,150 feet above the sea was formed in southern Minnesota in the basin of the Blue Earth and Minnesota rivers, outflowing southward by way of Union Slough to the East Fork of the Des Moines. In its maximum extent this lake probably had a length of 160 miles, from Waseca to Big Stone Lake, with a width of forty miles in Blue Earth and Faribault Counties, attaining an area of more than 3,000 square miles. The continued glacial recession afterward opened lower outlets eastward to the Cannon River, and at the time of the Waconia moraine had uncovered the lower part of the Minnesota Valley, permitting the lake to

* U. S. Geological Survey, Second annual report, p. 188.

† U. S. Geological Survey, Monograph XI, Geological History of Lake Lahontan, p. 273.

be wholly drained northeastward to the Mississippi.* The modified drift from the retreating ice on the upper Minnesota basin was deposited along the lower half of this valley, filling it with stratified gravel, sand and clay, to a depth 75 to 150 feet above the present river from New Ulm to its mouth, which shows that at least this portion of the valley was excavated in the sheet of till during the interglacial epoch, and remained with nearly its present form through the later glaciation. It seems also probable that the upper part of the channel above New Ulm, occupied by the River Warren at the time of the Herman beaches, remained from such interglacial erosion, so that the first outflow from Lake Agassiz was at a level some twenty-five feet below the general surface adjoining Lakes Traverse and Big Stone and Brown's Valley, being thus approximately marked by the Milnor beach.† As long as streams poured into this valley directly from the melting ice-sheet, its modified drift, gathered from the ice in which it had been held, continued to increase in depth; but when the ice had retreated beyond the limits of the Minnesota basin, the water discharged here from Lake Agassiz brought no modified drift, and was consequently a most powerful eroding agent. By this River Warren the valley drift, so recently deposited, was mostly swept away, and the channel was excavated to a depth lower than the present river. But since Lake Agassiz began to outflow northeastward, the Minnesota Valley and that of the Mississippi below, carrying only a small fraction of their former volume of water, have become considerably filled by the alluvial gravel, sand, clay and silt, which have been brought in by tributaries, being spread for the most part somewhat evenly along these valleys by their floods.‡

Modified drift of the Minnesota Valley.

Erosion by the River Warren.

Prof. J. E. Todd supplies me the approximate outline of a lake named by him Lake Dakota, which occupied the valley of the James or Dakota River contemporaneously with the foregoing, reaching from Mitchell 170 miles north to Oakes and varying from 10 to 30 miles in width.|| It outflowed southward by the present course of the James to the Missouri. The Dakota ice-lobe, which had filled this valley and in its recession formed the northern shore of Lake Dakota, was not therefore the cause of this lake in the same way that the lake in the Blue Earth and Minnesota basin and Lake Agassiz owed their

Lake Dakota, outflowing southward to the Missouri River.

* Geology of Minnesota, vol. i, pp. 460, 622, 642.

† Compare with Geology of Minnesota, vol. i, pp. 479-485, describing the chains of lakes in Martin County, Minnesota, which are apparently due to interglacial water-courses that were not wholly filled with drift in the last glacial epoch.

‡ "The Minnesota Valley in the Ice Age," Proc. Am. Assoc. for Adv. of Science, vol. xxxii, 1883, pp. 213-231; also in Am. Jour. Sci., III, vol. xxvii, Jan. and Feb., 1884.

|| This lake is partially mapped by Prof. Todd in Proc. Am. Assoc. for Adv. of Science, vol. xxxiii, 1884, p. 393.

existence to the barrier of the ice-sheet in its retreat. The bed of Lake Dakota has a nearly uniform elevation of 1,300 feet, or is within ten feet below or above this, throughout its length; and during the glacial recession it was covered by a lake whose shores have now a height of about 1,300 to 1,350 feet, probably ascending slightly from south to north, as compared with the present sea level. Professor Todd states that the surface of this lacustrine area in its southern part, from Mitchell to Redfield, is nearly flat till, but thence northward is sand and lœss-like silt, while considerable tracts of the eastern border of its north part consist of low dunes.

The outflowing James River was cutting down its channel during the retreat of the ice-lobe, and its erosion was so rapid as to prevent the northern part of Lake Dakota from retaining sufficient depth to outflow eastward into the south end of Lake Agassiz when the way was opened by the further departure of the ice, receding from the Head of the Coteau des Prairies and beginning to uncover the Red River Valley. A large tract of the sand and silt beds of Lake Dakota, and of a contiguous glacial lake formed in Sargent County, North Dakota, at the time of the Dovre moraine, now sends its drainage to the Red River by the head stream of the Wild Rice, which passes north of the Head of the Coteau and enters the area of Lake Agassiz near Wyndmere. The lowest portion of the water-shed on this lacustrine deposit, over which the James River would flow east to the Wild Rice River is scarcely ten feet above the general level of the James Valley or twenty-five feet above the present level of the James River, being at Amherst on the Aberdeen branch of the Saint Paul, Minneapolis and Manitoba Railway, 1,312 feet above the sea. The elevation of the upper portion of the lake beds in the vicinity of Oakes, and the lack of evidence that the lake waves have acted at any greater height upon the adjoining surfaces of undulating till and morainic hills, lead to the conclusion that the highest shore line of the north end of Lake Dakota is not more than 1,345 feet above the sea, showing that there was only a shallow expanse of water above the plain of lacustrine silt. On the north the depth of the channel of the inflowing James River, eroded apparently before the glacial retreat could permit an eastward outlet into Lake Agassiz, indicates that the surfaces of land and water in the James Valley had gained nearly their present relations, Lake Dakota being already drained away, when the Wild Rice River and the south end of the Red River Valley were uncovered by the recession of the ice-sheet. It is evident, therefore, that the long area of Lake Dakota has experienced only slight differential changes of level, at least in the direction from south to north, since the departure of the ice. The James River Valley is thus strongly contrasted with the northward

Less change of level on the area of Lake Dakota than of Lake Agassiz, since the departure of the ice.

uplifting that has affected the Red River Valley as shown by the beaches of Lake Agassiz, the highest of which rises from south to north about six inches per mile for 30 or 40 miles at its south end, but a foot or more per mile within 40 miles farther north, and indeed has an average northward ascent of about one foot per mile through an extent of 400 miles along the west side of this lake in North Dakota and Manitoba.

Lakes of the Saskatchewan and Souris, outflowing to Lake Agassiz by the Sheyenne.

As Lake Agassiz gradually extended to the north, following the receding ice-barrier, it received successively by three outlets the drainage of the glacial lakes of the Saskatchewan and Souris basins. These streams took the course of the Sheyenne, Pembina, and Assiniboine Rivers, each bringing an extensive delta deposit. With the first retreat of the ice from the Missouri Coteau a glacial lake began to exist in the valley of the South Saskatchewan in the vicinity of the Elbow, probably outflowing at an early time by the way of Moose Jaw Creek, and through a glacial lake in the upper Souris basin, to the Missouri near Fort Stevenson. Later the outflow from the Lake Saskatchewan may have passed to the Lake Souris by way of the Wascana River, after passing through a glacial lake which probably extended from Regina sixty miles to the west in the upper Qu'Appelle basin. When the Dakota ice-lobe was melted back to the vicinity of Devil's Lake, the drainage of Lake Souris passed southeast by the Big Coulée, one of the head streams of the Sheyenne, flowing thence for some time southward by the James River to Lake Dakota, but later eastward and southward by the Sheyenne into Lake Agassiz. A manuscript report of a reconnoissance in North Dakota by Major W. J. Twining, in 1869, describes the valley of the Big Coulée as 125 feet deep and a third of a mile wide, enclosing several shallow lakes along its course. "This great valley," he writes, "preserves its character to within twelve miles of the Mouse [Souris] River, and connects through the clay and sand ridge with the open valley of that stream."

Big Coulée.

The Sheyenne delta, formed partly of modified drift, and partly of alluvium from erosion of the Sheyenne Valley.

The Sheyenne delta, reaching from the Lightning's Nest fifty miles northwest to the south bend of the Maple River, and having a maximum width of nearly thirty miles to the northeast from the south bend of the Sheyenne, probably covers an area of 800 square miles to an average depth of 40 feet. A large portion of this delta is doubtless modified drift, which was brought down by glacial streams from the melting surface of the ice-sheet, their coarser gravel with much sand being deposited in the high plains that slope southward along the outer side of the great moraines that pass south of Devil's Lake, their finer gravel and sand being carried by the Sheyenne to this delta, and their finest silt and clay being spread in the quiet water of the lake over a much larger adjoining area of its bed, from near Breckenridge northward beyond the mouth of the Sheyenne. Much alluvium was also supplied from the erosion of the Sheyenne Valley, which, with that of the Big Coulée, probably averages three fourths of a mile in width and 150 feet in depth along a distance of 200 miles. This channel is cut in the drift sheet, mainly till, and in the underlying easily eroded Cretaceous shales. The volume of the material supplied from it would be equal, according to these estimates, to about three fourths of the Sheyenne delta, or perhaps to three eighths of both the delta and the finer clayey sediments that were deposited farther out in the lake. But the valley of the Sheyenne was doubtless also both a preglacial and an interglacial valley. It was probably wholly filled with till in the first glacial epoch, then was eroded, chiefly in this drift, to nearly its present size during interglacial time, and was partially but perhaps not wholly refilled with till in the last epoch of glaciation. If it retained in considerable degree its trough-like form beneath the last ice-sheet, as was evidently true of the Minnesota Valley, its erosion and its tribute to the Sheyenne delta would be less than the proportion estimated.

Alluvium deposited along the central part of the Red River Valley after the drainage of Lake Agassiz.

When the bed of Lake Agassiz was gradually uncovered from the water of the receding lake, some parts of its central plain through which the Red River flows probably remained as broad shallow basins of water, which that river and its tributaries have since filled with their fine clayey alluvium. The similar clayey silt brought into Lake Agassiz by its delta-forming affluents, the Buffalo, Sand Hill, Sheyenne, Pembina, and Assiniboine Rivers, and others farther north, had been spread over large areas of the lake bed, but more extensive portions had a surface of till, with no such lacustrine deposit. Over these formations, much alluvium has been laid down along the avenues of drainage of the old lake bed, and it has filled depressions of the original surface, whether of lacustrine sediments or of till, being only distinguishable from the former by its containing in some places shells like those now living in the shallow lakes of the country adjoining the area of Lake Agassiz, remains of rushes and sedges and peaty deposits, as of the present marshes of the Red River Valley, and occasional branches and logs of wood, such as are floated down by streams in their stages of flood. Thus the occurrence of shells, rushes and sedges in these alluvial beds at McCauleyville, Minnesota, 32 and 45 feet below the surface, or about 7 and 20 feet below the level of the Red River, of sheets of turf, many fragments of decaying wood, and a log a foot in diameter at Glyndon, Minnesota, 13 to 35 feet below the surface, and numerous other observations of remains of vegetation elsewhere along the Red River Valley in these beds, demonstrate that Lake Agassiz had been drained away, and that the valley was a land surface, subject to overflow by the river at its stages of flood when these remains were deposited.* Even at the present time much of the area of stratified

* Geology of Minnesota, vol. ii, pp. 529, 530, 663-4, and 668-9.

clay that almost continuously forms the central part of the valley plain is covered by the highest floods, and probably no portion of it is more than ten feet above the high water line of the Red River and its tributaries. The position of the thick beds of fine silt and clay in the central depression of the Red River Valley shows that they were not mainly deposited by the waters of Lake Agassiz, which must have spread them somewhat equally over both the lower and higher parts of the lacustrine area; but instead appears to prove that at least their upper and greater part was brought by the rivers which flowed into this hollow and along it northward after the glacial lake was withdrawn.

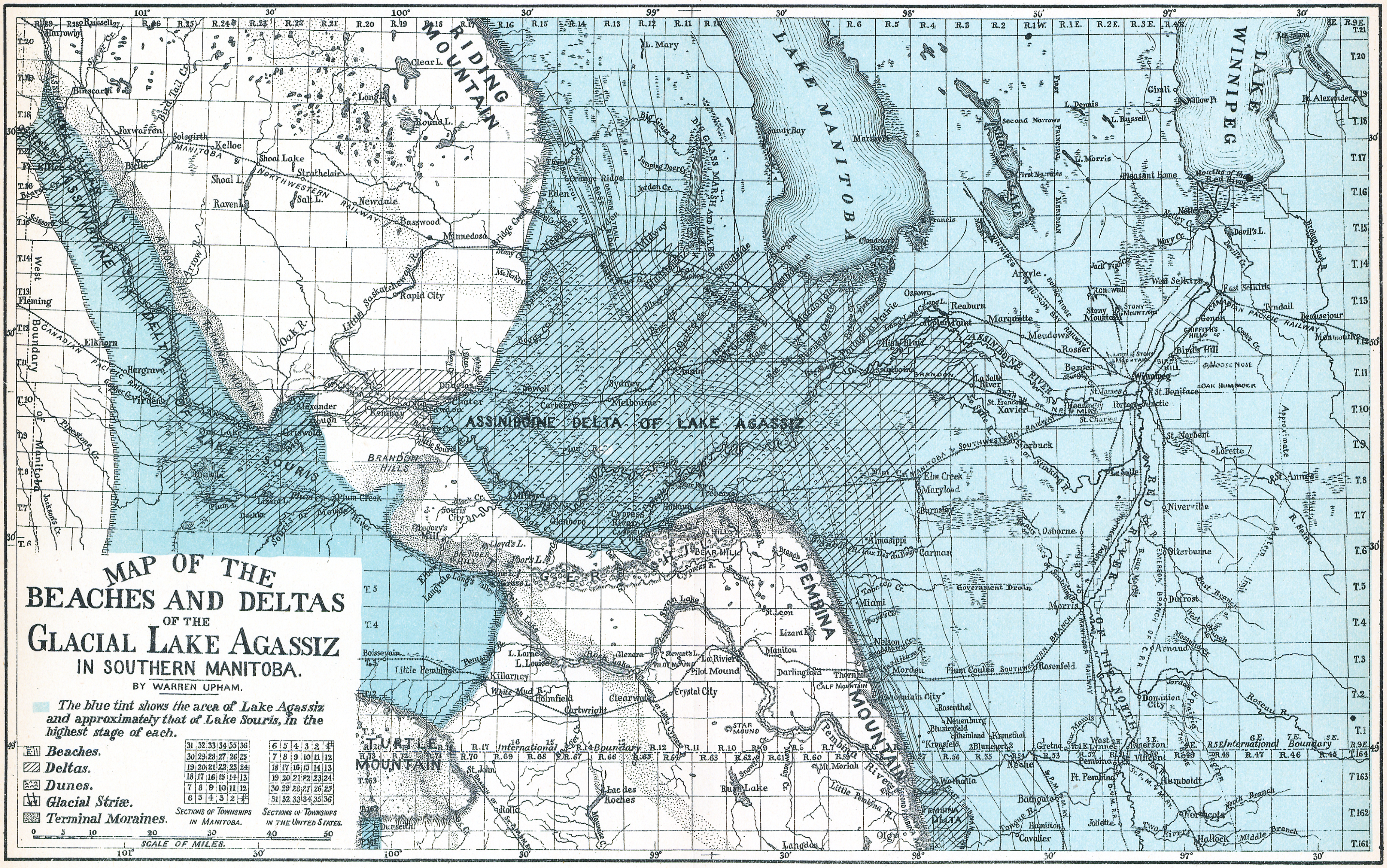
BEACHES AND DELTAS.

Size and material of the beaches.

A brief general description of the beach ridges of Lake Agassiz has been given on page 12 E, their usual height being there stated to be from three to ten feet above the adjoining land on the side that was away from the lake, and ten to twenty feet above the adjoining land on the side where the lake lay, their varying breadth between the bases of the slopes being from ten to thirty rods. The beach ridge is thus a broad wave-like swell, with a smooth gracefully rounded surface. Like the shore accumulations of present lakes and of the sea coast, these of Lake Agassiz vary considerably in size, having in any distance of five miles some portions five or ten feet higher than others, due to the unequal power of waves and currents at these parts of the shore. The usually moderate slope of the land toward Lake Agassiz was favorable for the formation of beach ridges, and they occur at many successive levels, marking pauses in the gradual elevation of the land and subsidence of the lake. The highest distinct beach ridge of Lake Agassiz has been traced in a continuous course along a distance of more than four hundred miles in Minnesota, South and North Dakota, and Manitoba. In calling it continuous, I mean to say that whenever interrupted, as through its having been carried away by streams or where portions of the lake shore received no beach deposits, it is found a little distance farther along, beginning again at very nearly the same height. Commonly the land upon each side of the beach ridges of Lake Agassiz is till or unstratified clay, containing some intermixture of sand and gravel and occasional stones and boulders. The material of the beach ridge is remarkably in contrast with this adjoining and underlying till, for it includes no clay, but consists of stratified sand and gravel, the largest pebbles being usually from two or three to six inches in diameter.

Their formation by wave action.

The action of the waves gathered from the deposit of till, which was the lake bed, the gravel and sand of its beaches; and corresponding


MAP OF THE
BEACHES AND DELTAS
OF THE
GLACIAL LAKE AGASSIZ
IN SOUTHERN MANITOBA.
BY WARREN UPHAM.
The blue tint shows the area of Lake Agassiz and approximately that of Lake Souris, in the highest stage of each.
Beaches.
Deltas.
Dunes.
Glacial Striæ.
Terminal Moraines.
SECTIONS OF TOWNSHIPS IN MANITOBA.
SECTIONS OF TOWNSHIPS IN THE UNITED STATES.
SCALE OF MILES.
0 5 10 20 30 40 50
ASSINIBOINE DELTA OF LAKE AGASSIZ
LAKE MANITOBA
LAKE WINNIPEG
RIDING MOUNTAIN
PEMBINA MOUNTAIN
TURTLE MOUNTAIN
BRANDON HILLS
PEMBINA DELTA
DELTA OF LAKE SOURIS
International Boundary
Winnipeg
Brandon
Portage la Prairie
Selkirk
Emerson
Pembina
Morden
Manitou
Carman
Morris
Minnedosa
Rapid City
Virden
Killarney
Boissevain
Pilot Mound
Crystal City
Cartwright
Walhalla
Neche
Cavalier
Langdon
101°
100°
99°
98°
97°

deposits of stratified clay, derived from the same erosion of the till, sank in the deeper part of the lake. But these sediments were evidently of small amount and are not noticeable upon the greater part of this lacustrine area, which consists of a smoothed sheet of till. Where the beaches cross delta deposits, especially the fine silt and clay that lie in front of the delta gravel and sand, they are indistinctly developed or fail entirely. On the other hand, the most massive and typical development of beach ridges is found on areas of till that rise with a gentle slope of ten or fifteen feet per mile. No boulders referable to transportation by floating ice have been found within or upon any of the beach deposits of this lake.

Absence of boulders.

When Lake Agassiz formed its first and upper beach, its outlet was about 85 feet above the present surface of Lake Traverse, or 1,055 feet above the sea. The channel which at this time had been excavated in the drift by its outflow was 40 to 50 feet deep along the distance of about fifty miles, where are now Lake Traverse, Brown's Valley, and Big Stone Lake. This beach is crossed by the Breckenridge line of the Saint Paul, Minneapolis & Manitoba Railway at a point about one and a half miles northwest of Herman, Minnesota, from which place it is denominated the Herman beach.

The upper or Herman beach.

At the next epoch after that of the upper or Herman beach, when the lake level in its southern part was again nearly stationary long enough to form a ridge of gravel and sand upon its shore, the outlet had been eroded about 25 feet deeper than at the time of the upper beach, but was still 60 feet above the present Lake Traverse and Brown's Valley. The beach of Lake Agassiz, when it had this lower level, is crossed by the Breckenridge railway line at Norcross, Minnesota, five miles northwest of Herman; and it is therefore named the Norcross beach.

Norcross beach.

The next two series of beach deposits were formed when the outlet of Lake Agassiz had been lowered respectively, for the first, 15 to 30 feet, and for the second, 40 to 50 feet below its level at the time of the Norcross beach. These beaches take their names from Tintah and Campbell, Minnesota, the next two stations northwest of Norcross on the Breckenridge railway line.

Tintah and Campbell beaches.

The fifth and lowest beach of Lake Agassiz, while it outflowed to the south, was formed after a further erosion of 20 feet, lowering the outlet to 960 feet above the sea, and completing the excavation of its channel to the present beds of Traverse and Big Stone Lakes. My first observation of this beach was three and a half miles northeast of McCauleyville, Minnesota, about fifteen miles north of Breckenridge. It is therefore named the McCauleyville beach. Five distinct series of beach ridges of gravel and sand were thus formed by Lake Agassiz at

McCauleyville beach.

successive stages of height during its process of deepening the channel by which it outflowed southward.

Northward ascent and subdivision of these beaches.

Tracing these beaches to the north, they are found to have a gradual ascent in that direction, diminishing in amount from the highest and earliest to the lowest and latest; and the single beach ridges of the south part of the lake are found to be represented northward by two or three or several parallel beaches. Accordingly, in the following descriptions of the beach ridges observed in Manitoba, those are grouped together which seem to represent the stages of the lake that southward were combined respectively in the Herman, Norcross, Tintah, Campbell and McCauleyville beaches. The Herman beach at the north is thus more or less clearly subdivided into seven, the Norcross and Tintah beaches each become double, and the Campbell and McCauleyville beaches each become threefold; so that seventeen stages are recorded in the elevation of the northern part of the area of Lake Agassiz and in the northward subsidence of the water level, belonging to the period of outflow southward by the River Warren.

Beaches formed while Lake Agassiz outflowed northeastward.

Eleven lower beaches were formed while Lake Agassiz outflowed to Hudson Bay; and these are named from localities in North Dakota and Manitoba. The first three are called the Blanchard beaches, and the next three are successively the Hillsboro, Emerado, and Ojata beaches, from towns in North Dakota near which they are well developed; while the remaining five receive their names from Manitoba, being in descending order the Gladstone, Burnside, Ossowa, Stonewall, and Niverville beaches. The rate of their northward ascent is only about a sixth or an eighth as much as that of the first Herman beach. In all these stages, excepting the lowest one when the Niverville beach was formed, Lake Agassiz extended south of the international boundary.

BEACHES OF THE HERMAN STAGES.

In T. 1, R. 5.

The west shore of Lake Agassiz enters Manitoba two miles west of the east line of range five, at a distance of thirty-six miles from the Red River. On the international boundary and for the next ten miles northward the shores of the highest stages of the lake were on the steep wooded escarpment of the Pembina Mountain, the base of which here is 1,100 to 1,150 feet above the sea, rising slightly northward, and the verge of its top 1,300 to 1,400 feet. This ascent, forming the steep face of the Pembina Mountain, is made upon a width of about a quarter of a mile.

Where the Pembina Mountain plateau is ascended by the Southwestern Branch of the Canadian Pacific Railway, and for a distance of about four miles south and two miles north of this railway, the principal line of escarpment is replaced by a moderate slope which is chiefly prairie. Across this tract the Herman beaches of Lake Agassiz are well developed. In order proceeding northward, the first point of examination of the highest beach was near William H. Oakley's house in the south edge of the S.W. ¼ of sec. 26, T. 2, R. 6. It is here a massive rounded ridge of gravel and sand, with descent of twelve to fifteen feet in a distance of as many rods both to the east and west from its crest, which is 1,253 feet above the sea. Northward this beach, with similar outline, extends to Francis J. Parker's house, which is built on its crest, having there also a height of 1,253 feet, in the north edge of the N.W. ¼ of this section. Westward from this beach is an undulating surface of till with few boulders. Half a mile farther north the beach is intersected by the deep and broad ravine of Dead Horse or Cheval Creek. Beyond this ravine the beach begins near Samuel B. Bowen's house. Its elevation one to one and a half miles north-northwest of Mr. Bowen's is 1,255 to 1,259 feet, and it is there spread more broadly than usual, having a nearly flat surface on a width of twenty to thirty rods, bordered on the east by a descent of ten or fifteen feet in twenty rods, and on the west by a descent of about four feet. The beach is gravel and sand, with till on each side. It has nearly the same features also a third of a mile farther north, near the center of sec. 10, T. 3, R. 6, where it is crossed by the road from Morden to Thornhill, the elevation of its crest being 1,258 feet, but the depression on the west is reduced to only one or two feet. In the same section this and lower beach ridges are excavated beside the railway for ballast, and are found to consist of sand and gravel with pebbles seldom exceeding two or three inches in diameter. About half of the pebbles are light gray magnesian limestone, and about half Cretaceous shale, such as forms the Pembina Mountain, with only a small proportion derived from Archæan rocks. Thence the highest shore continues north through the east part of secs. 16 and 21, T. 3, R. 6, and in sec. 28 comes to the steep escarpment of Pembina Mountain, with which it coincides along the next thirty miles north-northwest. The elevation of this beach shows that it is the continuation of the highest in the series of Herman beaches in Minnesota and North Dakota.

Highest beach in Ts. 2 and 3, R. 6.

About a quarter of a mile east of the foregoing is a parallel beach fifteen to twenty feet lower, the second in the Herman series. Newton Lane's house, next east of Mr. Oakley's, is built on its crest, 1,237 feet above the sea. It there has a descent of fifteen feet or more within an eighth of a mile to the east; but on the west the descent is only one or two feet or in part wanting, and a nearly level surface of sand and gravel reaches west to the upper beach. In sec. 10, T. 3, R. 6, at the road from Morden to Thornhill, this second Herman beach has a height

Second Herman beach, in Ts. 2 and 3, R. 6.

of 1,241 feet, and another beach at 1,247 feet lies between this and the highest, indicating similar conditions in the fall of the lake level as on the northwest side of Maple Lake in Minnesota, where such an intervening beach also occurs.

Third Herman beach, Ts. 2 and 3, R. 6.

Three small parallel beach ridges referable to the third stage in the Herman series are crossed in the west part of sec. 24, T. 2, R. 6, by the road leading northwest from Mountain City. The elevation of their crests is 1,198, 1,202, and 1,205 feet. Two miles farther north, near the center of sec. 35 in the same township, William Miller's house is built on the highest of these, at an elevation of about 1,210 feet. His well, sixteen feet deep, is gravel and sand to the depth of twelve feet, with till below. Northward these beaches are traceable through secs. 2, 11, 15, and the south part of 22, T. 3, R. 6, to Bradshaw's Creek, beyond which they pass, with the other Herman and Norcross beaches, along the Pembina Mountain escarpment.

Fourth Herman beach, Ts. 2 and 3, R. 6.

The fourth Herman beach passes through Mountain City, in sec. 24, T. 2, R. 6, the post-office and the south end of the principal street being on its crest, at 1,191 to 1,192 feet. Twenty-five rods farther east at the school-house is a less conspicuous parallel beach, at 1,183 to 1,184 feet. Both are terrace-like in form, having a descent of three to five feet or more on the east but only one to two feet or none on the west. The continuation of this shore was also observed, like the preceding, through a distance of six miles northward.

Pembina Mountain from Thornhill to Treherne.

From sec. 28, T. 3, R. 6, the Herman shores of Lake Agassiz coincide with the prominent escarpment of the Pembina Mountain through a distance of twenty-nine miles, passing in a nearly straight course north-northwesterly to sec. 30, T. 7, R. 8, about seven miles east-southeast from Treherne. Along this distance the base of the escarpment is 1,100 to 1,125 feet above the sea, and its crest about 1,400 feet. Seen from this elevation, the great plain of the Red River Valley on the east, when overshading clouds give to it in the distance a dark blue or azure color, appears not unlike the vast expanse of the ocean as viewed from an equal height a few miles inland. The highest shore of the glacial lake was about half-way up this ascent, and the lower Herman beaches and those of the Norcross stage were between this and the base.

Sec. 36, T. 7, R. 9.

At the north end of the Pembina Mountain the Herman shores of Lake Agassiz turned from a northward to a westward course, and at the sharpest portion of this bend, in sec. 36, T. 7, R. 9, the currents along the shore, caused by storms, brought a large amount of gravel and sand from their erosion on each side, and accumulated these deposits in a massive ridge which juts out north-northwesterly a mile or more from the curving line of the escarpment. This gravel and sand spit sinks from nearly 1,300 feet above the sea at its south end where it rests on the adjoining highland to about 1,125 feet, comprising deposits of the successive Herman, Norcross, and Tintah stages of the lake.

Vicinity of Treherne.

Five to six miles farther west the Herman beaches are well exhibited in the gradual ascent that rises to the Tiger Hills one mile south of Treherne. The highest beach here crosses the middle of the N.W. ¼ of sec. 31, T. 7, R. 9, where it forms a swell of sand and gravel, with pebbles mostly of Cretaceous shale, having its crest 1,272 to 1,273 feet above the sea. In some portions this reaches nearly flat an eighth of a mile south to the base of the Tiger Hills, but elsewhere it is divided from them by a depression of three to five feet. This appears to be the second (*b*) in the series of Herman beaches, the first of this series (*a* and *aa*) not being found here nor farther north. At the time when that uppermost beach of Lake Agassiz was formed, this locality and the country northward are believed to have been covered by the ice-sheet, its termination being at the tract of morainic drift which overspreads the east part of the Tiger Hills, as crossed in T. 7, R. 9, by the road to the south from Treherne. About twenty and fifty rods north of the beach just described, two inconspicuous beach lines, terrace-like sand and gravel deposits, are found at 1,266 and 1,254 feet, referable to subdivisions (b^1 and *bb*) of the second Herman stage. A little farther north the third Herman beach is represented at Irvine Scarrow's house in the south edge of sec. 6, T. 8, R. 9. This is a slight terrace with crest at 1,243 and 1,244 feet and descent of four or five feet on its north side. Mr. Scarrow's well on this beach, 31 feet deep, consists of black soil, 2 feet; interbedded sand and clay, 10 feet; very coarse shale gravel, 5 feet; beds of coarse and fine gravel and sand, 13 feet; and very hard dark bluish till at the bottom, dug into only 1 foot. This well shows an accumulation of shore drift to a depth of thirty feet, swept out by the currents of the lake from the curve where its beaches turned westward. About an eighth of a mile north of Mr. Scarrow's another beach, also referable to the third Herman stage, descends from 1,236 and 1,238 feet at its crest to 1,230 feet at the base of its northward slope. At the summit of the Manitoba & Southwestern Railway a mile east of the Little Boyne River, and on the slope thence eastward, very massive beach deposits are accumulated, due apparently to the same action of northwestward currents from the northern end of the Pembina Mountain. The summit of the railway is on such a beach, 1,217 to 1,220 feet above the sea, the fourth in the Herman series, forming a broad swell from which a gentle slope falls on its northeast and southwest sides. Arthur Willett's well here goes to a depth of 42 feet in beds of sand and gravel, obtaining a plentiful supply of good water from their lower portion, without reaching their bottom. A fifth of a mile farther east the railway cuts a beach ridge with its crest at 1,211 feet, also referable to the fourth Herman stage.

The Assiniboine delta occupies the western border of Lake Agassiz from Treherne westward about sixty miles to Brandon and thence northeastward about thirty-five miles to Neepawa. The shore of the lake along these distances is not generally marked by a definite beach ridge, the absence of which seems to be accounted for chiefly by the extreme shallowness of the lake upon the delta, so that powerful waves were not driven ashore by storms. The course of the highest shore between Treherne and Brandon, belonging to the time of the second Herman beach, passes first west-southwest along the foot of the Tiger Hills to the north and west side of Campbell's Hill in sec. 4, T. 7, R. 12; thence southwest and south to the Cypress River near Grange post-office in sec. 18, T. 6, R. 12; thence west-northwestward to Oak Creek and along the south side of this creek, within a mile or less from it, nearly to its mouth; and, crossing the Souris in sec. 31, T. 7, R. 16, passes thence northwest to Brandon. Beyond the Cypress a belt of till, moderately undulating or in part nearly flat, from two or three to ten miles wide, separates this lake shore from the northern border of the Tiger Hills and the eastern and northern base of the Brandon Hills. S. Martin's house, in the N.E. ¼ of sec. 28, T. 8, R. 17, about fifteen miles southeast of Brandon, is built on a small beach ridge of sand and gravel extending from southeast to northwest, only slightly below the highest stage of the lake, which is marked by a moderately sloping parallel escarpment, about ten feet high, eroded in till a half mile southwest of this beach. The unusually smoothed surface of the till extending thence west and south to the Brandon and Tiger Hills, on the area crossed by the Souris in its course from Gregory's mill to the mouth of Black Creek, is probably attributable to the deposition of its upper portion in a body of water held between these hills and the northwardly retreating ice-sheet before this area was drained to the level of Lake Agassiz by the retreat of the ice from the east part of the Tiger Hills and the north end of the Pembina Mountain.

Highest shore from Treherne to Brandon.

In the south part of the city of Brandon the second Herman beach, marking the stage *bb* of the table in a subsequent part of this report, is a well defined ridge of sand and gravel along a distance of about a mile. It extends from east to west, passing an eighth of a mile north of the court house, and thence close along the south side of Lorne Avenue from First to Fourth Streets. Between Fourth and Sixth Streets it is crossed by this avenue, and thence westward lies close on its north side. Its structure is shown by sections where it is intersected by Tenth, Eleventh and Twelfth Streets, exposing a thickness of ten feet of obliquely bedded sand and gravel containing abundant pebbles up to

Second Herman beach, Brandon.

two inches and rarely cobbles three or four inches in diameter, about two-thirds being Palæozoic magnesian limestones, from one-tenth to one-fourth Cretaceous shale, and the remainder mostly Archæan granites and schists. This beach ridge varies from ten to twenty rods in width and from five to ten feet or more in height, having a smoothly rounded wave-like form. The elevation of its crest near the court house ranges from 1,260 to 1,269 feet above the sea, and at Eleventh and Twelfth Streets it is 1,260 to 1,261 feet. No distinct beach ridge of the slightly higher Herman *b* stage of Lake Agassiz was found in the vicinity of Brandon, but evidence of the lake level in that stage is afforded in the southeast part of Brandon by the delta plateau of coarse gravel and sand at the court house and eastward, which is 1,270 to 1,282 feet above the sea, and by an old water-course crossed three to four miles west of Brandon on the road to Kemnay, both of which are more fully noticed in the description of the Assiniboine delta.

North of the Assiniboine the highest shore of Lake Agassiz passes from Brandon east and east-northeast by Chater and Douglas, being on or close below the verge of the plateau of till, overspread by delta gravel and sand, which lies close north of the Canadian Pacific Railway. About a mile north of Douglas station this shore is marked by a dune hillock, nearly at the middle of the line between sections 10 and 11, T. 11, R. 17. Thence its course is north-northeastward, and is indicated by an eroded escarpment, extending two or three miles with a height of ten to fifteen feet, and less distinctly observable a few miles beyond. The base of this escarpment where it crosses the south line of sec. 24 in this township is 1,269 feet above the sea; and the surface at the school-house a sixth of a mile farther west is about twenty feet higher. All the area eastward is delta sand and gravel; but the escarpment and the country rising thence slowly northwestward are till. The continuation of this line between a moderately rolling surface of till on the west, with plentiful boulders and frequent lakelets, and the slightly undulating sand and gravel delta on the east, with low dunes on many parts of its area, passes north-northeasterly in range sixteen across the west half of T. 12 and the east half of T. 13, and thence north through the eastmost tier of sections in T. 14, to Stony Creek. It evidently marks, at least approximately, the highest shore of the glacial lake; but it bears no distinct beach ridge nor line of erosion, partly because the lake was so shallow on the adjoining delta area, and partly because the prevailing trends of the inequalities in the till surface run nearly from east to west, transverse to the course of the shore currents and drift by which beaches would be formed, thus intercepting the scanty deposits of beach gravel and sand in their hollows, instead of permitting them to be accumulated in a distinct ridge.

Highest shore from Brandon to Neepawa.

Near Neepawa. The Manitoba & Northwestern Railway crosses two beach ridges at three and three-fourths miles and three miles west of Neepawa, the crests of which are respectively 1,323 and 1,304 feet above the sea. These elevations indicate that they belong to subdivisions of the second Herman stage, in the same manner that this stage is represented by three beach lines at Treherne. Each of these ridges has a height of about seven feet above the adjoining surface, and a width of thirty to forty rods. They consist of sand and gravel, and the railway company has therefore purchased a considerable tract occupied by the lower one of them for its excavation and use as railway ballast. This lower beach probably marks the same lake level as the beach observed at Brandon, having there an elevation of 1,260 to 1,269 feet. Gravel and sand brought into Lake Agassiz by Stony Creek seem to have contributed to the conspicuous development of beach deposits here, while they are wanting or less distinct upon most of the shore southward to Brandon and also northward through the next twelve miles to where the Herman and Norcross shores pass into the steep escarpment that forms the eastern face of Riding Mountain.

BEACHES OF THE NORCROSS STAGES.

East of Mountain City and Thornhill. Through T. 1, R. 5, the Norcross shores of Lake Agassiz lie on the escarpment of the Pembina Mountain; and the first observations of their beaches were in secs. 7, 18 and 19, T. 2, R. 5, where the mountain wall is reduced to a gradual ascent in the vicinity of Mountain City and Thornhill. About a half mile southeast of Mountain City the upper Norcross beach is well displayed at John Borthwick's house, which is built on its crest, 1,167 feet above the sea, in the southwest corner of sec. 19. Digging for wells here shows that the gravel and sand of the beach extend only to a depth of six or eight feet, there resting on the Fort Pierre shale. From the crest of this beach ridge its slopes fall eight or ten feet within a few rods on the east and about four feet on the west. It is bordered on the west at this locality by a surface strewn with very abundant boulders up to five feet or rarely more in diameter, nearly all being Archæan granites, with perhaps a third of one per cent. magnesian limestone. Generally, however, the surface in this vicinity has few or no boulders; and a shallow depth of ordinary till or of lacustrine deposits overlies the Cretaceous shale. The second Norcross beach, also forming a distinct ridge, lies a third of a mile farther east, with its crest about 1,150 feet above the sea. A large excavation for sand to be used in plastering has been made in this ridge, in the south edge of this sec. 19. A mile farther south John W. Stodders' house is built on it at an elevation of 1,148 feet. His well, twelve feet deep, passes through gravel and sand, eleven feet; and then enters the shale, the top of which, to a depth of six to twelve inches, is a hard calcareous layer, including nodules and veins of calc spar. Pieces of the hard surface of this layer, thrown out of the well, were plainly marked with glacial striæ. The continuation of these beaches is traceable through the next seven miles northward across the Southwestern Branch of the Canadian Pacific Railway, passing about three miles east of Thornhill, to Bradshaw's Creek, beyond which to near Treherne they again coincide with the Pembina Mountain escarpment.

About one and a half miles east of the Little Boyne River near Treherne the Manitoba & Southwestern Railway cuts the upper Norcross beach ridge, the crest of which is 1,195 feet above the sea, with a descent of about five feet on the west and ten feet on the east. A half mile farther east it cuts the lower Norcross beach, with its crest at 1,167 feet, from which there is a descent of ten feet to the west and fifteen feet to the east. This beach has been extensively excavated for ballast, a spur track being run along its course a quarter of a mile northwestward from the railway. The excavation, varying along this distance from six to eight rods in width and from five to fifteen feet in depth, shows that the ridge is composed of interbedded sand and gravel, the layers of sand constituting about half of the entire deposit. The gravel layers differ in coarseness from those that contain no pebbles more than one or two inches in diameter to others containing water-worn masses of shale a foot across and Archæan cobbles six inches in diameter. By estimate, nearly nine tenths of the gravel is the hard Fort Pierre shale which makes up the principal mass of the Pembina Mountain, the Tiger Hills, and Riding Mountain, this shale gravel being often almost unmixed with other material; about a twentieth part consists of two classes of limestones, derived in nearly equal proportions from the yellowish gray, arenaceous limestone of Niobrara age, plentifully fossiliferous, which outcrops beneath this shale on the Boyne and Assiniboine Rivers, and from the Palæozoic limestones of the flat country about Lakes Manitoba and Winnipeg; and the remaining twentieth is from the Archæan rocks that lie east and north of Lake Winnipeg. Continuing northwesterly and northerly, this massive beach ridge crosses secs. 8 and 17, and the eastern edge of sec. 19, T. 8, R. 9, beyond which it is lost sight of on the undulating and partly windblown surface of the Assiniboine delta.

Near Treherne.

The next definite observations of the Norcross shores of this lake are near Neepawa, where the Manitoba & Northwestern Railway a half mile west of this station crosses small beach ridges referable to the upper Norcross stage, with their crests 1,223 to 1,225 feet above the sea. Close to the west is an eroded escarpment of till fifteen feet high, rising from 1,225 to 1,240 feet. On the other side of the station, between a half mile and one mile east from it, the railway crosses a surface of wind-blown sand with hollows two to four feet deep, the crests of its low dunes being at 1,193 to 1,192 feet. These occupy the level belonging to the lower Norcross beach. The bed of the railway here, formed of the sand of the Assiniboine delta, further worn and redeposited by the lake waves, proves somewhat insecure because of its liability to be channelled by the wind. The road leading northward from Neepawa to Eden and Riding Mountain runs on the crest of the upper Norcross beach ridge through the east part of secs. 21 and 28, T. 15, R. 15, three to five miles north of the railway, its crest there having a nearly constant height of 1,223 feet, with a descent of five or six feet from it to the east and half as much to the west. Thence this beach ridge continues north-northeasterly to the east part of sec. 23, T. 16, R. 15, where it has an elevation of 1,225 to 1,230 feet, with width of about thirty rods and descent of ten to fifteen feet on its east side. It next runs north or slightly west of north to Thunder Creek in the south part of T. 17, beyond which its course, with that of the lower Norcross shore, is along the steep ascent of Riding Mountain. In the journey from Eden post-office (S.W. ¼ of sec. 22, T. 16, R. 15) to Orange Ridge post-office (N.W. ¼ of sec. 32, T. 16, R. 14), a nearly flat surface of till with frequent boulders is crossed upon the width of three miles between this beach and the upper Campbell beach, descending in that distance from 1,200 to 1,100 feet, approximately. Boulders are especially abundant within the first mile from the upper Norcross beach, whence the erosion of the lake bed supplied its gravel and sand. This even tract of till would seem most favorable for the accumulation of the beaches belonging to stages of Lake Agassiz between its upper Norcross and upper Campbell levels; but no beach ridge nor other deposit of gravel and sand, nor line of erosion which sometimes takes the place of these to mark a shore line, was seen in the intervening distance. It seems probable that not far south and north from this route of observation the lower Norcross and the two Tintah beaches will be found.

Neepawa and northward.

BEACHES OF THE TINTAH STAGES.

Ts. 1 and 2, R. 5.

In proceeding northward from the international boundary the Tintah beaches were first observed near the line between Ts. 1 and 2, R. 5, lying on a terrace which forms the lower part of the Pembina Mountain. On the boundary this terrace is about three fourths of a mile wide, its eastern margin being an escarpment that rises from 1,040 to 1,090 or 1,095 feet; and from its verge it gradually rises 25 to 35 feet in its width, so that its western limit at the base of the main escarpment has a height of 1,120 to 1,125 feet. Its surface is till with plentiful boulders, nearly all Archæan, up to five feet in diameter, mostly embedded or only projecting a foot or less; but the slope on its east side consists of weathering and pulverized Cretaceous shale, which is thus shown to form the principal mass of the terrace, beneath a thin mantle of till. In the distance of six miles northward across T. 1, this terrace widens to two miles, and its eastern verge sinks to 1,055 feet; but it is bordered by only a slight escarpment, about fifteen feet high, the base of which is thus at the same level as on the international boundary. In its width of two miles it there rises about 90 feet, to the base of the mountain escarpment at 1,140 to 1,150 feet. A quarter to a third of a mile east of this escarpment a line of erosion rises from 1,110 to 1,125 feet, approximately, marking the upper Tintah shore. In the S.E. ¼ of sec. 5, T. 2, this shore bears scanty deposits of beach gravel and sand, with their crest at 1,110 to 1,115 feet. The lower Tintah beach lies a third of a mile farther east, and is a distinct ridge of gravel and sand with its crest at 1,083 to 1,085 feet, bordered on each side by till, the surface of which is five feet lower on the east and three feet lower on the west. Thomas Kennedy's well, fourteen feet deep, in the N.E. ¼ of sec. 5, T. 2, R. 5, found the till only four feet deep, underlain by the Fort Pierre shale. This terrace doubtless owes its form, like the far more prominent Pembina Mountain, to preglacial erosion of these Cretaceous beds. It continues along the foot of the mountain, with a width of one and a half to two miles, at least to the South Branch of Tobacco Creek, which crosses it near Miami post-office, twenty-five miles north of the international boundary. Throughout its whole extent it has a considerable ascent upon its width from east to west, as in the localities noted. Much of its surface is till with many boulders, but some portions have no boulders, such tracts being overspread with lacustrine gravel and sand, or perhaps occasionally consisting of Cretaceous shale next below the soil, with no drift nor lacustrine deposits.

West of Morden.

A mile west of Morden the escarpment bordering this terrace has an ascent of about forty feet, with its top approximately 1,070 feet above the sea. Within an eighth of a mile to the west is the lower Tintah beach, a small ridge of gravel and sand which has been excavated for use in plastering, its crest being at 1,085 feet, nearly, with a descent of five or six feet from it to the east and two or three feet to the west. It extends a considerable distance nearly parallel with the verge of the terrace. The road thence to Thornhill ascends slowly in the next two miles across a somewhat uneven surface, on which eight or ten beach ridges are discernible, belonging to the upper Tintah, Norcross, and Herman stages.

Abundant boulders.

The most remarkable feature of this tract is its extraordinary abundance of boulders, nearly all Archæan, usually less than five feet in diameter, but in many places ranging in size to ten feet or more. Upon an area that extends at least one to two miles both south and north of the road and railway, the surface is as thickly strewn with boulders as are the most typical terminal moraines seen by me in Minnesota and South and North Dakota. Many of these rock-masses, instead of being imbedded in the drift, as is generally the case in this region, project two to three or four feet above the surface, or lie wholly on it with no portion concealed. Here the ice-sheet probably terminated, depositing these boulders in the west margin of Lake Agassiz, during the time of its accumulation of the terminal moraine that forms the west part of the Tiger Hills and the Brandon and Arrow Hills.

Near Nelson.

About a mile south and west of Nelson, the lower Tintah beach ridge, having an elevation of 1,085 feet, approximately, lies an eighth of a mile west from the margin of the terrace; and the upper Tintah beach probably extends along its west side, close to the base of the Pembina Mountain, where the elevation is about 1,100 to 1,120 feet. The width of the terrace here is about one and a quarter miles.

East of Treherne.

A half mile east of the lower Norcross beach near Treherne, the upper Tintah shore seems to be indicated where it crosses the railway by a line of erosion in the Assiniboine delta, with descent approximately from 1,140 to 1,120 feet.

Northeast of Neepawa.

On the profile of the Manitoba & Northwestern Railway the upper and lower Tintah beaches are apparently shown about three miles and five and a half miles east-northeast of Neepawa, with their crests respectively at 1,158 feet and in two ridges at 1,116 and 1,111 feet above the sea. Within its next three miles northward the upper beach is represented by a tract of low dunes extending through the east edge of T. 15, R. 15, to Snake Creek. Thence the course of these shore lines, as shown by the contour, is nearly due north to the foot of the escarpment of Riding Mountain in T. 17.

BEACHES OF THE CAMPBELL STAGES.

Upper Campbell shore from the international boundary to Treherne.

Along the course of the Cretaceous terrace which borders the base of the Pembina Mountain for at least twenty-five miles northward from the international boundary, as described in connection with the Tintah beaches, the upper Campbell shore line, there having an elevation of 1,045 to 1,050 feet, coincides with the low escarpment which forms the east margin of this terrace. A portion of the sculpturing of this escarpment was doubtless done by the waves of the lake; but the main outlines of the terrace as a bench intermediate between the expanse of the Red River Valley and the high Pembina escarpment seem clearly attributable to preglacial erosion. The first locality where I observed a distinct beach ridge of gravel and sand referable to this stage is in sec. 3, T. 4, R. 6, a half mile west of Nelson, and thence through a distance of a mile or more north-northwestward. It lies close east of the terrace escarpment, and has an estimated elevation at its crest of 1,055 feet. In T. 7, R. 8, this shore is marked by a conspicuous beach ridge, passing through secs. 22, 27, and the east edge of 33, lying an eighth to a half of a mile west of the Boyne River, with its crest about 1,055 to 1,060 feet above the sea. The descent from the crest is ten to fifteen feet on the east, and five to eight feet on the west. The lake at this stage, or at a slightly higher level, also cut an escarpment fifteen to twenty feet high, with its top at 1,075 feet, approximately, which passes northwestward across secs. 28 and 29 of this township and northward through the east part of secs. 6 and 7, T. 8, crossing the railway about seven miles east of Treherne.

Lower Campbell shore along the same distance.

The lower Campbell beach in its course northward from the international boundary lies close east of the terrace face which was the upper Campbell shore. In secs. 2 and 11, T. 1, R. 5, the elevation of its crest is 1,036 to 1,040 feet. On the west a nearly level surface extends an eighth of a mile to the terrace. On the east a slope of beach gravel and sand sinks to 1,028 feet in about twenty-five rods; and a similarly descending surface of till continues to 1,015 feet in the next twenty-five rods, beyond which there is a much slower descent eastward. The road on the line between Ts. 1 and 2, R. 5, crosses this shore about three eighths of a mile west of the northeast corner of sec. 34, T. 1, where it is marked by a typical beach ridge, with its crest at 1,034 feet, from which there is a descent of ten feet in ten rods to the east and three or four feet in ten rods to the west. This ridge was seen to hold nearly the same outline and height through a distance of one mile or more to the south and a half mile north to a small creek. About a half mile west of Morden, where it has been considerably excavated for plastering sand, it has a nearly flat top ten to twenty rods wide, with ascent on this width from 1,030 to 1,040 feet, approximately, resting on the base of the terrace escarpment. Five to six miles farther north, the road from Nelson to Miami runs along the top of this beach through the north half of sec. 3 and the S.W. ¼ of sec. 10, T. 4, R. 6. It is there a broad, low ridge of sand and gravel, twenty to thirty rods wide, the elevation of its crest being about 1,035 feet, or ten feet above Nelson. Continuing northward, it crosses the N.E. ¼ of sec. 6, T. 5, R. 6, a mile west of Miami.

The course of these shore lines was not traced across the Assiniboine delta, but their elevation shows that they lie on its eastward slope where they are intersected by numerous ravines and are doubtless obscured in many places among its dunes. On the Canadian Pacific Railway profile three massive beach ridges, the two higher referable to the upper Campbell stage, and the third to the lower Campbell stage of the lake, are shown three miles to two and a half miles west of Austin, their crests being respectively 1,087, 1,081, and 1,066 feet above the sea. These beaches are each about thirty rods wide, with descents of ten to twenty feet from their crests to their east bases and half as much to the west.

West of Austin.

On the Manitoba & Northwestern Railway the upper Campbell beach is a very massive rounded ridge, thirty to fifty rods wide, along whose eastern slope the railway runs about three miles, from the south side of sec. 6, T. 15, R. 13, north-northwest to Arden. Before the railway was built, the old trail from Winnipeg to the Saskatchewan River passed along the top of this ridge the same distance and to a point about a mile north of Arden, there leaving it and turning to the west. This portion of the trail was a good dry road throughout the year, being thus remarkably contrasted with the deep mud along most of its extent during rainy seasons. Because of this character of the road and the beauty of the smooth beach, which is prairie, without tree or bush, but is bordered on each side by groves, this avenue-like tract received its widely known name, the Beautiful Plain. It is not flat, however, as the name seems to imply; for the crest of the beach ridge, at Arden 1,090 feet above the sea, and not varying more than a few feet above or below this elevation in its course through several miles south and north, is fifteen to twenty-five feet above the nearly straight margin of the woods an eighth to a quarter of a mile east, and seven to ten feet above the more irregular margin of bushes and woods on the west commonly ten to thirty rods distant. The barrier of this beach ridge was sufficient to turn the White Mud River southward three miles along its west side. In a section cut six feet deep close north of Arden for the passage of the railway and in excavation of ballast, the material of this beach is mainly fine gravel with pebbles only a quarter to a third of an inch in diameter, but also includes layers of sand and coarse gravel, with pebbles up to two inches in diameter, of which about three quarters are from the Palæozoic formations of magnesian limestone that occupy the country eastward to Lake Winnipeg.

Vicinity of Arden.

Beautiful Plai

From Arden this beach extends north-northwest through the northeast part of T. 15 and nearly through the center of T. 16, R. 14. In the north half of T. 16 it has in several places a narrow terrace-like secondary beach on its eastern slope five to ten feet below the crest of the main beach; and it is closely bordered on the west by a low escarpment of till which rises five to ten feet above the beach ridge and forms the margin of a flat or slightly uneven expanse of till that ascends slowly westward. A post-office situated close west of this beach and escarpment in sec. 32, T. 16, is named Orange Ridge, in allusion to the orange-red lilies (Lilium Philadelphicum, L.) which grow in abundance on the sandy and gravelly soil of the beach. The elevation of the Orange Ridge or Beautiful Plain beach on the north line of the N.E. ¼ of sec. 32, T. 16, is approximately 1,080 feet above the sea; and of the escarpment on the west, which was eroded during the early part of this upper Campbell stage, 1,090 feet. Orange Ridge.

The lower Campbell beach is crossed by the railway near the southeast corner of sec. 6, T. 15, R. 13, where the elevation of its crest is 1,061 feet, with a descent of eight feet in about fifteen rods to the east and five feet in a few rods to the west. Through the next fifteen miles northward it lies a half to two thirds of a mile east of the Beautiful Plain and Orange Ridge. East of the latter, on the line between Ts. 16 and 17, R. 14, the elevation of its crest is about 1,070 feet, with descent of fifteen feet to the east and ten feet to the west. Lower Campbell beach near Arden and Orange Ridge.

The northward continuations of the Campbell beaches pass through secs. 5 and 8, T. 17, R. 14, to Thunder Creek, and thence a few degrees west of north to the Big Grass River in sec. 31 of this township. Thence they traverse secs. 6, 7 and 18 in T. 18, R. 14, and the northeast part of T. 18, R. 15, where a swamp on the west about two miles wide separates them from the base of the Riding Mountain. Ts. 17 and 18, Rs. 14 and 15.

BEACHES OF THE M'CAULEYVILLE STAGES.

In the S.W. ¼ of sec. 12, T. 1, R. 5, the upper McCauleyville shore is indicated by very scanty deposits of fine gravel, 1,006 to 1,007 feet above the sea, from which there is a descent of three or four feet in twenty rods east. Through the east half of sec. 23, the middle of 26, and the west half of sec. 35 of this township, two McCauleyville beaches are developed as small parallel ridges of gravel and sand. The upper one has an elevation of 1,000 to 1,002 feet at its crest, from which there is a descent of one to two feet within two or three rods to the west and five to eight feet in ten or twelve rods to the east. Thence a nearly level surface of till with frequent boulders occupies a width of ten or twelve rods, and is succeeded on the east by the second ridge, the western slope of which rises two or three feet to its crest. This is about five feet lower than the upper beach, and has a similar descent of five feet or more on its east side. T. 1, R. 5.

About a quarter of a mile east of Nelson the upper McCauleyville shore is a line of erosion with a descent of five to ten feet within a short distance from west to east. Four miles thence to the north-northwest From Nelson to Miami.

it is a well defined beach ridge running close to the bridge over Boyd's Creek, near the northeast corner of sec. 21, T. 4, R. 6; and it continues, but is less conspicuous, through the next three miles northward to the church in the northeast corner of sec. 5, T. 5, R. 6, a quarter of a mile east of Miami post-office. Its crest at Boyd's Creek is eight to ten feet, and at Miami five feet, above the more massive second or middle McCauleyville beach, which lies a quarter to a half of a mile farther east, passing north-northwesterly through the west edge of sec. 27 and the east half of sec. 33, T. 4, in which latter it is offset nearly a quarter of a mile to the east, and through the middle of sec. 4 and the west half of sec. 9, T. 5.

East and north of Arden.

Three McCauleyville beach ridges are crossed by the Manitoba & Northwestern Railway on the north side of secs. 32 and 33, T. 14, R. 13, about four miles, four and a half, and five miles southeast of Arden, the elevations of their crests being respectively 1,039, 1,029, and 1,016 feet above the sea. Each of these rises about five feet above the surface on the east. They continue as prominent gravel ridges north-northwestward through the west half of T. 15, and the southwest part of T. 16, R. 13, and through the northeast part of T. 16, the east half of T. 17, and the west half of T. 18, R. 14, to the vicinity of Phillips' ranch. In T. 15, R. 13, next east of Arden, the most western and upper one of these beaches is called Lowdon's Ridge from Thomas Lowdon, whose house, the first built on it, is in the middle of the east edge of sec. 30. The middle beach appears to be twofold in secs. 20 and 29, Joshua Ritchie's house being built on one of its ridges and the Rose Ridge school-house a quarter of a mile farther east on the other.

Rose Ridge.

About three quarters of a mile east of the Rose Ridge is the lower McCauleyville beach, on which the trail to Lake Dauphin runs northward through Ts. 15 and 16. Lewis McGhie's house is built on the eastern slope of this beach in the N.E. ¼ of sec. 28, T. 15. Lowdon's, Ritchie's and McGhie's wells, and others in this township on these beach ridges, pass through gravel and sand five to fifteen feet and through till below to total depths of thirty to fifty feet, obtaining water in gravelly seams, from which it usually rises ten to twenty feet within a few hours, to its permanent level.

BEACHES OF LOWER STAGES WHEN LAKE AGASSIZ OUTFLOWED NORTHEASTWARD.

Blanchard beaches, T. 1, R. 4.

On the international boundary the Blanchard shore lines enter Manitoba in the west part of T. 1, R. 4, passing near Kronsfeld in sec. 7 of this township, and extending north-northwest within about a mile east of Morden, but they are not marked along this distance by distinct beach deposits nor lines of erosion. The lowest of these shore lines crosses the Canadian Pacific Railway a mile west of McGregor, where it forms a slight swell on the gentle eastward slope of the Assiniboine delta. On the Manitoba & Northwestern Railway the three Blanchard beaches appear to be identifiable, being crossed successively two miles and three fourths of a mile west and one mile east of Midway. The upper two are nearly flat tracts of fine gravel and sand, an eighth to a quarter of a mile wide, at 994 and 979 feet above the sea, each being bordered on the west by a depression of about two feet and on the east by a gentle slope descending four or five feet. The third and lowest is a beach ridge of the usual form, about thirty rods wide, with a descent of five feet both to the east and west from its crest, which is at 969 feet. After crossing the McCauleyville beaches on the way from Arden to Gladstone, the surface is wholly silt and sand, with fine gravel, very flat, excepting these slight ridges and others at lower levels. In their continuation northward, portions of the Blanchard beaches are noted on the plats of the Dominion Land Surveys through Ts. 15 to 20, R. 13. McGregor. Between Arden and Gladstone.

The Hillsboro beach enters Manitoba near the middle of the south side of R. 4, and passes north-northwestward. It is not conspicuous on the international boundary, but near the west line of sec. 21, T. 1, R. 4, about a half mile east of Blumenfeld, it is a noticeable ridge with a descent of three to five feet on the east, its crest being about 940 feet above the sea. Its sand has there been excavated for use in plastering. Northward it passes about a half mile east of Oesterwick, one and a half miles east of Morden, and nearly four miles east of Miami, where Henry York's house is built on its crest at an elevation of about 950 feet. Thence its slopes descend fifteen feet in a short distance to the east and five feet or more to the west, the beach being much larger than along most of its course. Mr. York's cellar and well are in sand and fine gravel, but the lower land adjoining on each side is till. Twelve miles farther north this beach passes near Mr. Field's house in the S.E. $\frac{1}{4}$ of sec. 4, T. 7, R. 6, about three fourths of a mile west of Almasippi post-office. The road from Carman to Treherne there ascends a few feet, and in its next third of a mile northwestward crosses a tract of sand with hollows three to five feet below its highest portions, showing that it was formerly wind-blown. This beach deposit is derived from the erosion of the eastern margin of the Assiniboine delta, within a few miles to the north. On the road from Arden to Gladstone this beach was not noticed, but it seems to be traceable on the township plats northward nearly through the middle of Ts. 15, 16, and 17, and through the west part of Ts. 18, 19, and 20, in R. 12. Hillsboro beach. East of Blumenfeld. East of Miami. Almasippi.

The Emerado beach lies two to three miles east of the last. In Ts. 1

Emerado beach.

Rheinland.

and 2, R. 4, the Mennonite villages of Rheinland, Neuenburg and Rosenthal are partly built on it. At the wind-mill in Rheinland, and thence along its course as seen for a half mile or more to the south-southeast and north-northwest, this shore is marked by an ascent of three to six feet in as many rods from east to west; and from its crest, about 905 feet above the sea, the surface extends nearly level westward. The beach consists of loamy sand, while the adjoining land is fine lacustrine silt or clay. On the Canadian Pacific Railway this beach is raised a few feet above the general slope of the Assiniboine delta, passing in a west-northwest course two miles east and one mile north of Bagot. The Manitoba & Northwestern Railway crosses it five miles west of Gladstone, where it is a ridge about thirty rods wide, wind-blown in hollows one to two feet below the crest, which is 927 to 929 feet above the sea, with descent of five feet from it to the west and twelve to fifteen feet to the east. A lower and less conspicuous beach ridge, also belonging to this stage, lies three fourths of a mile farther east, with its crest at 916 feet. The Emerado beach continues north through the east part of Ts. 15 to 19, R. 12, and through the center of T. 20, to the east side of Lake Mary.

Bagot.

On the M. & N. W. Railway and northward.

Ojata beach.

Along the course of the Ojata shore, lying between the Emerado and Gladstone beaches, no ridge of gravel and sand nor line of erosion was observed where it was crossed on the international boundary and elsewhere in this exploration in Manitoba, excepting a slight beach ridge, three to five feet high, which runs from Pomeroy in sec. 19, T. 5, R. 4, north-northwest through the east part of T. 6, R. 5, passing about two miles west of Carman.

Gladstone beach.

The Gladstone beach on the international boundary and for several miles thence to the north-northwest is a prominent ridge, having an ascent of ten to fifteen feet in a distance of thirty to fifty rods west from its base to its crest, which is approximately 860 feet above the sea. The slightly undulating surface of this shore deposit occupies a width of a quarter of a mile or more; and thence westward there is no noteworthy descent, but a nearly level expanse. In many shallow pits dug to obtain sand for masons' use, the materal of the beach is shown to be fine sand, unmixed with gravel, excepting that very rarely a pebble is found enclosed in it, the largest being a half to two thirds of an inch in diameter. This ridge enters Manitoba about one and a half miles west of Blumenort, and crosses secs. 5, 7, and 18, T. 1, R. 2, to Kronsthal, which is situated upon it. Northward it passes about a mile west of Lowestoft post-office and a mile east of Carman. George Anderson's house is built on its crest in the N.E. ¼ of sec. 31, T. 6, R. 4, two miles north-northeast of Carman, at an elevation of about 965 feet. It crosses the Canadian Pacific Railway near the Rat Creek bridge, and is well

Blumenort and Kronsthal.

Carman.

developed along a distance of several miles thence to the northwest, passing through the southeast corner of sec. 12, T. 12, R. 9, where the elevation of its crest is about 875 feet, with a descent of four to six feet to the northeast and one to three feet to the southwest. Thence its course is along the southwest side of the Squirrel Creek marsh and east of the chain of Dead Lakes (a former channel of the White Mud River), which lie in secs. 17, 18 and 19, T. 14, R. 11. A half mile east of Gladstone this shore is marked by a line of erosion in the expanse of lacustrine silt, with slope in a short distance from 882 to 875 feet, and by a small beach ridge of sand with its crest at 878 feet. Continuing almost due north, this Gladstone shore line, occasionally marked by beach gravel and sand, lies a half mile to one mile west of the Big Grass Marsh through Ts. 15, 16 and 17, R. 11, the elevation of the marsh being approximately 865 feet, and of Lake Agassiz here during this stage about 875 feet above the present sea level. Gladstone.

The western Burnside shore enters Manitoba near Blumenort, nineteen miles west of the Red River, but it is not distinctly marked on the international boundary. Passing northward about a mile east of Lowestoft and three miles east of Carman, it crosses the Carman beach of the Manitoba & Southwestern Railway at Maryland, where the elevation of the crest of its beach ridge is 844 feet. About a mile north-northwest of Maryland this ridge has been extensively excavated, its gravel and sand being used for railway ballast. One and a half miles farther north it crosses the main line of this railway about a mile west of Elm Creek station (the junction of the branch), its crest there being at 845 feet, from which its slopes fall ten feet in twenty-five rods east and seven feet in an equal distance west. The Canadian Pacific Railway crosses this shore about half-way between Portage la Prairie and Burnside, and in the next ten miles of its course, passing northwest nearly through the center of T. 12, R. 8, it is marked by a large gravel ridge, the crest of which in the south part of sec. 11, one and a half to two miles north of Burnside, has an elevation of 858 to 860 feet, with descent from it of six to ten feet northeastward and half as much to the southwest. This beach is similarly prominent on the Manitoba & Northwestern Railway, by which it is crossed and excavated for ballast half-way between Westbourne and Woodside, its crest there being 860 to 862 feet above the sea. Along the next forty miles the Burnside shore line is generally marked by a well developed beach ridge which is traceable on the plats of the Dominion Land Surveys parallel with the west shore of Lake Manitoba and four to five miles distant from it, passing about half-way between the lake and the Big Grass Marsh. It thus lies near the line between Rs. 9 and 10 as far north as to the east side of the lake in secs. 13 and 24, T. 18, R. 10, beyond which it runs north-northwest.

Burnside beach. Maryland and Elm Creek. Near Burnside. On the M. & N. W. Railway and northward.

Eastern Burnside beach. "The Ridge," east of Emerson.

On the eastern side of Lake Agassiz this shore line is found at "The Ridge" about eleven miles east of the Red River and Emerson, where it is marked by a low escarpment rising from 835 to 850 feet, consisting of till with frequent boulders, nearly all Archæan, and by a deposit of gravel and sand a few feet deep, resting on the base of this slope, 835 to 840 feet above the sea. In the S.W. ¼ of sec. 15, T. 1, R. 4 E., the Burnside beach is a typical gravel and sand ridge twenty to twenty-five rods wide; its crest is 845 feet above the sea; and the descent from it to the east is about three feet and to the west six or seven feet. About a mile farther north, near the southeast corner of sec. 21, the elevation of this beach ridge is 844 feet, with a descent of one or two feet on the east and ten feet within twenty rods on the west. Another mile to the north its elevation is 846 feet, with two feet descent east and six feet west in six rods; next a surface of till, with many boulders, falls about five feet in forty rods to the west; beyond this a tract of gravel and sand continues with the same slope, falling from 835 to 830 feet, and is succeeded farther west by a slowly descending surface of till. The beach ridge continues with similar features through the east half of sec. 28, excepting a short distance in the S.E. ¼ of this section, where it is replaced by a line of erosion in the very rocky till. Through the next three miles the uneven contour causes the beach ridge to be somewhat irregular in its course and size; but it again attains its typical development in sec. 9, T. 2, R. 4 E., where it was excavated several years ago along a distance of a third of a mile for railway ballast, a branch track nearly eight miles long being laid for its transportation to Dominion City. The crest of the beach at Charles Aime's house near the north end of this excavation is 846 to 847 feet above the sea, with a descent of two to five feet on the east and six to eight feet in eight to twelve rods west. Its width, including both slopes, is fifteen to thirty rods, and the maximum depth of the gravel and sand deposit is about eight feet, lying on till. The coarser portions of the gravel contain pebbles up to three inches or rarely six inches or more in diameter. Nine tenths or a larger proportion of them are magnesian limestone, the remainder being almost wholly Archæan granite and gneiss. This shore line continues north and north-northeast by Green Ridge post-office and through the east part of Ts. 3 and 4, R. 4 E., beyond which it has not been traced.

Ts. 1 and 2, R. 4 E.

Proportion of limestone gravel.

Between the south ends of Lakes Manitoba and Winnipeg the country about Shoal Lake was uncovered by the fall of Lake Agassiz from the Gladstone to the Burnside beach, which latter is crossed by the Winnipeg & Hudson Bay Railway near the southwest corner of sec. 36, T. 14, R. 2, about three miles south of Shoal Lake. The crest of the beach is 860 feet above the sea, being ten feet above Shoal Lake. Here

Burnside beach in vicinity of Shoal Lake.

its course is from west to east along the verge of a nearly level expanse of till reaching to the lake, to which its drainage is tributary. Two or three miles farther east, where the road to Stonewall and Winnipeg crosses this beach, it has a descent of twenty feet in thirty or forty rods south from its crest, the whole slope being gravel and sand, the combined shore deposits of the Burnside and Ossowa stages of Lake Agassiz. Westward the beaches of these stages are separated by a width of one to two miles, the Burnside beach running southwest and west through the south half of T. 14, R. 3. Near the west side of this township it curves northward, and thence passes north and north-northwest between Shoal and Manitoba Lakes. East of the road before mentioned, the course of this beach is northeastward across T. 15, R. 1 E., and T. 16, R. 2 E., to Pleasant Home post-office. Numerous short beach ridges noted on the township plats northwest of this beach, between it and Shoal Lake, were probably formed during the Gladstone stage of Lake Agassiz where the highest parts of that area rose above its level.

Ossowa beach.

Ossowa post-office, near the middle of the north half of sec. 27, T. 13, R. 4, is situated on a well defined beach ridge which runs from west-southwest to east-northeast through this township. Its crest varies in elevation from 843 to 848 feet, with descent of three to eight feet on its north side and twelve to fifteen feet on the south. The Canadian Pacific Railway was originally constructed from Stonewall due west to this beach, which it cut through in the east edge of sec. 28. In the railway cut its material is wholly gravel, in part very coarse, containing pebbles and subangular rock-fragments up to four inches and rarely six or eight inches in diameter, of which fully nineteen twentieths are magnesian limestone. On each side the surface is till with plentiful boulders, mostly Archæan granite and gneiss, but including many of this limestone, which is the underlying rock of the region. In the north part of T. 13, R. 3, this beach curves to the south, east and northeast, and thence passes through the southeast part of T. 14, R. 3, and the north half of T. 14, R. 2, gradually approaching and in some places joining the Burnside beach, with which the Ossowa beach is approximately parallel. lying a half mile to one or two miles southeast of it onward to Pleasant Home. The only other locality where a beach referable to this stage was observed is on the top of Stony Mountain, on which a broad smoothly rounded ridge of gravel and sand extends nearly a quarter of a mile and is the site of some of the Penitentiary buildings. Its crest is about 835 feet above the sea, and the top of the underlying limestone about 825 feet. The western Ossowa shore line crosses the international boundary a few miles east of Gretna, and the eastern enters Minnesota about three quarters of a mile west of "The

From Ossowa east and north-east to Pleasant Home.

Stony Mountain.

Ridge," but they are not there marked by noteworthy beach deposits nor erosion.

Stonewall beach.

The main street of Stonewall crosses a conspicuous beach ridge which runs from south-southwest to north-northeast a third of a mile or more. Its crest is 820 to 825 feet above the sea, and its depth is about ten feet. Only two or three feet of till intervene between this gravel and sand and the underlying limestone, which, thinly covered by drift, rises in a swell here about twenty-five feet above the adjoining country a half mile distant to the east and west. Beach deposits belonging to this stage were not elsewhere observed, but they are doubtless traceable from Stonewall northward through the west half of Ts. 14 and 15, R. 2 E. Lake Agassiz at the time of the Stonewall beach probably extended on the flat Red River Valley to a distance of about twenty-five miles south of the international boundary, being some fifteen feet deep at Emerson, Saint Vincent and Pembina, while over the site of Winnipeg its depth was about sixty feet.

Niverville beach,

The road on the east side of the Red River between Winnipeg and Emerson crosses a beach ridge about a half mile southeast of Niverville. It has a width of fifteen rods, and its crest, 777 to 778 feet above the sea, is raised about four feet above the adjoining surface of lacustrine silt on each side. Beginning near Niverville station, it extends southeasterly at least a mile. Another beach ridge of similar size, with its crest at 780 feet, is crossed by this road a third of a mile farther south. This also runs southeast, holding its ridged form a mile or more, beyond which it is less distinct. Again, a few miles to the south from these, a beach ridge extends along this road in a nearly due south course across the S.E. $\frac{1}{4}$ of sec. 17 and the east half of secs. 8 and 5, T. 7, R. 4 E. It rises two to four feet above the land adjoining on each side, which is partly sloughs with water throughout the year, the elevation of the beach crest being 782 to 784 feet. Other beach deposits at nearly the same elevation occur a mile southwest of Otterburne; a few miles farther to the south in the northeast part of T. 5, R. 3 E.; and about a mile east of the Red River opposite to Morris. At the last named locality they are excavated for masons' sand. From the southern end of Lake Agassiz in this stage near Morris, its western shore extended north and northwest to the vicinity of Starbuck, thence north and northeast to Little Stony Mountain five miles northwest of Winnipeg, and thence nearly due north, passing between Stonewall and Stony Mountain and onward along the west side of Lake Winnipeg at a distance of a few miles from it. Gravelly and sandy deposits at the base of Stony Mountain on its north and south sides are attributable to erosion by the lake, there only a few feet deep, at the time of formation of the Niverville beach. Its level was fifteen to twenty feet

From Niverville to Otterburne.

Morris.

West shore of Lake Agassiz in this stage.

above the surface where Winnipeg is built and about seventy feet above Lake Winnipeg.

All the beaches thus far described must be referred to the glacial Lake Agassiz, held on its northern side by the barrier of the waning ice-sheet, as is shown by Dr. Bell's description of the outlet of Lake Winnipeg and the topography of the adjoining country, which could present no barrier of land so high as the Niverville beach. The original level of Lake Winnipeg, due to the height of the land upon which the Nelson River began to cut its channel in its present course, is probably that of the well defined beach observed by Hind between the mouths of the Winnipeg and Red Rivers, having "an elevation of twenty-one feet above the present level of Lake Winnipeg."* Traces of this shore line will probably be found at nearly the same height around the whole lake.

Old beach of Lake Winnipeg.

DELTA OF THE PEMBINA RIVER.

The Pembina delta lies wholly in North Dakota at a distance of four to sixteen miles south of the international boundary; but its deposition by the stream outflowing from the Lake Souris along the course of Lang's Valley, Pelican Lake, and the Pembina, associates it so intimately with this glacial water-course in Manitoba that it seems desirable to give some description of it here.

When the delta was deposited, the Pembina was swollen by a great affluent from the glacial Lakes Saskatchewan and Souris, and thus received the drainage from the melting ice fields of the Assiniboine and Saskatchewan region far beyond the present limits of its basin. The prominent delta of gravel and sand brought into the margin of Lake Agassiz by the Pembina extends twelve miles from north to south and has a maximum width of seven miles, with a maximum thickness exceeding 200 feet. Its average thickness is probably not less than 150 feet. About five sixths of its area of fifty square miles or more lie south of the Pembina River, reaching nearly to the Tongue River.

Extent and thickness.

The most elevated point of this delta, as it now remains, is about 1,270 feet above the sea, near the northwest corner of sec. 11, T. 162, R. 57, east of the Little Pembina and south of the Pembina River, and is nearly 300 feet above the junction of these streams, one and a half miles distant toward the northwest. The level of Lake Agassiz in its highest stage here was 1,220 or 1,225 feet above the sea, being fifty feet below this highest part of the Pembina delta, as is shown by the beach line of this level, 1,226 feet, in the central part of sec. 7, T. 162,

Highest part of the Pembina delta about fifty feet above the upper beach.

* Narrative of the Canadian Red River Exploring Expedition of 1857, and of the Assiniboine and Saskatchewan Exploring Expedition of 1858, vol. i, p. 122.

R. 56, where an eastward descent begins. This is the east verge of the nearly flat area of the delta in secs. 12 and 7. Like all of this vast delta deposit, the material here is sand and gravel, covered by a fertile soil. A small proportion of the pebbles of this gravel is limestone; a large part is Cretaceous shale; but more was derived from Archæan formations of granite and gneiss.

On the road from Olga to Walhalla the crest of the east margin of this delta is crossed in the north part of sec. 33, T. 163, R. 56, about two miles southeast from Walhalla. Its elevation is 1,190 to 1,196 feet above the sea. This is a beach accumulation, belonging to the third Herman stage. Toward the west and southwest the undulating delta plateau, mostly covered with bushes and occasional trees, is ten to thirty feet lower for a width of one to one and a half miles, averaging about 1,175 feet. Northeast from the crest of this road a short descent is made to a prairie terrace 30 to 60 rods wide, varying in elevation from 1,182 to 1,169 feet, but mainly within two feet above or below 1,175. In general the verge of this terrace is its lowest portion. Thence a very steep descent of 169 feet is made on the road from 1,173 to 1,004 feet, this being the very conspicuous wooded escarpment called the "first Pembina Mountain." It is the eroded front of the great Pembina delta, the eastern part of which, originally descending more moderately, has been swept away by the waves and shore currents of the lake during its Norcross, Tintah, Campbell, and McCauleyville stages. From this sec. 33 the "first mountain" extends southeast to secs. 13 and 24, T. 162, R. 56, and northwest across the Pembina, passing close southwest of Walhalla and onward to secs. 10 and 3, T. 163, R. 57. Its highest part is intersected by the Pembina River, above which it rises on each side in bluffs of gravel and sand 200 to 250 feet high, with their crests a half mile to one mile apart. From this upper portion the delta slopes down gradually toward the southeast and toward the northeast and north, extending only two to four miles north of the Pembina.*

First Pembina Mountain.

Sources of the gravel.

In the gravel of this delta, as seen in the bluffs of the Pembina near Walhalla and at noteworthy springs two miles to the south on the

*The first Pembina Mountain was visited by D. D. Owen in 1848. He describes it as follows:—"Pembina Mountain is, in fact, no mountain at all, nor yet a hill. It is a terrace of table land, the ancient shore of a great body of water that once filled the whole of the Red River Valley. On its summit it is quite level and extends so for about five miles westward to another terrace, the summit of which I was told is level with the great buffalo plains that stretch away towards the Missouri, the hunting grounds of the Sioux and the half-breed population of the Red River."—Report of a Geological Survey of Wisconsin, Iowa and Minnesota, 1852, p. 178.

Both the first and second Pembina Mountains were examined in 1857 by Palliser, who says of the flat Red River Valley and the Pembina delta:—"This plain, no doubt, had formed at one time the bed of a sheet of water, and the Pembina Hill, consisting of previously deposited materials, was its western shore."—Journals, detailed reports, &c., presented to Parliament, 19th May, 1863, p. 41.

south side of the river, the pebbles of some beds are mainly Cretaceous shale, of others mostly limestone, and of others granite, gneiss, and dark trappean rocks. In the aggregate, these three classes have a nearly equal representation; and they are more commonly intermingled in the same beds. The shale was doubtless chiefly derived from the erosion of its strata along the glacial water-course from the Lake Souris, and was occasionally deposited in layers almost unmixed with drift materials; but the other constituents of the gravel were derived from the overlying drift and from the melting ice-sheet. White quartz and moss agate are frequent, and bits of silicified wood occur rarely; but no banded agates were found. Numerous pieces of lignite, rounded by water-wearing, from two to four inches in diameter, noticed in this delta gravel at the springs, have caused some to look for workable beds of this kind of coal in the vicinity; but the proportion of these fragments is no greater than in the glacial drift generally throughout this region and for hundreds of miles to the south.

Fragments of lignite.

The deposition of this delta took place during the highest Herman stage of Lake Agassiz. It seems to have been very rapid, the supply of sediments being so great that about the mouth of the Pembina Valley they were accumulated in a fan-like sloping mass to a height of more than fifty feet above the lake level. When the recession of the ice-sheet caused the cessation of its supply of modified drift, and permitted the Souris to flow as now to the Assiniboine, the growth of this delta ceased; and its subsequent history is that of the deep channels cut through it by the Little Pembina and the Pembina, and of the steep escarpment sculptured on its east side. From the erosion of this first Pembina Mountain large amounts of gravel and sand were swept southward, notably during the Campbell stages of the lake, when they were deposited in a very massive curving beach ridge that crosses the Tongue River in the west part of T. 161, R. 55, about seven miles west of Cavalier. In the Herman stage, while the delta was being accumulated, much fine clay and silt, brought by the same glacial river, were carried farther and spread upon the lake bed along the central part of the Red River Valley, perhaps extending in appreciable amount nearly a hundred miles southward to the belt of till that reaches across the valley at Caledonia and forms the Goose Rapids. But on the west edge of the lacustrine area this fine sediment is absent, probably because of currents trending off shore; and the surface is till both south and north of the gravel and sand delta, as from Park River north to Gardar and Mountain and nearly to the Tongue River, and from two miles north of the Pembina to the international boundary and onward.

Time and manner of deposition.

Erosion and redeposition.

Lacustrine silt and areas of till.

DELTA OF THE ASSINIBOINE RIVER.

At Brandon the Assiniboine enters the area of Lake Agassiz, and thence the gravel and sand delta of this tributary extends eastward seventy-five miles to Portage la Prairie, northeastward fifty miles to Gladstone, and east-southeastward eighty miles to Almasippi post-office, nine miles west of Carman. On the northwest this delta is bordered by an expanse of moderately undulating or rolling till which rises slowly above the ancient lake level and stretches northwestward from Brandon, Chater and Douglas to the Little Saskatchewan and Oak Rivers. From Brandon to Douglas the boundary of the delta is close north of the Assiniboine and the Canadian Pacific Railway; but at Douglas the line dividing the delta sand and gravel and the adjoining surface of till turns north-northeastward and extends about twenty miles in a nearly direct course toward Neepawa, then bends northward in the east part of Ts. 13 and 14, R. 16, and crosses Stony Creek a few miles west of Neepawa. Between Brandon and the mouth of the Souris the delta reaches three or four miles southwest of the Assiniboine, being there also bordered by a smoothly undulating or rolling tract of till, but the morainic Brandon Hills rise prominently within a few miles farther west. From the Souris east to the Cypress, a distance of nearly twenty-five miles, the southern margin of the delta is similarly divided from the Tiger Hills by a belt of undulating and rolling till which averages about five miles in width. Farther to the east the delta deposits abut directly upon the northern base of these hills from Cypress River by Holland and Treherne to the north end of the Pembina Mountain. Thence to the southeast the head streams of the Boyne, after their descent from the plateau of the Pembina Mountain, cross the southeastward extension of this delta to Almasippi. This portion, however, is not probably a part of the delta as it was at first deposited, but has been derived from the erosion of the eastern front of the original delta by the waves of the lake in its later and successively lower stages, being transported thence southward by shore currents. The same lacustrine action has doubtless extended the delta of gravel and sand generally five to fifteen miles eastward beyond its original area, thereby giving its eastern face a more gradual slope. As thus enlarged, its east boundary runs north from Almasippi to Portage la Prairie, curving eastward between these places; and thence it passes west-northwest to near Gladstone, Arden, and Neepawa. The eastern base of the delta, where it adjoins the flat expanse of the Red River Valley and the country bordering the lower Assiniboine and Lake Manitoba, has an elevation of 850 to 900 feet above the sea; while the high delta plateau, which was submerged only about fifty

Extent and boundaries.

feet or less by the lake when it was being deposited, and was in part shoals and low islands, has an elevation from 1,200 to 1,275 feet above the sea. The western and southern limits of the plateau are those already noted, and on the east its boundary runs north and northwest from Treherne to Sydney and Neepawa. The area of the plateau is about 1,300 square miles, and the eastern slope adds to this fully two thirds as much, making the total area of this delta somewhat more than 2,000 square miles. **High plateau and eastern slope of the delta, and area of each.**

The thickness of the Assiniboine delta is seldom shown by wells, which generally obtain a plentiful supply of water upon this area within moderate depths, ranging from ten to fifty feet. In some localities, however, near the great valley that the Assiniboine has cut through the delta, the plane of saturation probably lies much deeper, and wells must be sunk a hundred feet or more to obtain water. Better measures of the depth of these gravel and sand deposits are supplied by the valleys of the Assiniboine and other streams, which are eroded in their deeper portions 100 to 200 feet below the top of the delta plateau before reaching the underlying till. Deep ravines are especially numerous on the northern part of the delta, where many springs issue near the plane of junction between the porous gravel and sand beds and the till, giving rise to the Squirrel, Pine and Silver Creeks which flow northeast to the White Mud River. The descent of 200 to 300 feet made within a few miles upon the eastern face of the delta is a further indication of its thickness, which reaches its maximum at the verge of the plateau. In the vicinity of the outcrop of Niobrara beds on the Assiniboine in sec. 36, T. 8, R. 11, the thickness of the delta gravel and sand appears to be about 200 feet; and it probably ranges from 100 to 200 feet along the outer limit of the plateau through the greater part of its extent of more than fifty miles. The average thickness of this very extensive delta is probably between fifty and seventy-five feet. Computing its volume for an average of fifty feet on an area of 2,000 square miles, it is found to be about twenty cubic miles. **Thickness and volume.**

Fifty miles east-southeast from Brandon the highest portions of the surface of the delta south of the Assiniboine and east of the Cypress, where it has not been heaped in sand hills by the wind, are 1,225 to 1,240 feet above the sea, the latter being its elevation in a broad swell near the centre of sec. 24, T. 8, R. 11. Ten to twenty miles thence westward, between Cypress River and Glenboro, the elevation of the slightly undulating surface of the delta is mostly 1,235 to 1,245 feet, with frequent sloughs and permanent ponds, up to a quarter of a mile or more in extent, lying at 1,225 to 1,235 feet. These ponds abound near Glenboro and for four miles east. Along the Canadian Pacific **Elevation of the plateau of the Assiniboine delta.**

Railway from Sydney westward by Melbourne, Carberry, and Sewell, to Douglas, twenty to twenty-five miles north of the foregoing, the undulating delta ranges in elevation from 1,230 to 1,275 feet; and it holds the same height through twenty-five miles northward, to within three miles southeast of Neepawa. Adjoining the undulating and rolling area of till which borders this part of its area on the west, its expanse of gravel and sand slowly rises northward from 1,265 and 1,270 feet two to three miles northeast of Douglas to 1,275 and 1,280 feet between Willow or Boggy and Spring Creeks. These elevations represent the plateau before mentioned, which forms the greater part of this delta.

Highest portion of this delta in the vicinity of Brandon and Kemnay.

While the extensive area of this plateau, reaching fifty miles from east to west and nearly the same distance from north to south, is thus so uniform in its elevation that its deposition must be attributed to stages of the lake when its level was not much higher, probably those of the Herman beaches *b* and *bb* near Treherne and Neepawa, there is a considerable tract lying on both sides of the Assiniboine in the vicinity of Brandon and Kemnay, upon which delta deposits closely associated with this plateau ascend from a few feet to 125 feet above it in a distance of twelve or fifteen miles from east to west. A mile north of Brandon the bluff on the north side of the Assiniboine rises about 140 feet above the river to 1,300 feet, approximately, above the sea. It consists of till to a height of 100 feet or more; but its crest and the surface thence northward for five miles is mostly undulating gravel and sand to a thickness of 10 to 20 feet, thinly covering the till, which forms the surface farther north. Eastward this bluff, eroded by the Assiniboine since the deposition of this stratified gravel and sand, extends along the north side of the railway by Chater and Douglas, having a height of about 75 and 50 feet, respectively, at these stations, but declining only slightly in the elevation of its crest, which is 1,275 to 1,290 feet. Delta gravel and sand, and on some portions fine silt, cover a width of three or four miles thence northward through the south half of Ts. 11 of Rs. 18 and 17, having an elevation at their northern limit 1,300 to 1,290 feet above the sea, beyond which the surface, gradually ascending northward, is till. The most eastern point of this higher delta deposit is in sec. 14, T. 11, R. 17. Measured thence to its western limit on the north side of the Assiniboine half-way between Kemnay and Alexander, its length is twenty-four miles. Its width north and south of Brandon is about twelve miles. Through it the Assiniboine has eroded its valley, and has carried it away, cutting also into the underlying till, upon a large area from Brandon east to Chater and Douglas and thence south nearly to the Brandon Hills.

North of the Assiniboine.

South of the river, at the court house in the southeast part of Brandon, very coarse gravel and sand of this higher part of the Assiniboine delta, containing water-worn cobbles up to six and eight inches in diameter, form a plateau mostly 1,270 to 1,275 feet above the sea, but rising to 1,282 feet at a distance of one mile to the east. One and a half to three miles west of Brandon, a similar plateau varies in height from 1,290 to 1,305 feet. Between these small plateaus or plains, which slope about five feet per mile to the east and were once continuous, a former water-course, diminishing from a half to a quarter of a mile in width, passes southeast from the valley of the Assiniboine through the south part of Brandon and thence continues east nearly three miles, opening in sec. 7 or 8, T. 10, R. 18, upon the broad lower area eroded by the Assiniboine. The bed of this old channel is at 1,250 feet to 1,255 feet, and it appears to have been eroded at the time of the formation of the Herman beach *bb* in Brandon, when the level of Lake Agassiz was approximately at this height. Three to four miles west of Brandon, the road to Kemnay crosses another water-course of similar character, diminishing from one and a half miles to a half mile in width within two miles from northwest to southeast, passing from the Assiniboine Valley to the head of Baker's or Stony Creek. Its bed, which is strewn with plentiful boulders, showing that the erosion here extended through the stratified gravel and sand to till, is about 1,270 feet above the sea, and marks nearly the Herman *b* stage of Lake Agassiz, being about 30 and 40 feet, respectively, below the adjoining areas of delta gravel and sand on the east and west. In three miles westward to Kemnay this delta expanse rises 50 to 60 feet, and continues to ascend more slowly in the next three and a half miles to 1,390 and 1,400 feet in secs. 1, 12, and 13, T. 10, R. 21. Thence the surface for the next six miles westward about Alexander, including nearly all of this township and the east edge of that next west, is till.

South of the Assiniboine.

Former water-courses.

Many portions of the fine sand deposits of the Assiniboine delta have been channelled and piled by the wind in dunes from 10 to 75 feet high, mostly covered with bushes and a scanty growth of herbaceous plants, but in part destitute of vegetation, which is prevented from obtaining a foot-hold by the drifting of the sand. On the southeast part of this area these sand hills, seldom exceeding 30 or 40 feet in height, occur in secs. 1 to 4, T. 7, R. 7, and are thence frequent northward upon a width of ten miles northeast of the Boyne and southeast of the Assiniboine. On the north side of the Assiniboine the most eastern dunes extend to within three miles southwest of Portage la Prairie. Both these tracts lie on the lower part of the eastern slope of the delta, and thence westward dunes are found here and there over this entire slope. Even where no distinct hillocks and ridges have been formed, the surface is often channelled and ridged in hollows and elevations of a few feet, though now wholly grassed or covered with bushes or small poplar groves. Upon the delta plateau tracts of dunes, commonly raised 20 to 40 feet above the general level, interspersed with occasional smooth areas where the original surface remains undisturbed, extend on the south side of the Assiniboine from the Cypress to the Souris, occupying a width that varies from one to five miles. Their southern limit is about four miles north of Holland, three miles north of Cypress River station, and two miles north of Glenboro. One to four miles west of the mouth of the Souris, an isolated tract of dunes about three miles long from southeast to northwest is crossed by Spring Creek near its mouth. North of the Assiniboine much of its delta plateau is occupied by dunes, which extend north to the White Mud River. Their most northern area is a belt that reaches north of this stream through secs. 12, 13, 24 and 25, T. 15, R. 15, to the junction of Hazel and Snake Creeks. But the northwestern part of this plateau includes a belt of smooth and fertile land, several miles wide, extending from Carberry north and northwest to the limit of the delta. Also, from Douglas and Chater southeastward a belt of good agricultural land, free from dunes upon a width of three to five miles, reaches fifteen miles along the northeast side of the Assiniboine. On the extreme western and highest part of this delta, conspicuous sand hills rise 60 feet above the adjoining surface, with their crests about 1,445 feet above the sea, in secs. 6 and 7, T. 10, R. 20, two to three miles southwest of Kemnay; and lower hillocks of wind-blown sand continue from these two miles to the southeast.

Tracts of dunes.

Within six miles west from the dunes last noted and from the boundary of this Assiniboine delta, after crossing a belt of till that reaches about three miles east and the same distance west from Alexander station, the Canadian Pacific Railway thence west to Griswold, Oak Lake and Virden, lies upon the delta which was brought into the Lake Souris by the Assiniboine. In Ts. 9 and 10, R. 22, and T. 9, R. 23, including the vicinity of Griswold, this deposit consists of fine clayey silt and sand, having a moderately undulating or rolling surface with broad smooth swells elevated 10 to 30 feet above the depressions, their tops being 1,400 to 1,435 feet above the sea. Three to seven miles southwest of Griswold this delta has been much channelled and uplifted by the wind in sand hills, which thence continue ten miles southeast along the north side of Plum Creek to sec. 11, T. 8, R. 22, four miles west of Plum Creek village. The crests of these dunes are 1,420 to 1,430 feet above the sea, being 30 to 40 feet above the adjoining surface. Nearly all of them are now covered by grass and bushes.

Delta and dunes of Lake Souris in the vicinity of Griswold.

An ancient water-course, now occupied by a body of water called the Big Slough, thirteen miles long and mostly twenty to fifty rods wide, but in its west part about three-fourths of a mile wide, extends from southwest to northeast nine miles through this delta of Lake Souris and thence continues four miles east through an area of till. Its west end is two miles southwest of Griswold, and its east end about half a mile east of Alexander, its whole extent being on the south side of the railway. Its elevation in the stages of low and high water ranges from 1,385 to 1,388 feet, and its depth at low water varies from two to six or eight feet. The shores of the Big Slough rise in gentle slopes fifteen to twenty feet in twenty to thirty rods, to the general level, not having the usual steepness of banks undermined by streams; yet it doubtless marks the course of a stream that outflowed at one time westward into Lake Souris from a small glacial lake north of the Brandon Hills, and of a later stream that flowed in the opposite direction, eastward from the basin of Lake Souris into the Brandon glacial lake, before that became merged in Lake Agassiz by the departure of the ice-sheet. The succession of events indicated by this channel, together with that of the present Souris and with the great glacial water-course of Lang's Valley, is as follows. Lake Souris outflowed eastward by Lang's Valley, Pelican Lake, and the Pembina River, until the receding ice formed a lake north of the Tiger Hills and east of the Brandon Hills, which, outflowing south to the Souris, cut a deep gorge through the Tiger Hills moraine, where the Souris now flows through it to the north. Similarly, north of the Brandon Hills, a lake was probably held by the barrier of the ice during its recession from Alexander east by Kemnay and Brandon, outflowing westward to the Lake Souris by the course of the Big Slough. As soon as the continued glacial recession left the Brandon Hills wholly uncovered from the ice, these lakes on the east and north were merged in one, and the outflow from the lake so formed passed south through the Tiger Hills to Lang's Valley until that channel was cut down nearly to 1,350 feet. During this stage of a continuous lake east and north of the Brandon Hills, this independent part of Lake Agassiz, before it was merged with the main body of this lake by the recession of the ice from the east end of the Tiger Hills, received an extensive delta, already described as the highest portion of the Assiniboine delta in the vicinity of Brandon and Kemnay, consisting partly of modified drift from the retreating ice and partly of fine sand and silt brought by a stream then flowing east from the Lake Souris delta along the Big Slough. The tribute of the latter is spread over an area of several square miles southwest of Kemnay, and upon it are raised the conspicuous dunes of secs. 6 and

Connection between Lakes Souris and Agassiz by Big Slough.

7, T. 10, R. 20. With the retreat of the ice northward from Treherne, the Brandon lake was lowered nearly 100 feet to the level of Lake Agassiz in its Herman *b* stage. For a short time the Souris probably continued to flow southeastward through Lang's Valley until the deposition of the alluvium, perhaps ten or fifteen feet thick, brought into that valley by Dunlop's Creek four miles east of the Elbow of the Souris, raised a barrier a few feet higher than the gap that had been cut through the Tiger Hills north of the Elbow, whereby the river was turned through this gap, which it has since eroded 100 to 150 feet deeper.

The modified drift and alluvium that form the plain of coarse gravel and sand sloping eastward from Kemnay to Brandon and reach along the north side of the Assiniboine to Douglas, were probably deposited mostly while the barrier of the waning ice-sheet stretched from the Tiger Hills to Riding Mountain, enclosing on its west side a lake that afterward became the bay of Lake Agassiz covering the Assiniboine delta, but was then held about a hundred feet above Làke Agassiz, to which it outflowed by the way of Lang's Valley and the Pembina.

History of the formation of the Assiniboine delta.

The deposition of this highest part of the Assiniboine delta, lying above the Herman *bb* beach observed in Brandon, appears to have been in progress through a considerable period, beginning when this Brandon glacial lake was held at an elevation of about 1,400 feet, and continuing while it was lowered nearly 150 feet. During this time the Brandon lake had three outlets: first from its two parts respectively westward by the Big Slough and southward across the Tiger Hills moraine; second, from the whole lake, when these parts became confluent, by the southward one of these outlets, namely, the gap where the Souris now flows through the Tiger Hills; and third by confluence with Lake Agassiz, when this was permitted by the recession of the ice. Much modified drift was probably brought into the Brandon lake by drainage along the course of the Little Saskatchewan; and it is significant that in the line of continuation of the valley of that stream the plain between Kemnay and Brandon is crossed by a broad water-course, which was evidently eroded after this lake became merged in Lake Agassiz, thereby falling nearly a hundred feet below its former level when outflowing through Lang's Valley, but before the Assinboine had cut its broad valley through this delta. More exactly, as before noted, this water-course seems referable to the Herman *b* stage of Lake Agassiz; and the similar water-course about twenty feet lower, passing through the west and south parts of Brandon, was probably formed during the Herman *bb* stage. During these two stages of the lake the principal expanse of the Assiniboine delta was formed, lying only slightly below the levels which the lake then had.

At the time of formation of the Herman *bb* beach, the Assiniboine had already eroded a deep and wide valley in its delta at Brandon; and as Lake Agassiz sank to successive lower levels this erosion continued, cutting at least the lower part of the great valley, 200 to 300 feet deep, in which this river flows above Brandon, and wearing its channel to a nearly equal depth through its own delta. The Canadian Pacific Railway crosses the Assiniboine about two miles east of Brandon, near the division between the main area of its delta in Lake Agassiz and the deep portion of its upper valley. There the high land on each side of the river recedes, allowing the descent to the stream to be made by easy grades on each side, and supplying upon the gradual slope south of the river the beautiful site of Brandon. No other so favorable point for this crossing exists within sixty miles to the east or west, where the river flows in a deeper and narrower valley. The greater part of this delta was modified drift derived from the melting ice-sheet on the upper part of the basin of the Assiniboine and on Riding Mountain, being carried down from the latter area by the Bird Tail Creek and the Oak and Little Saskatchewan Rivers. It was deposited in this delta chiefly during the early Herman stages of the lake, as is indicated by the elevation of the outer part of its principal expanse; and its deposition continued until the ice-sheet was melted away on Riding Mountain and the upper Assiniboine. The erosion of the Assiniboine Valley above Brandon also supplied a considerable part of the delta. During the ensuing stages of Lake Agassiz, to those of Gladstone and Burnside, the border of this great delta was undergoing erosion by the lake waves and shore currents, by which its outer portion was spread in more gentle slopes, extending farther into the lake, and much of it was swept southward along the shore.

Channel of the Assiniboine.

Erosion by Lake Agassiz.

By this erosion of the sloping face of the delta, and especially by earlier transportation into the deep water of the lake while the gravel and sand were being deposited in its western embayment between the Tiger Hills and Riding Mountain, a large expanse of fine clayey sediment of the same origin with this delta was spread far into the lake, extending to the east beyond the Red River and to the south beyond the international boundary. This deposit of lacustrine silt covers the till from the eastern and southeastern limits of the delta, as before defined, to the low ridge first east of the Red River, about ten miles east of Emerson, while similar sediments cover the central part of the Red River Valley southward to Goose Rapids, more than a hundred miles east-southeast from this delta. Toward the north and northeast lacustrine sediments and subsequent alluvial deposits associated with the Assiniboine delta cover the nearly flat country north from Burnside,

Lacustrine silt of same origin with this delta.

Between Portage la Prairie and Lake Manitoba.

Portage la Prairie and High Bluff to Lake Manitoba. On this area the water-shed between the Assiniboine and Lake Manitoba is very low, and the river has sometimes overflowed its low banks, sending part of its floods north to the lake, which in turn in its highest stages has occasionally become for a short time tributary to the lower part of this river. But the transportation of the silt in the lake was of less extent in this direction than to the east and south, as is shown by areas of till on both sides of the Big Grass Marsh west of Lake Manitoba, and from Ts. 13 and 14, R. 5, southeast of this lake, eastward to Shoal Lake, Stonewall, and Selkirk.

Adjoining areas of till.

Projecting boulders.

Five to ten miles west of Portage la Prairie till with frequent boulders forms the surface, or is only overlain to the depth of a few feet by the sediments associated with this delta. Again, ten miles farther west, the sandy eastern slope of the delta in the vicinity of McGregor shows very rarely projecting boulders, the size of the few noticed being from two to six feet in diameter. They probably lie on till that has been somewhat eroded by the lake waves, so that these boulders are not embedded in it as usual, while the sand and silt afterward spread there on the surface are not sufficiently thick to conceal them. No boulders were elsewhere seen on the general surface of the delta and of the great area of associated lacustrine silt, nor in any observed sections of these deposits.

CHANGES IN THE LEVELS OF THE BEACHES.

Stages of Lake Agassiz during the formation of its beaches.

The successive shore lines of Lake Agassiz are not parallel with each other and with the present levels of the sea and of Lakes Winnipeg and Manitoba, but have a gradual ascent from south to north, which is greatest in the earlier and higher beaches and slowly diminishes through the lower stages of the lake, being at last only slightly different from the level of the present time. On the west side of Lake Agassiz the elevations of its beaches have been determined by continuous leveling, referred to sea level by railway surveys, through a distance of more than 300 miles from its mouth at Lake Traverse northward to near Riding Mountain in Manitoba; and the accompanying table shows approximately the stages of the lake during the formation of these shore lines, in their relations to each other and to the present level. These stages of the water surface have been assumed to coincide generally with the foot of the lakeward slope of the beach ridges, and with the base of eroded shore escarpments, the crests of the beaches having had a variable height from five to fifteen feet above the lake, corresponding with their less or more massive development, while the escarpments rose from the water's edge ten, twenty, or rarely thirty feet.

In this table the estimated stages of the lake are noted for comparison at its mouth, where it outflowed by the River Warren at the north end of Lake Traverse, and on four lines of latitude which are nearly equidistant from each other, passing through Fargo, Grand Forks, Emerson, and Gladstone, respectively 75, 150, 224, and 308 miles north of Lake Traverse. Though the fourth of these intervals is somewhat greater than the others, it may still be considered equivalent to them in the observed elevations and northward ascent of the lake shores, because, as will appear farther on, the northward rise of the land and subsidence of the lake had their maximum increase from south-southwest to north-northeast, or nearly in that direction. Therefore the more western course of these beaches in the northern part of the area examined compensates approximately for the additional distance between the third and fourth of these groups of observations. Comparison on lines of latitude through Fargo, Grand Forks, Emerson, and Gladstone.

The letters *a*, *b*, *c*, *d*, represent successive beaches along the northern part of Lake Agassiz, which are merged in a single beach toward its south end. Several of the beaches thus noted in a preliminary report * are found to become double in some parts of their northward extent; and a correspondence in notation is here preserved by designating subordinate stages by double letters, as *aa*, *bb*. There are also added the two stages of the Tintah beaches, which were discovered after the publication of that report. Successive stages designated by letters.

The lake shore belonging to the highest or Herman stage *a* has now a northward ascent of about 35 feet in the first 75 miles north from Lake Traverse, about 60 feet in the second 75 miles, and about 80 feet in the third distance of 74 miles to the international boundary. Its whole ascent thus in 224 miles is 175 feet, by a slope which increases from slightly less than a half of a foot per mile in its southern third to slightly more than one foot per mile in its northern third. Through six lower stages represented by separate beaches northward which seem to be united in the single Herman beach along the southern third of the lake, the northward ascent is gradually diminished to approximately 30, 40, 60, and 70 feet in the four portions of the observed course of these shore lines, amounting thus to 200 feet in about 300 miles. On the international boundary the lowest Herman stage *dd* is about 55 feet below the Herman stage *a*, while the probable erosion of the outlet and consequent lowering of the south end of the lake between these stages appears not to have exceeded ten feet. Northward ascent of the Herman shore lines.

Between the series of the Herman beaches and that of the Norcross beaches, the River Warren eroded its channel about fifteen feet; and the upper Norcross shore ascends northward in these successive

* U. S. Geological Survey, Bulletin No. 39, p. 20.

STAGES OF THE GLACIAL LAKE AGASSIZ, WESTERN SHORE.

Stages	Beaches.	Mouth of Lake Agassiz outflowing by the River Warren, at the north end of Lake Traverse.	On the latitude of Fargo and Wheatland, North Dakota, 75 miles north of Lake Traverse.		On the latitude of Grand Forks and Larimore, North Dakota, 150 miles north of Lake Traverse.		On the international boundary, 224 miles north of Lake Traverse.		On the latitude of Gladstone, Arden and Neepawa, Manitoba, 308 miles north of Lake Traverse.	
		Feet above the sea.	Feet above the sea.	North ascent from Lake Traverse.	Feet above the sea.	North ascent from Lake Traverse.	Feet above the sea.	North ascent from Lake Traverse.	Feet above the sea.	North ascent from Lake Traverse.
Stages during outflow southward.	Herman beaches. *a*	1055	1090	35	1150	95	1230	175		
	aa	1055	1090	35	1145	90	1222	167		
	b	1050	1085	35	1135	85	1212	162	1315	265
	bb	1050	1085	35	1132	82	1205	155	1295	245
	c	1045	1080	35	1125	80	1190	145	1275	230
	d	1045	1075	30	1117	72	1180	135	1255	210
	dd	1045	1075	30	1115	70	1175	130	1245	200
	Norcross beaches. *a*	1030	1055	25	1090	60	1145	115	1215	185
	b	1025	1050	25	1080	55	1130	105	1185	160
	Tintah beaches. *a*	1015	1035	20	1065	50	1105	90	1150	135
	b	1000	1017	17	1045	45	1080	80	1120	120
	Campbell beaches. *a*	990	1000	10	1015	25	1045	55	1080	90
	aa	985	995	10	1010	25	1035	50	1070	85
	b	980	988	8	1000	20	1022	42	1055	75
	McCauleyville beaches. *a*	970	977	7	987	17	1007	37	1035	65
	aa	965	971	6	981	16	998	33	1023	58
	b	960	965	5	975	15	990	30	1012	52
Stages during outflow northward.	Blanchard beaches. *a*	(945)*	950	(5)	960	(15)	975	(30)	995	(50)
	b	(935)	940	(5)	948	(13)	960	(25)	980	(45)
	c	(925)	928	(3)	935	(10)	947	(22)	965	(40)
	Hillsboro beach	(915)	918	(3)	923	(8)	935	(20)	953	(38)
	Emerado beach	(882)			890	(8)	902	(20)	920	(38)
	Ojata beach	(860)			865	(5)	877	(17)	895	(35)
	Gladstone beach	(840)			845	(5)	857	(17)	875	(35)
	Burnside beach	(822)			827	(5)	837	(15)	855	(33)
	Ossowa beach	(810)					822	(12)	840	(30)
	Stonewall beach	(795)					805	(10)	820	(25)
	Niverville beach	(755)							775	(20)

* Figures in parentheses in the first column give approximately the elevations which the stages of the lake during its outflow northward would have had at Lake Traverse, if the land there had been low enough to permit the lake to extend south to its former outlet. From these estimated elevations the northward ascents of these stages, also in parentheses, are obtained so as to be directly compared with the northward ascents of the beaches that were formed while the lake outflowed southward, showing the changes which were gradually taking place in the levels of the beaches of Lake Agassiz during the whole time of its existence.

distances about 25, 35, 55, and 70 feet, amounting to 185 feet in the entire distance of 308 miles. In the most southern quarter its ascent is a third of a foot per mile, and this gradually increases to nearly one foot per mile in the most northern quarter. These rates of ascent are slightly reduced in the second Norcross stage, where the total ascent is 160 feet. While the outlet was being eroded probably five feet between the Norcross stages, the combined rise of the land and decline of the lake level were about 10 feet on the international boundary and 25 feet on the latitude of Gladstone. The lake shore belonging to the Tintah stage *a* ascends about 20, 30, 40, and 45 feet in the successive distances from south to north, amounting in total to 135 feet; in the same distances the Campbell *a* shore ascends about 10, 15, 30, and 35 feet, in total 90 feet; the McCauleyville *a* shore ascends about 7, 10, 20, and 28 feet, in total 65 feet; and the McCauleyville *b* shore ascends about 5, 10, 15 and 22 feet, in total 52 feet. The erosion of the River Warren from the Norcross *a* stage to the McCauleyville *b* stage, at the end of which the southward outflow ceased, was about 70 feet; but the vertical distance between the shore lines of these stages on the latitude of Gladstone is about 200 feet, the difference of 130 feet being attributable to the northward rise of the land and the fall of the lake level on account of the diminished attraction of the ice-sheet. The rate of northward ascent is reduced to less than an inch per mile along the southern part of the lowest McCauleyville shore, and to three or four inches per mile along its northern part, the average being two inches.

Northward ascent of the Norcross, Tintah, Campbell, and McCauleyville shore lines.

From the time of this lowest beach formed during the southward outflow of Lake Agassiz to the time of the first beach formed during its northeastward outflow, the lake fell only about 15 feet. Thence there is now a descent, on the latitude of Gladstone, of about 220 feet to the Niverville beach, below which Lake Agassiz, while its northern barrier of ice remained, fell about 45 feet more before it was reduced to Lake Winnipeg. The northward ascent of these shore lines of northeastward outlet decreases only very slightly in the distance of 75 or 80 miles examined north of the international boundary, the change being approximately from 20 feet to 15 feet or less, that is, to the rate of about two inches per mile. If these stages of the lake had reached south to Lake Traverse, they would probably show a decrease from about 50 feet to 25 feet or only 20 feet in their total northward ascent above the level of the present time along the distance of more than 300 miles from Lake Traverse to the south ends of Lakes Manitoba and Winnipeg. The whole descent on the latitude of Gladstone, between the lowest McCauleyville beach, where Lake Agassiz ceased to outflow southward, and the original level of Lake Winnipeg, about 20 feet above the present surface of that lake, is about 280 feet, of which

Northward ascent of the shore lines formed during the outflow to Hudson Bay.

probably 25 or 30 feet may be due to the northward rise of the land and diminution of gravitation toward the ice-sheet, while about 250 feet are due to the gradual lowering of Lake Agassiz by its successive outlets to Hudson Bay.

Successive depths of Lake Agassiz above Lake Winnipeg.

The depth of Lake Agassiz above the present surface of the south end of Lake Winnipeg was about 600 feet during its higher Herman stages, 500 feet at the upper Norcross stage, 440 feet at the upper Tintah stage, 370 feet at the upper Campbell stage, and 325 feet and 300 feet in the upper and lower McCauleyville stages, being thus reduced to half of its earlier depth before it ceased to flow to the south. During the lower stages of outflow to the northeast, the depth of Lake Agassiz above Lake Winnipeg decreased to 285 feet at the upper Blanchard stage, about 240 feet at the time of the Hillsboro beach, 210 feet in the Emerado stage, and successively about 185, 165, 145, 130, 110, and 65 feet in the Ojata, Gladstone, Burnside, Ossowa, Stonewall, and Niverville stages. By nearly proportionate gradations the area of Lake Agassiz was diminished through these successive stages, having when the outflow to Hudson Bay began probably about half of its maximum extent attained during the formation of the Herman beaches.

Proportionate decrease in area.

Exploration of the beaches formed on the east side of Lake Agassiz has been mostly limited to Minnesota, because the eastern part of this lake area in Manitoba is covered by forest and is almost wholly without settlements or roads, so that for the present a survey of the shore lines there is impracticable. For the same reasons the upper shores in Minnesota have not been exactly traced east of Maple Lake, which lies twenty miles east-southeast of Crookston. Within the prairie area across which the highest eastern shore has been surveyed and its elevation determined by levelling, its northward ascent is about 115 feet in 140 miles, from 1,055 feet above sea at Lake Traverse to 1,170 feet at the north side of Maple Lake. As on the western shore of Lake Agassiz, the rate of ascent gradually increases from south to north, ranging from six inches to one foot per mile in its southern portion for about 75 miles, and from one foot to sixteen inches per mile farther north. Before the lake in Minnesota had fallen below its highest eastern beach in the south half of its explored extent, the rise of the land and diminished attraction of the waning ice-sheet had caused a slightly lower parallel beach, three fourths of a mile to one and a half miles distant, to be formed through the northern third of Clay County; and this secondary beach, sometimes double or treble, is observable at several places along the next 30 miles northward. At the northwest side of Maple Lake definite beach ridges belonging to the Herman stages of Lake Agassiz lie successively about 8, 15, 30, and 45 feet below its highest beach. Yet all these shore lines were formed while

Comparison with the eastern shore lines in Minnesota.

the relative heights of the land and the lake continued stationary or with only slight change, not sufficient for the formation of any secondary beach ridge, along a distance of some 75 miles northward from Lake Traverse and Herman. The Norcross beaches in Minnesota have been explored and their height measured through the same extent of 140 miles, in which the upper Norcross beach ascends northward about 65 feet by a slope that increases slightly from south to north, averaging nearly six inches per mile. In like manner the northward ascents of the Tintah, Campbell, and McCauleyville beaches in Minnesota, and of the lower beaches formed on this east side of the lake during its outflow to the northeast, show a gradual decrease nearly as on the west in North Dakota and Manitoba. But comparison of the western and eastern shores reveals another very interesting feature of the levels of this glacial lake, namely, an ascent from west to east similar to that from south to north, but of less amount and diminishing in a similar ratio between the successive stages of the lake. On the latitude of Larimore and Grand Forks the ascent of the highest Herman stage of Lake Agassiz above a line now level is approximately 33 feet in about 70 miles from west to east, the rate per mile being very nearly half as much as from south to north; and in the later Herman stages it is diminished to about 30, 25, and 20 feet. On the Norcross shore lines this ascent toward the east is approximately 10 feet in about 60 miles, and it is reduced in the McCauleyville stages to only three or four feet in about 50 miles; yet it continues through all these stages approximately half as much per mile as the ascent toward the north. The rate of ascent eastward also increases, like that northward, in proceeding from south to north. At the latitude of Wahpeton and Breckenridge, 35 miles north from the mouth of Lake Agassiz, the ascent of its highest stage is 10 feet from west to east in 45 miles; at the latitude of Fargo and Moorhead, 75 miles north from the outlet, it is 15 feet in 50 miles; and at the latitude of Grand Forks, 150 miles north from the outlet, it is 33 feet in 70 miles.

The eastern higher than the western shore lines.

These observations, with those of the northward ascent of the west and east shores, indicate that the changes in the relations of the land and surfaces of level during the existence of Lake Agassiz and through subsequent time have given to the former levels of this glacial lake an ascent from south-southwest to north-northeast, its rate being somewhat greater than that noted in following the shores in their nearly due north course. The maximum rates of northward ascent of about one foot per mile observed in North Dakota and Manitoba, and of one foot to sixteen inches per mile in Minnesota, therefore belong to a lake level which in its northern portion differs from the present level by an ascent of approximately one and a half feet per mile toward the north-

Maximum ascent of the stages of Lake Agassiz toward the north-northeast.

northeast. Similar north-northeastward ascent continues through the successive lower stages of the lake, in which its amount north of the international boundary is reduced to about four inches per mile at the lowest stage of southward outflow; and probably it was not more than two inches per mile when the course of the Nelson River was uncovered by the receding ice-sheet.

Changes in relative elevations nearly or quite completed during the existence of Lake Agassiz.

Nearly the entire amount of the changes in the levels of the beaches of Lake Agassiz was evidently contemporaneous with the existence of this lake, taking place gradually, but apparently progressing comparatively fast between the stages marked by the formation of definite beaches, which doubtless belong to times when these changes advanced very slowly or were interrupted by intervals of repose. Great as were these modifications of the geoid surface of level, causing a differential uplift of the highest western shore of the lake in Manitoba to the extent of 175 feet at the international boundary, 265 feet at the latitude of Gladstone, and about 400 feet at latitude 51°52′ on the east side of Duck Mountain, 200 miles north of the international boundary, in the relation of the land to the water level, as compared with the vicinity of Lake Traverse, they were yet almost or perhaps quite completed before the ice-sheet was so far withdrawn that it was no longer a barrier to prevent free drainage from the basin of the Red River and Lake Winnipeg. During the subsequent postglacial epoch, to the present time, only very slight changes, or possibly none, have taken place in the relative elevations of the part of this area where the beaches of Lake Agassiz have been traced with levelling in Minnesota, North Dakota, and Manitoba; and if there have been such small postglacial changes, they were merely a continuation of the geoid movements which accompanied the recession of the ice-sheet and are recorded by the successive shore lines of this lake.

Relation to the upheaval of the Cordillera region and of the great plains.

Further important evidence is supplied by this survey of the beaches of Lake Agassiz in respect to the limitation in time and in area of the upheaval of the Cordillera region, comprising the Rocky and Sierra Nevada Mountains, and of the great plains which stretch from the Rocky Mountains east to the border of the Red River Valley. The somewhat higher elevation of the eastern than of the western shore lines of this lake proves that its area during the recession of the ice-sheet of the last glacial epoch and since then has not participated in this extensive uplift, which increases from east to west across the plains. Prof. Joseph Le Conte has shown that the Sierra Nevada range and other portions of the Cordillera region obtained a great part of their elevation within the glacial period; * and Profs.

* American Journal of Science, III, vol. xix, pp. 176-190, March, 1880; and vol. xxxii, pp. 167-181, Sept., 1886. Compare also J. S. Diller's observations on the time of the uplifting and faulting which produced the Sierra Nevada, Eighth annual report of the U. S. Geological Survey, pp. 428-432.

Chamberlin] and Salisbury conclude that the upper portion of the Mississippi basin was raised 800 or 1000 feet during the principal interglacial epoch.* Simultaneously with these movements, the plains between Lake Agassiz and the Rocky Mountains doubtless received a considerable part of their slope of ascent westward; but comparison of the opposite shores of Lake Agassiz indicates that the western uplift was probably completed before the departure of the last ice-sheet.

Gravitation of the lake toward the ice-sheet, causing part of the changes in the levels of the beaches.

Consideration of the character of the changes in the levels of the beaches, resulting in a greater ascent upon the northern part of the area examined than farther south, and gradually approximating through the successive stages of the lake to parallelism with the present geoid surface of level, led me in my earlier studies to attribute these changes almost wholly to gravitation of the water of the lake toward the ice-sheet. The cause of the present relations of the old shore lines seemed to be discovered in the explanation that at first this attraction had a large effect upon the lake level because of the nearness of a great depth of ice on the east in northern Minnesota and on the north in British America, but that afterward it was gradually diminished to a comparatively small influence when the southern portion of the ice-sheet had been melted and the attracting force proceeded from the region far north between Lake Winnipeg and Hudson Bay.† Under this view the earth's crust was believed to be so rigid that it was not depressed by the vast weight of the ice nor raised when relieved of that weight, and the changes were believed to consist chiefly in the differential subsidence of the lake level, not in the differential elevation of the land basin.‡ The general uniformity of these changes in their direction and extent, and their probable completion during the departure of the ice-sheet seemed to accord with this hypothesis. The exact comparison of the shore lines observed on both the east and west sides of the lake, extending for its upper stages 140 miles from south to north in Minnesota and more than 300 miles from south to north in North Dakota and Manitoba, shows no considerable irregularity in the rates of northward and eastward ascent, that is, of north-northeastward ascent of the former lake levels, which thus seem to be attributable to gravitation toward the waning ice-sheet, rather than to a progressive elevation of the land, for that would be

* Sixth annual report of the U.S. Geological Survey, p. 314.

† Geological and Natural History Survey of Minnesota, Eleventh annual report, p. 152; U. S. Geological Survey, Bulletin No. 39, p. 18.

‡ Similar oscillations in the relative heights of sea and land, associated with glaciation, have been thus ascribed to ice attraction by Adhemar, in Révolutions de la Mer, 1840; by Croll, in Climate and Time, 1875; and by Penck, in Schwankungen des Meeresspiegels, Jahrbuch der Geographischen Gesellschaft zu Munchen, bd. vii, 1882.

expected to present noteworthy irregularities upon so large an area. It is probable, however, that close scrutiny of the shore lines will disclose small divergencies, within limits of a few feet, from the uniformity of slopes which they should have for agreement with this explanation; and it is to be noticed that the highest shores in the vicinity of Treherne, Brandon, and Neepawa have more nearly a northward than north-northeastward ascent, also that a slightly disproportionate increase in the ascent of the highest Minnesota shore line in the next ten or fifteen miles north of the Buffalo River was ascribed to the proximity of a portion of the ice-sheet on the east, where it was forming the Fergus Falls and Leaf Hills moraines. Though it now appears true that the greater part of these changes of level are due to the differential rise of the land, the gravitation of the lake toward the ice-sheet certainly operated in conjunction with that cause, contributing to the full extent of its competency in producing the results observed.

Mathematical investigation of ice attraction, by R. S. Woodward.

Mr. R. S. Woodward, of the United States Geological Survey, has worked out the mathematical problem of determining the effect of any added mass, as an ice-sheet, upon the earth's surface, to disturb the levels of the sea and of lakes.* Assuming an ice-sheet with a radial extent of 38°, or about 2,600 miles, and a central depth of 10,000 feet, from which the depth decreases at first slowly and then more rapidly to its border, he finds that the average slope within one degree of the border of the ice would be about five inches per mile, or less than one third of the north-northeastward ascent of the highest shore lines of Lake Agassiz in the north part of the area where they have been explored. Comparing the premises in this problem with the probable conditions affecting this glacial lake, it seems sure that the North American ice-sheet in its maximum extent during the last glacial epoch covered not more than one fourth so great area, its extent being equivalent to a spherical circle with radius of 1,000 miles, or at the most 1,300 miles; but, on the other hand, it is probable that the maximum depth of this ice-sheet somewhat exceeded 10,000 feet, and that the area of this great depth was a belt extending eastward from a few hundred miles north or northeast of the south part of Lake Agassiz to a distance of about 1,000 miles east-northeast, lying thus much nearer than in the assumed case of Mr. Woodward's investigation. The smaller area and less total mass of the ice-sheet attracting Lake Agassiz may have been offset by the nearer position of a large part of its mass than in the assumption of the problem, so that possibly its influence might

* U. S. Geological Survey, Sixth annual report, pp. 291—300; and Bulletin No. 48, "On the Form and Position of the Sea Level." Compare also Prof. Edward Hull's computations, "On the Effect of Continental Lands in altering the Level of the adjoining Oceans," Geological Magazine, Dec. III, vol. v, pp. 113-115, March, 1888.

be as great in producing an ascent of the lake level above the level of the present time; but, if this mathematical investigation is reliable, gravitation of the lake toward its ice-barrier could not give to its highest shore a northward ascent of more than a few inches per mile, at the most not so much as half a foot, whereas its observed ascent attains a maximum rate of one foot to sixteen inches per mile, and this belongs to a north-northeastward ascent of fully one and a half feet per mile. A quarter part, or perhaps less, of the changes in the levels of the beaches is therefore referable to ice attraction; while the remaining three quarters, amounting to about 130 to 300 feet, from south to north, in western Manitoba, belongs to differential elevation of the earth's crust.

Effect of changes in the temperature of the earth's crust, due to the ice-sheet.

Among the conditions producing changes in the height and slopes of the land on which Lake Agassiz lay are the cooling and contraction of the earth's crust by the ice-sheet and glacial waters, and the subsequent warming and expansion owing to the amelioration of the climate. The superficial portion of the earth's crust in the Red River Valley has a temperature of 47° to 42° Fahrenheit, as shown by the water of artesian wells situated respectively at Ada and Donaldson, Minnesota.* But during the time when this district was covered by the ice-sheet, the temperature of the underlying land surface was reduced to the freezing point, 32° Fahrenheit, and a similar lowering of temperature may have affected the crust to a considerable depth, largely through the influence of percolating water, causing a slight depression of the isogeotherms, with consequent contraction of the rocks and lowering of the land surface. By comparison with the present mean annual temperature of the Red River Valley, ranging approximately from 41° at Lake Traverse to 33° at Winnipeg,† it is evident that the artesian waters before noted receive part of their heat from the earth's interior. In like manner probably the interior heat kept the superficial portion of the earth's crust beneath the ice-sheet as warm as 32°, at which temperature the earth's heat would be continually melting the ice, though doubtless at a very slow rate. The differences in the temperatures of the earth's crust, due to the ice-sheet and to water permeating downward from it, would not therefore probably exceed 15° from that of the present time in the southern part of the basin of Lake Agassiz, and would decrease to 10° at Donaldson in Kittson County, the most northwestern in Minnesota, and to even a less amount at Winnipeg. The extent to which these slight changes

* Geological and Natural History Survey of Minnesota, Eleventh annual report, pp. 147, 148.

† C. A. Schott in Smithsonian Contributions to Knowledge, vol. xxi, 1876; Atlas of the Tenth Census of the United States; Report of the Department of Agriculture and Statistics of Manitoba for 1882, p. 318.

in the crustal temperatures would depress the land while it was ice-covered and raise it when the ice was withdrawn depends on the ratios of contraction and expansion of the underlying rocks. These ratios have been experimentally determined in the case of various building stones, and computations therefrom indicate that only a very small amount of subsidence and elevation of the land could be caused in this way.* The total elevation so produced was probably not more than fifty feet in the southern part of the Red River Valley and not more than thirty feet at Winnipeg, and its slight differential effect would be in the opposite direction to that which has given to the beaches of Lake Agassiz their northward ascent. This element in the causation of the changes of elevation appears to be comparatively insignificant in itself, and its small component in the oscillation of the shore lines would be opposed to that for which we are seeking an explanation.

Probable dependence of the northward ascent of the beaches upon the departure of the ice-sheet.

It seems to be very clearly indicated, however, by the gradual diminution in the northward ascent of the beaches until the lowest and latest have nearly the level of the present time, that these progressive changes of elevation were directly dependent upon the departure of the ice-sheet, with which great geologic event they were contemporaneous. As already noted, these changes were so directly proportionate with the glacial recession that the northward ascents of the successive beaches were at first referred to the diminishing gravitation of the lake toward the ice-sheet; but, apart from the inadequacy of this cause, determined by Mr. Woodward's investigations, the great extent of the highest beach and its relation to terminal moraines marking stages in the glacial recession sufficiently demonstrate that other causes contributed even more than ice attraction to produce the changes observed in the levels of the beaches. In the discussion of this subject, to be presented in the monograph of Lake Agassiz for the United States Geological Survey, there remain to be considered, as probable causes, first, the relationship between the earth's crust and its interior which may have permitted a sinking of the crust beneath the vast weight of the ice-sheet and a re-elevation when that weight was removed, and, second, oscillations which may have occurred without dependence on the glaciation. For the discrimination of these movements, it will be very instructive to notice the changes of elevation that have been going forward at the same time in other parts of the North American and European glaciated regions, and also in various areas which were never thus ice-laden. If Lake Agassiz is found to be an instance where nearly all these changes are apparently referable to glaciation, there will be no lack of opportunity for comparing it with other

*T. C. Chamberlin in Sixth annual report, U.S. Geol. Survey, p. 302, and in paper read before the Philosophical Society, Washington, March 13, 1886; G. K. Gilbert, in Am. Jour. Sci., III, vol. xxxi, p. 297, April, 1886.

regions where the effects due to glaciation are combined with independent crustal movements. *

RECORDS OF WELLS.

The following notes of common wells in various parts of Manitoba show in considerable detail the character and order of the drift deposits, and in a few instances of the underlying rock formations. Nearly everywhere an ample supply of good water, permanent throughout the year, is found at a moderate depth. In the Red River Valley and westward it usually is hard water, as is also the water of springs and streams, containing so much dissolved carbonate of lime that it cannot be used satisfactorily for washing with soap. For this use rain water is commonly collected from the roofs. When this is stored in large cisterns, it is more desirable also for drinking and cooking than the often somewhat alkaline well water, which, however, is seldom found to be injurious to health.

Hard water.

But wooden well-curbing, commonly pine, which has been often used in this region, soon contaminates the water, especially if it is notably alkaline; and when such wells are left stagnant or only drawn from slightly, the water becomes too foul in smell and taste to be drank, even by cattle, and it may be the cause of sickness before reaching this stage. If bricks, stone, or iron or cement pipe are used for lining wells, and the water in them is frequently renewed by being largely drawn from, it is entirely wholesome and palatable, and is well adapted for nearly all uses, excepting for washing with soap, as before mentioned, and for steam-boilers, in which the large amount of scale deposited from it in evaporation is objectionable.

Wells often contaminated by decay of wooden curbing.

Artesian or flowing wells are obtained near the Red River, as in in Winnipeg and southward, where water often rises to the surface from layers of sand and gravel in the drift.

Artesian wells.

Winnipeg. About forty wells have been bored by the city authorities of Winnipeg for supplying water for domestic use. Mr. H. N. Ruttan, the city engineer, states that about a dozen of these wells go into the bed-rock, which is limestone, while the others derive their water from layers of quicksand in or beneath the till. Several of them in the west part of the city are artesian, but eastward the water rises only to five or ten feet below the surface. The water is considered of good quality for drinking and cooking, but it contains much mineral matter in solution, chiefly the sulphates of lime and magnesia.

City wells.

* These Quaternary changes of level have been partly considered in a paper on the "Probable Causes of Glaciation," forming an appendix of Prof. G. F. Wright's Ice Age in North America, pp. 573-595.

Alluvial and drift deposits.

Alluvial stratified clay extends to a depth that varies from three to ten feet or more. This is underlain by the glacial till or boulder-clay, which encloses thin veins and layers of fine gravel and sand, and frequently is underlain by sand and gravel, but in many places extends to the limestone. The upper part of the till here shows an imperfect stratification, due to its deposition in Lake Agassiz, and contains a less proportion of boulders and gravel than its lower part, which is very hard, and is therefore commonly denominated "hard pan." The depth to the limestone varies from thirty to sixty feet in the west part of the city, and increases to about seventy-five feet eastward.

Character of the till.

Underlying limestone.

One of these wells, bored in the west edge of the city, close north of the Assiniboine and one and a half miles west of the Osborne street bridge, went 32 feet in stratified clay and till, and then 100 feet in limestone, mostly of light buff or cream color, obtaining water of good quality at 132 feet, which rose to five feet below the surface. The bed-rock is nearly like that which outcrops at Lower Fort Garry and East Selkirk.

General section of superficial deposits at Winnipeg.

A general section of the superficial deposits at Winnipeg is noted by J. Hoyes Panton as follows, from information supplied by Mr. Piper, known as having an extensive experience in well-boring throughout the city.

"1. Surface mould, one to four feet, dark color, and exceedingly fertile.

"2. 'Yellow gumbo,' two to three feet, a very sticky form of yellowish clay, which usually holds considerable water.

"3. Dark gray clay, thirty to fifty feet thick, with boulders scattered throughout; some of them four feet in diameter, and chiefly gneissoid, and no doubt derived from Laurentian rocks.

"4. Light-colored clay, one to three feet, containing many small stones.

"5. Hard pan, two to ten feet, a very solid and compact form of clay.

"6. Sand, gravel, and boulders, five to twenty-five feet.

"7. Angular fragments, one to three feet, usually limestone, and largely derived from the solid rock which lies immediately below it.

"This loose material is far from being uniform, and varies so much in its arrangements that scarcely any two borings show the same distribution. Sometimes there is little or no hard pan, while in other parts it is several feet thick. However, as a usual thing, these seven forms of strata are passed through in boring, and varying in thickness to the number of feet already mentioned."*

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*Report of the Department of Agriculture and Statistics, Manitoba, for 1882, p. 176.

Saint Boniface. Wells in St. Boniface are nearly the same as in Winnipeg, on the opposite side of the river. The deepest learned of is on the Exhibition Ground, 156 feet deep, being stratified clay and till, 36 feet, its lowest 10 feet very hard and compact; sand, 44 feet, to the bedrock at 80 feet; then limestone, of light cream color or nearly white, penetrated 76 feet and extending below.

Niverville. Thomas W. Craven, hotel; well, 65 feet deep, in alluvium and till; water rises to fifteen feet below the surface. Other wells in this village have nearly the same depth or less, none coming to the bed-rock; but it was reached by a well a third of a mile east at a depth of about 100 feet.

Four miles south-southeast of Niverville, in the N. E. ¼ of sec. 5 in this same T. 7, R. 4 E., Cornelius Freesen's well, situated on the Niverville beach, passed through alluvium and glacial drift, 65 feet, and shale, 30 feet, obtaining an ample artesian flow of excellent water.

In the S. W. ¼ of this section, a half mile from the foregoing, Adam Freesen has a similar flowing well, 107 feet deep, which went 37 feet into the shale. This is said to be the deepest of about twenty flowing wells in this Mennonite Reserve, their range of depth being from 40 to 107 feet.

Flowing wells in the Mennonite Reserve east of the Red River.

Dominion City. James Spence, Victoria Flour Mills: flowing well, 170 feet deep, in alluvial clay and till, the latter very hard below the depth of 120 feet; bed-rock not reached; water brackish, flowing feebly, not used.

The common wells of this village, 12 to 16 feet deep, have good water which seeps from the alluvial clay.

The Roseau River has much softer water than the wells and most of the short streams of this region, so that the railway tank at Dominion City, taking water from the Roseau, is preferred by the locomotive engineers above any other source of water on this branch line.

Soft water of the Roseau.

Emerson. Wells in Emerson range from 10 to 25 feet in depth, in alluvial clay, and obtain water tolerably good for drinking and cooking, but it is very hard and unsuited for laundry use.

West Lynne. Hudson Bay Company's steam flouring mill: well, 108 feet deep; dug 68 feet in alluvial and lacustrine clay, and bored 40 feet lower, apparently in the same deposit. The only water found, not enough to supply the engine, is that which seeps from the clay, coming almost wholly within the first twenty feet below the surface. The ordinary wells in this village, 14 to 18 feet deep, obtain good water seeping in sufficient amount for domestic use.

Artesian wells near Letellier and on the Low farm. An artesian well on the French Reserve at the center of T. 2, R. 1 E., near Letellier, twelve miles northwest from Emerson and West Lynne, is 250 feet

Brackish artesian wells west of the Red River.

deep, not reaching the bed-rock. It supplies brackish water, which is drank by cattle. Another artesian well of similar depth is on the Low farm, about twelve miles west of Morris, the water of which is strongly saline.

West Selkirk. The well at the Lisgar House, 100 feet deep, reached the bed-rock, which is limestone, at 65 feet.

Stonewall. J. B. Rutherford's flouring mill: well, 82 feet deep, consisting of beach gravel and sand, 10 feet; till, 2 feet; and limestone, including red shaly beds, 70 feet, to the bottom, where the drill fell one foot and water rose immediately to 22 feet below the surface. Several other wells in Stonewall have had a similar experience, obtaining water which rises from hollows in the limestone.

T. 15 *R.* 2 *E.* William Andrew, S. E. ¼ of sec. 7: well, 94 feet deep; till at the surface and to a depth of 11 feet; and limestone, 83 feet, mostly hard and of light buff color, but enclosing some 25 feet of reddish shaly beds between the depths of 45 and 70 feet. There are several such wells in the same vicinity.

Between Pleasant Home and Gimli. Mr. Andrew states that, about twenty-five miles northeast from the last, a well between Pleasant Home and Gimli has been sunk 120 feet, wholly in the glacial drift, not reaching the bed-rock.

Rosser. The railway well at Rosser is 29 feet deep, in till, which forms the surface there and east to Little Stony Mountain; water rises fifteen feet from a sandy layer at the bottom.

T. 11, *R.* 1 *E.* Robert D. Bathgate, sec. 27: well, 60 feet deep; till, 24 feet, from which alkaline water seeps; and light buff, hard limestone, 36 feet, and continuing lower; water of good quality rises from the bottom to 20 feet below the surface. Other wells in this vicinity mostly get good water in veins or thin layers of sand and gravel contained in the till.

St. Francois Xavier. On Mr. Nanton's ranch, about ten miles west of Headingly and a quarter of a mile south of the Assiniboine, a well 114 feet deep passed through alluvial clay, 14 feet; till, 34 feet; limestone of light cream color, 47 feet; and reddish limestone, 19 feet. Brackish water rises from the bottom to 14 feet below the surface.

Meadow Lea, sec. 30, T. 13, R. 2. Wells in this vicinity range from 20 to 95 feet in depth, and are wholly in till, not reaching the bed-rock.

T. 13, *R.* 6. Charles Cuthbert, sec. 21, ten miles north-northeast from Portage la Prairie: well, 16 feet deep; soil and loamy silt, to water in quicksand and fine gravel. The surface here is only a few feet above the high water level of Lake Manitoba.

Portage la Prairie. The common wells are 12 to 16 feet deep, being black soil, 2 to 4 feet; then yellowish gray loamy silt, the alluvium of the Assiniboine, in which fragments of driftwood, as small limbs of trees, are occasionally found; to water in quicksand and fine gravel. The deepest well here is that of the Manitoba and Northwestern Railway tank, which reaches 30 feet, to till at the bottom, obtaining a very large supply of water.

T. 12, *R.* 8. Kenneth McKenzie, jr., in the north edge of sec. 2, close west of Rat Creek: well, dug 86 and bored 72 feet, to a total depth of 158 feet; soil, 2 feet; sand, 4 to 5 feet; yellow till, 4 feet; blue till, 76 feet, easy to excavate, with scanty intermixture of gravel, but containing occasional stones up to one foot or more in diameter, undoubtedly true till, for the surface generally through the south part of this township has plentiful embedded boulders up to two or three feet in diameter; below was "hard pan," a more indurated deposit of till, very hard to dig or pick, bored or drilled 72 feet, and found to vary much in its hardness through this depth, some portions being much softer than where the boring began. A seam of sand and fine gravel, about an inch thick, was noticed between the upper part of the till, which was dry, and the harder lower portion. At the bottom the drill struck a harder layer, which was called rock. It was probably shale, for the drill, being dropped a few times upon it, seemed in danger of becoming stuck so that it could not be removed. Water rose from the bottom within the first day to a depth of 20 or 30 feet in the portion of the well that was dug; and within a few days it reached its permanent level about 20 feet below the surface. It does not sink below this level in dry seasons, but in wet seasons it rises to seven feet below the surface, near the bottom of the sand. It is somewhat salty, so that it is not suitable for house use; but it is drank freely, and with no ill effect, by horses and cattle during the entire winter.

A quarter of a mile south of this, Mr. McKenzie's father has a similar well as to its depth and succession of deposits passed through to rock, but it obtains a less ample supply of water. Both wells are 864 feet, approximately, above the sea; and the top of the bed-rock is accordingly about 706 feet above the sea level.

Gladstone. Wells vary from 10 to 15 feet in depth, in sandy fine silt. Water abundant and of excellent quality.

Arden. In the vicinity of Arden wells are 10 to 50 feet deep, the section being till, excepting where this is overlain by beach deposits from 5 to 15 feet thick.

Neepawa. John A. Davidson & Co., store: well, 60 feet, the deepest in the town; soil, 2 feet; gravel and sand of the Assiniboine delta, 12 feet; and till, dark bluish, with the usual proportion of gravel and boulders, 46 feet, and extending below; water good. Other wells, mostly 15 to 25 feet deep, reach till at nearly the same depth.

T. 13, *R.* 16. The deepest wells in this township go 50 to 70 feet, wholly in till; but commonly a sufficient supply of water is found within 30 feet or less.

Carberry. Wells 10 to 20 feet deep in sand, the Assiniboine delta; plenty of good water.

Chater. At the elevator, 42 feet, and at the hotel, 31 feet, wholly in till, yellowish above and dark bluish below; water rose several feet.

Brandon. Wells 10 to 30 feet deep, in delta gravel, underlain by till; good water.

Carman. Depths 10 to 15 feet, in alluvial clay with sandy layers; good water. Two miles south of Carman, James Stewart's and George E. Laidlaw's wells are respectively about 100 and 120 feet deep, probably passing through the alluvial and lacustrine clays and glacial drift, to underlying Cretaceous shales. The water of the deeper of these is too brackish for house use, but is drank by cattle.

Treherne. In the vicinity of Treherne wells vary from 15 to 50 feet in depth, the section being beach and delta deposits of stratified gravel and sand; excellent water.

Holland. Wells at Holland are 10 to 20 feet deep, in till to shale, which is reached at about 10 feet; water good, generally better from the shale than from the drift. Shale is not encountered by wells farther north, on the Assiniboine delta. In the adjoining Tiger Hills on the south, the depth to shale varies commonly from 2 or 3 to 10 or 15 feet.

Cypress River and Glenboro. Depths 10 to 17 feet, in fine silt, the delta of the Assiniboine; water good, issuing from quicksand.

T. 8, *R.* 18. Rounthwaite post-office, sec. 14: well, 20 feet deep; soil, 2 feet; yellowish gray till, 13 feet; harder blue till, 5 feet and lower; water seeps, plentiful and good.

T. 7, *R.* 17. Williamson, Dignum & Co., farmhouse in sec. 3: well, dug 30 feet and bored 32 feet more; seen while the boring was in progress at depth of 62 feet; all till, mostly yellowish, to that depth. This is half a mile north of the northern base of the Tiger Hills, at an elevation of about 1,350 feet above the sea.

Lang's Valley. Langvale post-office, at James Lang's house, sec. 2, T. 6, R. 18: well, 18 feet deep; all gravel and sand, with quicksand at the bottom. This is on the bed of the channel of outflow to the Pembina from the glacial lake in the Souris basin.

Plum Creek. Wells in this village, at the junction of Plum Creek with the Souris, are 10 to 30 feet deep, in till, not reaching bed-rock; but outcrops of the Fort Pierre shale occur on the Souris near by.

Gretna. Common wells, 10 to 20 feet deep, in alluvial and lacustrine clay, obtaining a scanty supply of water. A boring is said to have been made here for the railway tank, to a depth of 150 feet, without finding a supply of water, and it is now pumped from the Pembina River.

Rheinland. Wells 15 to 20 feet deep, in somewhat sandy lacustrine clay; excellent water.

T. 2, R. 5. John Johnston, sec. 3: well, 22 feet; soil, 2 feet; yellowish till, containing boulders up to five feet in diameter, 20 feet; to gravel with water which rises from it two or three feet. This is between the Campbell and Tintah beaches, on the low terrace at the foot of the Pembina Mountain escarpment. Other wells near show that this terrace consists of the Fort Pierre shale, thinly covered with glacial drift.

Morden and Nelson. Wells 10 to 25 feet deep, in till; water frequently alkaline.

Thornhill. The wells of Thornhill and vicinity are 8 to 25 feet deep, their material being till, with sandy streaks from which water seeps. The till is yellowish to a depth of about 15 feet, and dark bluish below. Shallow wells, stopping in the yellow till, have better water than those that pass into the blue till.

Darlingford. David Brown, S. E. ¼ of sec. 6, T. 3, R. 7: well, 30 feet; soil, 2 feet; till, 28 feet, its lowest six feet mostly débris of the Fort Pierre shale; to quicksand at the bottom, from which water rose in a few hours to 10 feet below the surface.

Manitou. Canadian Pacific Railway well, 175 feet deep, wholly in the Fort Pierre shales, excepting about five feet of soil and drift at the surface. The common wells are 20 to 30 feet deep, going into shale at 5 to 12 feet from the surface; water good.

Saint Leon, secs. 34 and 35, T. 4, R. 9. In this village wells are 10 to 15 feet deep, being till to a depth of 6 to 12 feet, and extending into shale below; water good. Other wells in the vicinity are 10 to 30 feet deep, reaching the shale usually less than 15 feet below the surface.

Mowbray, Snowflake, and Star Mound. Wells in this district, T. 1 of Rs. 8, 9, and 10, are commonly 15 to 30 feet deep, in till, or in many cases going several feet into the underlying Fort Pierre shale; good water is found in both formations.

Pilot Mound. In the village of Pilot Mound wells are 15 to 20 feet deep, commonly passing into the shale at ten feet; water good.

West of Pelican Lake. The deepest wells within a few miles southwest of Pelican Lake, on the nearly level expanse of till about 150 feet above this lake, often reach shale at 25 to 30 or 40 feet; but many get good water at 10 or 15 feet in the overlying till.

GEOLOGIC AND AGRICULTURAL RESOURCES.

The great fertility of the soil in this district, its water-power, the value of its timber for building purposes, manufactures, and fuel, of its stone for construction and lime-burning, and of its deposits of clay for brick-making, are its chief natural resources.

Soil and subsoil. Over nearly the entire prairie portion of Manitoba, both in the lacustrine area of Lake Agassiz and upon the higher and more undulating or rolling country that stretches thence westward, a sandy clay, often with some intermixture of gravel and occasional boulders, forms the soil, which has been colored black to a depth of one or two feet below the surface by decaying vegetation. The alluvial and lacustrine beds, or the glacial drift, the same as the soil, excepting that they are not enriched and blackened by organic decay, continue below, being usually yellowish gray to a depth of ten or fifteen feet, but darker and bluish beyond, as seen in wells. The glacial drift contains many fragments of Cretaceous shale, magnesian limestone, granites, and crystalline schists; and its fine detritus, and the silty deposits carried into Lake Agassiz by its tributaries, are mixtures of these rocks pulverized, presenting in the most advantageous proportions the mineral elements needed by growing plants.

Agricultural products. Wheat has been the principal crop, but stock-raising and the dairy have also received much attention. A large variety of crops is profitably cultivated throughout the region, including wheat, oats, garden fruits and vegetables, potatoes, and hay. The natural prairie supplies rich pasturage for the herds of the first immigrants; but it is rapidly becoming mainly occupied by farms and brought under cultivation.

Water-power and manufactures. Valuable water-powers are available on many of the streams, especially in the wooded northern and eastern portions of Manitoba. The rapids and waterfalls of the Winnipeg River, with its magnificent reservoirs of the Lake of the Woods and Rainy Lake, besides a multitude of smaller lakes, will doubtless some day become the sites of large manufacturing cities, where the wheat of the prairies will be made into flour, and the timber of the adjoining forests will be manufactured into lumber, furniture, and various wooden wares. While agriculture will be the leading occupation in the prairie region, more diverse industries will grow up in the wooded country on the east.

Fuel. Even the prairie has important resources of fuel in its belts of timber, which border streams and lakes, and also extend along the escarpment of the Pembina Mountain and cover the Tiger Hills and Turtle Mountain. With the more full settlement of the prairie, however, some systematic plan may be adopted for securing coal or wood by railway freight in large amounts, and therefore at much lower cost than now.

Quarries of magnesian limestone have been extensively worked at East Selkirk, Stonewall, Stony Mountain, and Little Stony Mountain, partly for lime-burning, but also in large amount for foundations, bridges, and buildings. The East Selkirk stone, which is beautifully mottled and banded, is easy to cut when first quarried, but hardens much when its moisture dries out. It contains so much water that newly quarried blocks in winter are damaged by freezing; but after drying no such frost fracture is observed where this rock has been used in masonry. By exposure many years the streaked contrast in color is mostly weathered out, the brown portions losing their darker color. The Volunteers' Monument in Winnipeg is a fine example of the adaption of this stone for ornamental purposes. The quarry at Stonewall, situated close east of the village, has been opened to an average depth of six or eight feet on an area about fifteen rods square. Inexhaustible supplies of stone of the most durable quality, in many portions capable of being quarried in blocks of large dimensions, outcrop there and at Stony Mountain, and have been much used for building in Winnipeg. Similar stone has been slightly quarried on the N.E. ¼ of sec. 4, T. 15, R. 2 E., on land of Allen Bristow, nine miles north-northeast of Stonewall. The outcrop of Cretaceous limestone on the Assiniboine in sec. 36, T. 8, R. 11, has also been quarried in small amount. Quarried stone.

The quarry of Little Stony Mountain was actively operated several years ago for burning lime, a spur track about a mile long being laid to it from the Canadian Pacific Railway; but work had been suspended at the time of this survey in 1887. Besides the outcrops of the bed-rock which thus supply lime, it is conveniently obtained by collecting and burning limestone boulders that occur in the glacial drift throughout all the prairie district of Manitoba, having been originally derived from these rock-formations and distributed by the currents of the ice-sheet. The more abundant granitic boulders of the drift also commonly serve the immigrant for the construction of foundations of farm buildings and for the walls of cellars and wells. Lime.

Nearly every part of the province also has beds of brick-clay, which are utilized in proportion to the demands of settlement. Four brick-yards in Saint Boniface, on the east side of the Red River opposite to Winnipeg, produced in total in 1887 about four million bricks. This business began to be extensively developed there in 1880. The soil is stripped off to a depth of two feet, beneath which the next two or three feet of yellowish, horizontally laminated, somewhat sandy clay is used for brick-making. It requires no further admixture of sand for tempering. The bricks, which are cream-colored and very durable, are Bricks.

sold at $11 to $12 per thousand, loaded on the cars or delivered in the city of Winnipeg. Another brick-yard in Saint James, close southwest of Winnipeg, makes about 1,500,000 bricks yearly. The light cream color of these bricks, like those of Milwaukee and of most brick-yards in Wisconsin, Minnesota, and North Dakota, is due, as shown by President Chamberlin, to the calcareous and magnesian ingredients of these glacial clays derived in part from magnesian limestone formations, which unite with the iron ingredient to form a light-colored silicate, instead of the ferric oxide which in other regions destitute of magnesian limestone gives to bricks their usual red color.

APPENDIX I.

COURSES OF GLACIAL STRIÆ.

The following table of glacial striæ in the region of Hudson Bay and Lake Superior and westward shows the directions of the currents of the ice-sheet within the basin of Lake Agassiz and upon the country where it lay as the barrier or dam of this lake. They are derived chiefly from the reports of the Geological and Natural History Surveys of Canada and of Minnesota, and are all reduced to refer to the true or astronomic meridians. Unless they are otherwise credited, the observations in British America are by Dr. Robert Bell, and in Minnesota by the present writer. All are in the area that is supposed to have been covered by the ice-sheet of tne last glacial epoch.

Hudson' Strait and Bay.

Hudson Strait, Port Burwell, ten miles southwest from Cape Chudleigh........	S. 85° E.
do., Ashe's Inlet, on the north side of the strait, about..	S. 65° E.
do., Cape Prince of Wales, on the south side, opposite to the last.....................	E. to N. 70° E.
do., south part of Nottingham Island............	S. 80° E.
do., Digges Island, off Cape Wolstenholme..........	N. 55°–75° E.
Ottawa Islands, in the northeast part of Hudson Bay................	N. 75° E., N. 40°—20° E., and N. 5° W.
East coast of Hudson Bay, northern part, successively, proceeding southward............	N. E., N. and N. W.
do., from Cape Dufferin southward to Hopewell Head and the most northern of Nastapoka Islands, in lat. 58° to 57° N., near the middle of the east side of Hudson Bay, numerous localities,	S. 70°, 60° and 35° W.

It is probable that the first two of these courses record the direction of the ice-flow during the time of maximum depth and area of the ice-sheet, or during a somewhat later stage; and that the last belongs to the time of final melting of the ice.

East coast of Hudson Bay, thence southward to the entrance of Richmond Gulf, numerous localities, mostly between...............	S. 65°–75° W. and N. 75° W.,
but in two localities, probably a later glaciation	S. 35°–45° W.

East, Cairn Mountain Island, Richmond Gulf, several localities, mostly........................ N. 60°–70° W.,
but in one place varying from this to.......... S. 45° W.
do., from Richmond Gulf and Little Whale River southward to Esquimaux Harbor, many localities.................................N. 80° W. to W.
do., thence to Red Head, fifty-seven miles northeast of Cape Jones, eight localities................W. to S. 75° W.,
and one locality............................ S. 55° W.
do., Red Head Island.............................. N. 70° W.
do., thence southward to forty miles south of Big River, many localities.....................S. 40°–60° and 70° W.;
but on the southwest extremity of Long Island, near Cape Jones, striæ bear in every direction from...........S. 70° W., around by S. W. and S., to S. 40° E.
The two prevailing directions are about.....S. 45° W. and S. 15° E.;
the former being probably the older, but perhaps deflected to the south from the direction of the glacial current when the ice-sheet was thickest, and the latter, with further deflection southeastward, belonging to the closing stages of the glacial period. An island off the southwest point of Long Island has three sets of glacial striæ.....................S. 60° W., S. 40° W., and S. 20° E.
East coast of Hudson Bay, from forty miles south of Big River southward along the east coast of the south half of James Bay, many localities...... S. 30°–55° W.;
but in one locality, about three miles northwest of the Paint Hills, three sets of glacial striæ occur, bearing...........N. 75° W., S. 55° W., and S. 30° W.
The first probably records approximately the course of glaciation here when the ice attained its greatest area, belonging thus to a striation which was chiefly effaced by a later glacial movement to the southwest during the departure of the ice-sheet. Again, at the Paint Hills, two sets of glacial striæ are found, bearing......S. 75° W. and S. 35° W.;
and on Governor's Island, at the mouth of Eastmain River, the course is.................. S. 75° W.
Marble Island, northwest part of Hudson Bay....... S. 15°–25° E.
West coast of Hudson Bay, east side of the mouth of Churchill River.............................. S. 5° E.
do., two and a half miles east from the last........ S. 20° W.
do., five miles east from the mouth of Churchill River.................................... S. 15° E.

Region of the Churchill and Nelson Rivers, Lake Winnipeg, and southwest to the Assiniboine.

Churchill River, at Fort Churchill	S. 30°–40° W.
do., four miles below the mouth of the Little Churchill River	S. 20° W. and S. 80° W.
do., six and eleven miles above the mouth of the Little Churchill River	S. 10°–15° W.
Little Churchill River, three localities, four, thirteen and eighteen miles below Was-kai-ow-a-ka Lake, respectively	S. 40° W., S. 80° W., and N. 85° W.
do., outlet of Lower Recluse Lake, various directions from	S. 15° W. to S. 50° W.; also, W.
do., Eagle Rapid, two miles in a straight line below the last, two sets, both distinct	S. 20° W. and W.

The courses to the west, or nearly so, probably mark the motion of this part of the ice-sheet during the time of its greatest depth and extent; while the southerly courses show its deflected motion during the final melting.

Along the Nelson River, Third Limestone Rapid, a hundred miles by the course of the river above its mouth	S. 30°–50° E.
do., Broad Rapid, five miles long, eleven to sixteen miles above the last, mostly	S. 50° W.;
also	S. 15° W. and S. 55°–75° W.
do., thence to Middle Gull Rapid, numerous localities.	S. 55°–80° W.
do., Upper Gull Rapid, and thence to the middle portion of Split Lake, numerous localities	N. 85°–75° W.
do., southwestern part of Split Lake, two localities	S. 85° W.
do., Chain-of-rocks Rapid, three miles above Split Lake, one set, probably the older	S. 85° W.,
the other	S. 10° E.
do., on Grass River, tributary to the Nelson River from the west a few miles above Split Lake, numerous localities	S. 85° W. to W.;
but in one place, at the outlet of Witchai (Stinking) Lake	N. 75° W.
do., between Split Lake and Sipi-wesk Lake, numerous localities, mainly	S. 55°–75° W.,
and occasionally	W.
do., Sipi-wesk Lake, outlet and northeastern part, mostly	S. 70°–75° W.;
also, in numerous localities	S. 45°–65° W.
do., Sipi-wesk Lake, average course throughout the southwestern half of the lake	S. 55°–60° W.;
but in some places	N. 85° W.
do., southwest extremity of Sipi-wesk Lake	S. 65° W.
do., from Sipi-wesk Lake to the outlet of Pipestone Lake, six localities	S. 55°–65° W.
do., Pipestone and Big Reed Lakes and vicinity, five localities	S. 40°–55° W.

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Along the usual boat route from Hudson Bay by Hayes and Hill Rivers to Lake Winnipeg, six miles below the Rock, Hill River............	S. 12° E.
do., the Rock, Hill River........................	S. 10° E.
Dr. Bell reports also at this locality another and older set of striæ.............................	N. 79° W.
do., Borwick's Fall, and one mile above White-mud Fall, Hill River, both within a few miles southwest from the Rock, respectively, S. 18° W.,	and S. 28° W.
do., Knee Lake, numerous localities................	S. 35°–60° W.
do., from Knee Lake to Pine Lake, seven localities..	S. 45°–60° W.
do. from Pine Lake and Molson's Lake to Great Playgreen Lake, many localities..............	S. 35°–60° W.
Around God's Lake, southeast of the foregoing route, 140 to 180 miles east-northeast from the north end of Lake Winnipeg, many localities (Cochrane)............S. to S. 52° W., mostly	S. 15°–40° W.;
but in two localities........................	S. 80° W.
Between Jackson Bay, on Oxford Lake, and the southern part of God's Lake, seven localities (Cochrane).................................	S. 28°–40° W.
Around Island Lake, about forty miles south of God's Lake, many localities (Cochrane)............	S. 10°–36° W.
Between Hudson Bay and Lake Winnipeg, along the Severn, Fawn, Poplar and Beren's Rivers, on almost all exposed rock-surfaces (A. P. Low), generally.................................	S. W.,
varying only a few degrees from this on either side.	
Mouth of Lake Winnipeg and its vicinity, several localities..................................	S. 40°–45° W.
East shore of Lake Winnipeg, Spider Islands, on the adjacent mainland, and at the Shoal Islands, about thirty and forty-five miles south from the north end of the lake.........	S. 30°–40° W.
do., Poplar Point, four miles southeast of Poplar Point, and opposite to George's Island, a few miles farther southeast..........................	S. 30°–35° W.
do., four localities near the mouth of Beren's River, half-way from the north to the south end of the lake..................................	S. 57°–60° W.
do., near the mouth of Beren's River (Panton)...S. W.	and S. S. W.
do., east side of Beren's or Swampy Island (Panton)..	S. W.
do., Rabbit Point, near the Narrows...............	S. 48° W.
do., Black Bear Island, also near the Narrows (Panton)................................	S. S. W.,
intersected by other glacial striæ, bearing....	S. S. E.

The latter, agreeing in direction with striæ observed at Stonewall, Stony Mountain and Little Stony Mountain, near Winnipeg, appear to belong to the basal portion of the divergent glacial current which continued south and southeast in the Minnesota lobe of the last ice-sheet.

East shore of Lake Winnipeg, between the Narrows and the mouth of Winnipeg River, numerous localities....	S. 40°–45° W.
Stonewall, in many places (Panton, Upham).........	S. 20°–25° E.
Stony Mountain (Panton, Upham)................	S. 20°–25° E.
Little Stony Mountain (Upham)..................	S. 25° E.
Assiniboine River, sec. 36, T. 8, R. 11, in three places (Upham)................................	S. 4°–8° W.,
and in one place..............................	S. 10° E.

Athabasca River and Lake, Wollaston and Reindeer Lakes, and southward to Cumberland House.

Mountain Portage, Athabasca River, seven miles above the mouth of Clearwater River...........................	S. 54° E., or more probably N. 54° W.
Fort Chipewyan, near the mouth of Lake Athabasca, also one mile west and eight miles southwest of Fort Chipewyan..........................	S. 78°–83° W.

The following observations, to Cumberland House, are by Mr. A. S. Cochrane, and are communicated by Dr. Robert Bell, having never before been published.

North shore of Lake Athabasca, ten miles north from the Burntwood Islands......................	S. 81° W.
do., twenty miles west of Black Bay................	S. 61° W.
do., half-way from the west to the east end of the lake..	S. 43° W.
do., twenty miles west of the Hudson Bay Company's post at Fond du Lac..................	S. 21°, 27°, and 31° W.
do., H. B. post, Fond du Lac, fifty miles west from the east end of the lake......................	S. 53° W.
On the western outlet of Wollaston (Hatchet) Lake, fifteen miles east from its mouth at the east end of Athabasca Lake..........................	S. 85° W.
Junction of Porcupine River with the western outlet of Wollaston Lake, fifty miles east of Athabasca Lake..	S. 75° W.
North shore of Wollaston Lake, half-way between its western and eastern outlets....................	S. 27° W.
Jackfish Lake, about half-way between Wollaston and Reindeer Lakes, by way of Hatchet Lake River..	S. 17° W.
North end of Reindeer Lake (average of numerous observations)...............................	S. 31° W.
do., mouth of Hatchet Lake River................	S. 17° W.
East shore of Reindeer Lake, Porcupine Point.......	S. 24° W.
do., half-way from the north to the south end of the lake..	S. 18° W.

South end of Reindeer Lake, and on its outlet........	S. 18° W.
Churchill River, near Frog Portage, 110 miles north-northwest of Cumberland House..............	S. 40° W.
do., at a small lake ten miles east from the mouth of Isle à la Crosse Lake......................	S. 18° W.
On the canoe route, seventy miles north of Cumberland House..................................	S. 16° and 26° W.
do., fifty-five miles north of Cumberland House......	S. 26° W.

As on the lower part of Churchill River, before noted, the more westerly courses of this list are believed to indicate the glacial motion when the ice had its maximum depth, or nearly that, continuing probably through the greater part of the epochs of glaciation; and the southward currents seem referable to deflection during the recession of the boundary of the ice-sheet, most of the earlier westward striæ being thereby effaced.

From Hudson Bay to Lake Superior and the Lake of the Woods.

On the route of Dr. Bell from James Bay to Lake Huron, commonly......................	S. 5° E. to S. 5° W.;
rarely varying to..........................	S. 25° E.
Between James Bay and the east end of Lake Superior, from Long Portage of the Missinaibi River to Mattagami Lake, both belonging to the Moose River system, mostly..................	S. S. W.
do., Wasquagami Portage, Missinaibi River, two sets..............................	S. 15° W., and S. 60° E.

The last is doubtless a local deflection, belonging to the time when the ice-sheet was being melted away.

do., Missinaibi River, east of Brunswick Lake.......	S. 15° E.
do., around Mattagami Lake.....................	S. 30–65° W.
do., Lake Manitowick, on Michipicoten River.......	S. 30° W.
do., Long Portage of the Michipicoten River, six miles east of its mouth....................	S. 40° W.
North shore of Lake Superior, Falls of St. Mary, and thence twenty miles south (Agassiz)...........	S. S. E.
do., twenty-five miles north of the Falls of St. Mary, and thence to the northeast angle of the lake, seventy-five miles east of St. Ignace Island, many localities (Agassiz)..................	S.
do., fifty miles east of St. Ignace Island (Agassiz)....	S. S. W.
do., St. Ignace Island, and the same twenty-five miles east (Agassiz)..........................	S.
do., southwest side of Nipigon Bay (Agassiz).........	S. S. W.
do., islands in Thunder Bay (Agassiz)..............	S. W.
do., between Thunder Bay and Pigeon River (Agassiz)................................	S.
Isle Royale, Lake Superior, numerous localities (Desor)................................	S. 20°–75° W.
Along the Pic River, tributary to Lake Superior......	S. 20°–30° W.

Kenogami or Long Lake, at the head of the Kenogami River, tributary to Albany River, many localities .... S. to S. 25° W.

"The grooving is as well marked on the tops of the highest hills as in the valleys."

In the country northwest of Kenogami or Long Lake, several localities .... S. 30°–40° W.
Along the Kenogami River, mostly .... S. 30°–50° W.; but varying to .... S. and S. 60° W.
Lake St. Joseph, mostly .... S. 30°–45° W.; also, in two localities .... S. 15° W. and S. 60° W.
Albany River between Lake Saint Joseph and Maminiska Lake, three localities .... S. 20°, 25°, and 40° W.
Maminiska Lake .... S. 65° W.
Patawonga Lake .... S. 75° W.
Eabamet Lake, two localities .... S. 75° and 80° W.
Inlet of Sturgeon Lake, Boulder River .... S. 70° W.
Attawapishkat River, respectively 3, 13, 22, and 23 miles below the junction of the two channels from the lake of the same name .... S. 60°, 42° 22°, and 15° W.
do., lowest exposure of Archæan rocks .... S. to S. 10° E.
do., on limestone about 75 miles from the southern mouth of the river .... S. 18° W.
do., on limestone nine miles below the last, two sets of striæ, the older .... S. 8°–12° W.; and the newer .... S. 60°–70° E.
do., on limestone at the head of Lowasky Island, about 44 miles from the southern mouth of the river .... S. 2° W.
do., southern channel or Lowasky River, four miles below the last, the older striæ .... S. 35° W.; and newer striæ varying in course from the foregoing to .... S. 80° W.
Around Lake Nipigon two sets of glacial striæ are common, and are often found crossing each other on the same rock surface. The southward set, which is the older, varies from S. 18° E. to S. 25°. W.; and the westward and newer set varies from .... S. 50° W. to due W.
Along and near Kaministiquia River .. S. to S. W., averaging S. S. W.
Dog Lake, mean of several localities (Hector) .... S. 10° W.
Lac des Mille Lacs, mean of several localities (Hector) S. 5° E.
Sturgeon Lake, fifty miles southeast of Lonely Lake, commonly .... S. 20°–30° W.; but in one locality .... S. 50° W.
Minnietakie Lake and vicinity, west of Sturgeon Lake, several localities .... S. 20°–55° W.
Abram's Chute .... S. 10° W.
Islands in the middle of Abram's Lake .... S. 40° W.

Lonely Lake (Lac Seul), three localities.............. ......S. 70° W., S. 85° W., and N 80° W.
do., three other localities, respectively 10, 13, and 16 miles east of the Hudson Bay Company's post. ....S. 60° W., S. 25° W., and S. 55° W.
do., east extremity of the lake...................... S. 45° W.
Root River, tributary to the east end of Lonely Lake, two localities..............................S. 50° and 45° W.
English River, below Lonely Lake, five localities.... S. 30°-60° W.
and one locality............................. S. 80° W.
Winnipeg River, several localities.................. S. 20°-55° W.
Around the Lake of the Woods, observations in about 180 localities by Dr. A. C. Lawson and assistants, and in about 60 localities reported by Dr. G. M. Dawson, "the great majority," i.e., 82 per cent. S. 35°-55° W.;
but 13 per cent. are......................... S. 10°-34° W.,
and 5 per cent. are.......................... S. 56°-83° W.
Only four localities showed courses more westerly than S. 65° W.: one of these is on the southeast side of Big Island, where striæ bearing........ S. 75° W.
intersect others bearing...................... S. 37° W.;
on the west side of Bigsby Island, which, like the preceding, lies near the middle of Sand Hill Lake (the southern and largest part of the Lake of the Woods), double sets of striæ were observed in two places, respectively..N. 80° W. and S. 20° W.,
and...............................N. 83° W. and S. 33° W.;
and on a point projecting from the south shore in the southwestern part of this Sand Hill Lake, striæ bear..................................S. 70° and 65° W.,
with others.................S. 35° and 33° W.; also, S. 10° E.

Probably the bearings S. 10° E. to S. 20° or 30° W. belong to the time of maximum depth and area of the ice-sheet; the prevailing southwestern courses, to later glaciation; and the more westerly deflections to the time of final melting of the ice.

Minnesota.

North shore of Lake Superior southwesterly from Pigeon Point, numerous localities (Norwood and Whittlesey)................................. S. 25°-45° W.
Duluth (N. H. Winchell)........................ W. S. W.
Otter Track, Sucker (or Carp), and Long Lakes, in northeastern Minnesota, south of Hunter's Island (Winchell)........................ S. W.
Vermilion Lake, two places (Winchell), about...... S. 20° W.,
and in another place (Winchell).............. S. 40° W.
Vermilion Lake (Whittlesey)...................... S. 15° W.
Pike River, tributary to Vermilion Lake, two places (Winchell)................................S. 10° and 20° W.

In T. 59, R. 14, about twenty miles south-southeast of Vermilion Lake (Winchell), estimated........ S. 30° W.

The following, to Knife Lake, inclusive, are observations by Prof. N. H. Winchell, noted in his Fifteenth annual report, Minn., 1886, pp. 385-6:

Vermilion Lake, twenty localities.................. S. 17°–24° W.
do., three other localities...............S. 28° W., S. 10° W., and S.
Birch Lake...............................S. 12° W. and S. 22° W.
Sec. 30, T. 63, R. 8.................................. S. 8° E.
Sec. 35, T. 63, R. 9.................................. S. 12° W.
Sec. 27, T. 63, R. 10................................. S. 15° W.
Basswood Lake, Northeast Cape......................... S. 15° W.
Ima Lake, north shore...................S. 36° W. and S. 23° W.
Island in Thomas Lake................................. S. 25° W.
Sec. 11, T. 64, R. 7.................................. S. 30° W.
Knife Lake.. S. 48° W.

The two following are from Prof. N. H. Winchell, in his Sixteenth annual report, for 1887, p. 114:

East end of Delta Lake, west of Ogishke Muncie Lake. S. 25° W.
Island in Pseudo-Messer Lake.......................... S. 40° W.

Mr. Horace V. Winchell, in the report last cited, pp. 395–478, notes the following glacial striæ, to Trout Lake, inclusive, corrected by him for magnetic variation:—

Little Fork of Rainy River, five localities............ S. 10°–42° W.
Rainy River, 3½ miles below Fort Francis........... S. 32° W.
Rainy Lake, nine localities............................ S. 32°–64° W.
North fall on outlet from Namekan Lake to Rainy Lake.. S. 30° W.
Bowstring River (Big Fork of Rainy River), probably in T. 63, R. 26, intersecting striæ, mainly..S. 10° W. and S. 30° E.
do., a short distance above the last, very distinct glaciation.. S. 60° E.
Deer River, at dam about a half mile above its junction with the Big Fork, probably in T. 62, R. 25...............................S. 80° E. to due E.
Big Fork, about three miles above the mouth of Deer River.. Due E.
do., in or near sec. 35, T. 150, R. 25.................. S. 52° E.

The southeastward and eastward striation on the Bowstring River or Big Fork belongs to the east part of the glacial current that moved to the south and southeast from the region of Lakes Winnipeg and Manitoba, carrying plentiful boulders and gravel of limestone from those lakes and the lower part of the Red River Valley southeast to this stream and to the mouth of Rainy Lake.

Lower Falls of Prairie River, sec. 34, T. 56, R. 25..... S.
Elbow Lake, T. 64, R. 18, two localities......S. 26° W. and S. 28° W.
Pelican Lake, mostly in Ts. 64 and 65, R. 20, four localities.. S. 24°–36° W.
Net Lake, in the Bois Fort Indian Reservation...... S. 20°–24° W.
Trout Lake, north of Vermilion Lake, two localities. ....S. 16° W. and S. 36° W.

Sand Point Lake and Sturgeon or Namekan Lake (Whittlesey) .... S. W. to S. 55° W.
Rainy Lake (Whittlesey) .... S. 40°–60° W., and W. S. W.
Big Fork of Rainy River, about 82 miles from its mouth (Whittlesey) .... S. 80° E.

This seems to be near the locality noted by H. V. Winchell about three miles above the mouth of Deer River.

Hinckley, Pine County .... S. and S. 5° W.
Watab, Benton County .... S. 15° W.
Sauk Rapids, Benton County, numerous places .... S. 45°–55° W.;
but in one place .... S. 15° W.
Sauk Center, Stearns County, forty miles west of the last .... S. 40° E.
Minneapolis, several places .... S. 5°–28° E.
One to seven miles southeast from Big Stone Lake, numerous places .... S. E.
Granite Falls, several places .... S. 45°-50° E.
Beaver Falls .... S. 60° E.
In the valley of the Minnesota River two miles below Birch Cooley .... S. 60° E.
One and a half miles west of Fort Ridgely .... S. 60° E.
Redstone, near New Ulm .... S. 25° E.
Jordan, at mill of Foss, Wells & Co .... S. E.
Posen, Yellow Medicine County .... S. 50° E.
Echo, Yellow Medicine County .... S. 50°–55° E.
T. 111, R. 38, Redwood County .... S. 50°–60° E.
Stately, Brown County .... S. 50°–55° E.
Germantown, Cottonwood County .. S. 30° E., S. 50° E., and S. 70° E.
Amboy, Cottonwood County, mostly .... S. 35°–50° E.;
but also rarely deflected to .... S. 70° E.

In one place all these courses intersect on the same surface.

Delton, Cottonwood County, numerous localities, mostly .... S. 15°-40° E.;
also, in one place, all courses from .... S. to S. 80° E., intersecting on the same surface.
Selma, Cottonwood County .... S. 18°–22° E.
Amo, Cottonwood County .... S. 30°–32° E.
Dale, Cottonwood County .... S. 20°–34° E.
Adrian, Watonwan County .... S 20°–30° E.

APPENDIX II.

TABLES OF ALTITUDES.

Much care has been taken to determine the elevations of the beaches of Lake Agassiz with the greatest possible accuracy, in their relation to each other and to the sea level. The railway surveys which have been used as the basis for my levelling along these ancient beaches are found to agree very closely with each other, giving assurance of their reliability throughout the basin of Lake Agassiz, as stated at the beginning of this report, within probable limits of error nowhere exceeding five feet. By the courtesy of the engineers of these railways, their profiles have been mostly submitted to my examination, and I have copied from them the greater part of the notes which are here tabulated; but small portions have been received in manuscript compiled from the profiles by the engineers or their assistants, who have taken much interest in this work, and to whom I desire to express my grateful acknowledgments. **Altitudes compiled from railway profiles.**

The plane of reference in the following tables, and for the altitudes stated throughout this report, is the mean tide sea level. Heights on railways designate the top of the rail in front of passenger stations, at summits from which the grade descends both ways, and at the middle of bridges. The lowest and highest known stages of water in rivers is noted when it is given on the profiles; but in many instances only the ordinary low stage is recorded. **Reference to mean tide sea level.**

Altitudes of lakes, rivers, hills, mountains, and depressions in lines of water-shed, within the basin drained to Lake Agassiz north of the international boundary, are also here tabulated for convenient consultation. Portions of these lists are compiled from former reports of this Survey, and from Hind's Narrative of the Canadian Exploring Expeditions, which was published in 1860. Wherever subsequent railway surveys have supplied means for more accurate reference of these to the sea level, the needed corrections have been made. In all cases, whether of railways or other lists, the source of observations, and the amount of change from the original, if any, with the reasons for it, are noted. **Lakes, rivers, mountains, and lines of water-shed.**

CANADIAN PACIFIC RAILWAY.

A published profile of this railway gives the elevation of Lake Superior as 598 feet above the sea, while on the profiles in the engineers' offices it is shown as 600 feet. Assuming the mean of these figures to represent the mean lake level, a uniform addition of three feet is here made to the eastern part of the profile, extending from Port Arthur to Eagle River station, to accord approximately with the mean elevation of Lake Superior, 601.56, determined by the United States Lake Survey.

The profile shows a discrepancy of eight feet close west of Eagle River station, 232 miles west of Port Arthur, on account of which its elevations thence west to Cross Lake require a subtraction of five feet, which is here made, to agree with the foregoing. Again at Cross Lake, 334.4 miles west from Port Arthur, a discrepancy of five feet to be added is found in the profile, so that its original elevations thence west to the Red River and south to Emerson are here copied without change, being in accord with the corrected profile on the east.

The main line from East Selkirk to the junction of the Emerson branch close east of Winnipeg, and this branch, extending from Saint Boniface to the international boundary, are supplied by Collingwood Schreiber, chief engineer and general manager of the Canadian government railways, and are on the same system of levelling with the main line from Port Arthur to East Selkirk, which, however, is subject to the slight adjustments mentioned. This whole series thus adjusted is surely correct within very close approximation, as is shown by its exact agreement at Emerson with the Saint Paul, Minneapolis & Manitoba Railway and with levelling by the United States Engineer Corps along the Red River of the North.

Two smaller discrepancies also appear in the profile, but are here neglected. At 117 miles from Port Arthur (close west of Scott's River) and thence west, a subtraction of two feet is indicated; and at 256.5 miles (close west of Parrywood) and thence west, a subtraction of one foot. If these were taken into account, the west part of this profile would be lowered three feet; but it seems more probable that it should agree with the elevation of Emerson determined by surveys in the United States.

A large discrepancy is found between the eastern system of levelling and that which begins at Winnipeg and extends west to the Rocky Mountains. The latter includes the branches west of the Red River at Winnipeg and westward, also the Manitoba & Northwestern Railway and its branches, which refer their elevations to that of the Canadian Pacific profile at Portage la Prairie. The system east of the Red River is reliable, as already stated; and levelling from Saint Boniface station (754 feet) to the Louise bridge (752 feet, instead of 728 on the profile extending westward) shows that the system west of the Red River requires a uniform addition of twenty-four feet, which is here made in the lists of elevations at Winnipeg and thence west. With this correction, the Southwestern Branch from Winnipeg to Gretna agrees with the Saint Paul, Minneapolis & Manitoba Railway at the international boundary; the survey from this branch at Rosenfeld to Emerson agrees with the Emerson branch; and the West Selkirk branch agrees with the main line east of the Red River.

a. Main line, from Port Arthur to Winnipeg.

Between Port Arthur and East Selkirk from profiles in the offices of P. A. Peterson, engineer, Montreal, and R. M. Pratt, engineer, Winnipeg; and between East Selkirk and Winnipeg from Collingwood Schreiber, engineer of government railways, Ottawa.

	Miles from Port Arthur.	Feet above the sea.
Lake Superior, mean surface, Nov. 1, 1870, to Jan. 31, 1888, according to U.S. Engineers' gauge, Sault Ste. Marie	0.0	601.56
Lake Superior, extreme low and high water (range, 4.9 feet), approximately	0.0	599–604
Port Arthur (a summit of grade), 993.0 miles from Montreal	0.0	628
McIntyre or Second River, water, 603; grade	6.0	610
Neebing or First River, water, 603; grade	6.2	610
Fort William	7.0	615
Kaministiquia River here, 1½ miles above its mouth, bed, 586; low water (1879), 600; high water (1859), 612.		
Fort William West (station disused)	10.0	635
Kaministiquia River here, bed, 584; low and high water	10.0	602–614
Murillo	17.6	947
Summit, grade (three feet above natural surface)	20.6	1080
Lofoden	20.8	1078
Depression, filling 7 feet; grade	21.8	1055
Summit, cutting 2 feet; grade	22.3	1081
Strawberry Creek, bed, 987; low and high water, 990–993; grade	27.3	1002
Kaministiquia	27.9	1013
Kaministiquia River, bed, 973; low and high water, 982–996; grade	28.2	1013
Mattawan River, bed, 1078; low and high water, 1082–1089; grade	32.4	1099
Sunshine Creek, first crossing, bed, 1106; low and high water, 1109–1113; grade	33.9	1122
Sunshine Creek, third crossing, bed, 1151; low and high water, 1158–1162; grade	35.5	1168
Finmark	37.1	1180
Sunshine Creek, bed, 1330; water, 1334; grade	41.3	1352
Buda (a summit, natural surface and grade the same)	44.4	1473
Oskondiga River, bed, 1415; water, 1421; grade	45.3	1453
Tunnel, grade, 51 feet below top of rock above	46.1	1458
Oskondiga River, bed, 1426; water, 1428: grade	52.2	1441
Nordland	55.5	1543
Summit, natural surface and grade	57.8	1584

	Miles from Port Arthur.	Feet above the sea.
Southeast branch of Savanne River, bed, 1544; water, 1545; grade	59.9	1554
Southeast branch of Savanne River, bed, 1537; water, 1538; grade	62.0	1546
Linkooping	65.2	1534
Savanne	75.8	1506
North branch of Savanne River, bed, 1487; water, 1489; grade	76.4	1506
Upsala	86.2	1579
Carlstad	93.6	1515
Fire-steel River, bed, 1500; water, 1505; grade	98.5	1513
Beaver River, bed, 1519; water, 1525; grade	102.2	1532
Bridge River station	103.6	1543
Hawk Lake, water, 1509; grade	113.6	1518
English River, bed, 1504; water, 1510; grade	115.2	1515
English River station	116.0	1517
Scott's River, bed, 1505; water, 1511; grade	116.6	1516
Summit, cutting 11 feet; grade	123.6	1558
Martin	124.0	1557
Depression, grade	127.4	1483
Summit, grade	131.6	1549
Bonheur	134.0	1530
Summit, grade	136.4	1554
South Lake, water, 1495; grade	138.3	1510
Depression, grade	139.7	1478
Gull River, bed, 1456; grade	143.7	1490
Falcon	144.8	1509
Ahgimac River, bed, 1470; grade	151.3	1490
Ignace	152.3	1487
Osaquan River, bed, 1398; grade	158.7	1420
Butler	160.5	1423
Little Wabigoon River, bed, 1398; grade	165.7	1408
Glencoe River, bed, 1398; grade	167.0	1405
Raleigh	170.4	1440
Little Wabigoon River, bed, 1350; grade	180.0	1366
Taché	180.2	1366
Burnt Stick Creek, bed, 1314; grade	182.5	1347
Kirkpatrick Creek, bed, 1320; grade	183.9	1352
Bear Creek, bed, 1333; grade	186.6	1348
Brulé	190.4	1355
McHugh's Creek, bed, 1207; grade	198.6	1235
Summit, grade	200.4–200.8	1255
Hughes River, bed, 1198; grade	202.2	1211
Wabigoon	202.6	1211
Blackwater Creek, bed, 1200; grade	204.5	1211
Thunder Creek, bed, 1205; grade	206.1	1225
Barclay	209.8	1251
Summit, cutting 10 feet; grade	211.5	1267

	Miles from Port Arthur.	Feet above the sea.
Wabigoon River, bed, 1178; grade	215.4	1219
Shoshogawae River, bed, 1151; grade	220.8	1159
Oxdrift	221.8	1162
Beaver River, first crossing, bed, 1129; grade	225.8	1149
" " second crossing, bed, 1125; grade	226.4	1139
" " third crossing, bed, 1123; grade	229.4	1153
Eagle River station	231.8	1186
Eagle River, bed, 1148; grade	232.2	1190
Summit, cutting 7 feet; grade	234.9	1278
Vermilion Bay station	242.0	1221
Grass Creek, bed, 1183; grade	242.5	1213
Eagle Lake, water about 1182; grade	246.9	1210
Gilbert	249.8	1217
Muskrat Lake, water, about 1174; grade	251.0	1206
Summit, natural surface and grade	255.4	1295
Parrywood	256.3	1292
Stewart Lake, water, 1303; grade	258.3	1328
Summit, near Forest Lake, natural surface and grade	259.8	1382
Outlet of Swan Lake, bed, 1332; grade	260.8	1362
Parrywood Lake, water, about 1362; grade (a summit)	262.1	1379
Outlet of Ulverston Lake, bed, 1318; grade	262.9	1364
Mud Lake, water, 1328; grade	263.3	1355
Feist Lake, water, 1326; grade	264.3	1347
Turtle Lake, water, 1366; grade	265.1	1376
Summit station, cutting near, 10 feet; grade	265.4	1385
Summit Lake, water, 1384; grade	265.6	1385
Clare Lake, water, 1284; grade	270.3	1295
Viaduct Lake, water, 1246; grade	271.6	1282
Hawk Lake station	272.9	1289
Outlet of Narrow Lake, bed, 1220; grade	275.1	1256
Trout Lake Creek, bed, 1213; grade	280.6	1248
Beaver (depression of grade near Beaver Dam Lake)	284.1	1186
Rossland	288.9	1128
Rat Portage	297.3	1087
Winnipeg River, outlet of the Lake of the Woods, low water, at same level with this lake, 1057; grade	298.1	1087
Lake of the Woods, mean, 1060; low and high water.	298.1	1057–1063
Keewatin	300.8	1075
Winnipeg Bay, water, 1043; grade	301.6	1062
Mink Bay, water, 1043; grade	302.4	1070
Winnipeg Bay, water 1043; grade	303.7	1078
War Eagle Rock Lake, water, 1082; grade	305.8	1121
Ostersund	308.3	1105
Summit, cutting 33 feet; grade	311.4	1187
Lake Bobo, water, 1138; grade	312.7	1151

	Miles from Port Arthur.	Feet above the sea.
Lake Deception, water, 1094; grade	313.1	1143
Deception	313.4	1136
Bear Lake, grade	315.2	1192
Summit, at west end of a cut 35 feet deep; grade	315.7	1218
Monument Lake, grade	318.3	1218
Red Pine Lake, grade	319.2	1226
Fellows Lake, water, 1235; grade (eleven feet lower than the lake)	319.7	1224
Kalmar	320.4	1217
Summit Lake, water, 1252; grade	322.1	1255
Kennedy Lake, water, 1245; grade (two feet lower than the lake)	323.1	1243
White Fish Lake, water, 1213; grade	323.8	1243
Summit, 30 rods west from the centre of a cut 33 feet deep; grade	325.8	1221
Ingolf	328.2	1184
Summit, cutting 30 feet; grade	328.9	1190
Cross Lake station, water, 1045; grade	334.4	1092
Depression, grade	336.2	1053
Telfòrd	338.5	1059
Summit, grade, two feet above the natural surface	342.3	1115
For two and a half miles east and one mile west the surface is very smooth, 1105 to 1113.		
River Brenton, water, 1041; grade	348.7	1050
Rennie	349.0	1053
Bog River, water, 996; grade	354.7	1007
" water, 993; grade	356.2	996
Darwin	359.4	971
Westward to the Red River the country is mostly swamp, bearing alders and tamaracks. The swamp is underlain by a hard bottom at depths varying commonly from 5 to 15 feet.		
Bog River, water, 927; grade	364.0	935
Whitemouth River, water 877; grade	368.1	900
Whitemouth	368 9	907
Beaver Creek, water, 885; grade	369.8	904
Shelly	374.9	929
Monmouth	384.9	879
Bear Creek, water, 820; grade	387.4	831
Broken Head River, water, 784; grade	391.1	796
Beausejour	394.3	814
Tyndall	400.9	796
Devil's Creek, water, 770; grade	402.3	777
East Selkirk	408.9	743
Red River at West Selkirk, two miles west of East Selkirk, "ice, 1876" [probably two or three feet above extreme low water], 712; flood of 1876, 723; flood of 1875, 725; extreme high water, flood of 1826, 732; range, 22 feet	411.0	710–732

	Miles from Port Arthur.	Feet above the sea.
The railway at East Selkirk turns southward, leaving the line of its original survey, which crossed the Red River here.		
Lake Winnipeg, mean, 710; low and high water, approximately		708–713
Cook's Creek, water	409.1	728
Gonor	415.0	757
Bird's Hill station	422.1	759
Winnipeg Junction, Emerson branch	427.8	752
Red River, extreme low water, 723; highest water in ordinary years, 735–740; high water, 1882, 749; grade, Louise bridge	429.0	752
Winnipeg	429.8	757

b. Main line, from Winnipeg to the Rocky Mountains and Donald.

From profile in the office of R. M. Pratt, engineer, Winnipeg. With uniform addition of twenty-four feet, as before explained.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg, 1422.8 miles from Montreal	0.0	757
Junction of Southwestern branch	1.1	760
Junction of Manitoba & Southwestern Railway	1.2	760
Junction of West Selkirk branch	1.5	759
Point of beginning of the original profile (at 0 of distances measured thence westward)	1.8	761
Air Line Junction, of Stonewall branch	1.9	761
Colony Creek, water, 769; grade	3.3	776
" water, 772; grade	4.0	780
Junction of Winnipeg & Hudson Bay Railway	4.7	780
Bergen	7.4	784
Rosser	15.2	796
Meadows	22.3	793
Marquette	28.9	807
Reaburn	35.2	806
Long Lake, ordinary low and high water, 798–803; grade	35.7	804
Poplar Point	40.4	815
High Bluff	48.7	829
Portage la Prairie, junction of the Manitoba & Northwestern Railway	56.0	854
Dry Creek, bed, 858; grade	63.4	872
Burnside	63.5	872
Rat Creek, water, 862: grade	65.1	890
Bagot	71.1	935
Image Creek, water, 939; grade	75.6	953
McGregor	77.6	961
Austin	84.5	1005
Apparently a beach ridge (the lower Campbell beach of Lake Agassiz), crest, 1066; grade	86.9	1061

	Miles from Winnipeg.	Feet above the sea.
Again, apparently a beach ridge (the upper Campbell beach, second ridge), crest, 1081; grade....	87.2	1076
Again (the upper Campbell beach, first ridge), crest, 1087; grade....	87..5	1085
These beach ridges are each about 30 rods wide, with descents of 10 to 20 feet from their crests to their east bases and half as much to the west.		
A very uneven profile, intersected by numerous ravines, extends from 89.3 to 92.0 miles, in which distance the grade rises from 1124 to 1232 feet.		
Sydney	92.6	1232
It is again very uneven from 93.7 to 95.9 miles, in which distance the grade ranges from 1234 1251 feet.		
Here and westward the profile shows frequent lakelets, but no names for them are given.		
Melbourne	98.0	1248
Pine Creek, water, 1199; grade....	99.7	1224
An uneven surface of low dunes extends from 101.1 to 102.7 miles, the grade varying from 1244 to 1257 feet.		
Carberry	105.5	1258
Herman beach (*dd*) of Lake Agassiz, crest, 1263; grade	107.6	1264
Herman beach (*d*), crest, 1268; grade....	108.9	1267
Each of these beach ridges is about 20 rods wide, with crest about five feet above the adjoining land; but west of the west beach (*d*) is a depression of 10 to 12 feet, about 50 rods wide, succeeded farther west by land slightly, only a few feet, above these beaches.		
Very rough contour of dune sand reaches from 110.2 miles (grade, 1274) to 112.7 miles (grade, 1249).		
Sewell....	114.2	1255
Two slight summits of grade, probably crests of the Herman beach *d*, natural surface and grade the same, 1268 feet, are crossed at 116.3 and 116.8 miles.		
Douglas....	121.5	1222
Chater	127.2	1213
Assiniboine River, water, 1161; grade....	131.0	1177
Brandon	132.7	1194
Kemnay	140.9	1364
Alexander	148.4	1406
Griswold	157.4	1417

	Miles from Winnipeg.	Feet above the sea.
Flat Creek, water, 1376; grade	162.4	1391
Oak Lake station	164.7	1415
Gopher Creek, water, 1404; grade	178.9	1422
Virden	180.0	1444
Hargrave	188.1	1579
Elkhorn	196.6	1630
Fleming	210.8	1794
Moosomin	219.1	1884
Red Jacket	226.4	1917
Wapella	235.2	1930
Burrows	242.8	1948
Whitewood	249.2	1966
Percival	256.2	2038
Summit, grade	257.9	2054
Broadview	263.8	1960
Oakshela	272.0	1952
Grenfell	279.9	1957
Summerberry	287.4	1938
Wolseley	295.1	1950
Sintaluta	303.9	1984
Indian Head	314.1	1924
Qu'Appelle	323.8	2134
McLean	332.4	2284
Summit, grade	334.3	2286
Balgonie	341.5	2187
Pilot Butte	348.0	2016
Regina, junction of the Regina & Long Lake Railway	356.6	1885
Pile of Bones Creek (Wascana River), grade	358.6	1861
Grand Coulée station	366.1	1857
Grand Coulée (Creek), grade	368.7	1842
Pense	373.5	1881
Belle Plaine	381.3	1902
Pasqua	390.2	1872
Moose Jaw Creek, grade	398.1	1761
Moose Jaw	398.3	1767
Boharm	406.5	1792
Caron	414.5	1841
Mortlach	423.6	1961
Parkbeg	432.8	1982
Summit, grade	442.9	2282
Secretan (on the Missouri Coteau)	443.2	2262
Chaplin	452.0	2202
Ernfold	461.4	2288
Summit, grade	464.2	2374
Morse	471.8	2274
Herbert	480.6	2311
Summit, grade	485.2	2377

	Miles from Winnipeg.	Feet above the sea.
Rush Lake station	489.3	2301
Summit, grade	495.4	2420
Waldec	496.7	2357
Aiken's	504.8	2401
Swift Current Creek, grade	509.7	2415
Swift Current station	510.6	2423
Leven	519.6	2467
Goose Lake station	528.9	2465
Summit, grade	532.3	2586
Depression, grade	533.7	2542
Summit, grade	535.5	2590
Antelope	538.5	2556
Gull Lake station	546.3	2562
Cypress	554.8	2637
Sidewood	565.4	2478
Crane Lake station	575.5	2518
Summit, grade	583.9	2568
Colley	585.9	2509
Summit, grade	589.2	2561
Maple Creek station	596.7	2495
Maple Creek, grade	597.2	2497
Kincarth	605.9	2531
Summit, grade	608.9	2546
Forres	615.5	2428
Walsh	627.9	2430
Summit, grade	636.4	2522
Irvine	638.3	2493
Dunmore, junction of the Northwest Coal & Navigation Company's Railway	652.8	2405
Medicine Hat	660.3	2171
South Saskatchewan River, low and high water, 2137–2154; grade	660.6	2173
Stair	667.3	2431
Bowell	675.1	2582
Summit, grade	675.7	2594
Depression at tank, grade	682.6	2384
Suffield	686.6	2455
Langevin (a summit of grade)	695.2	2495
Kininvie	704.1	2429
Tilley	713.3	2462
Summit, grade	719.3	2506
Bantry	723.1	2471
Tank four miles west of last	727.1	2474
Cassils	733.1	2517
Southesk	740.7	2501
Lathom	748.9	2559
Bassano	757.5	2589
Summit, grade	764.4	2722

	Miles from Winnipeg.	Feet above the sea.
Crowfoot	765.9	2698
Summit a half mile east of tank	768.4	2739
Crowfoot Creek, grade	770.1	2689
Cluny	776.5	2850
Gleichen	784.8	2952
Summit, grade	790.0	2997
Namaka	793.8	2971
Summit, near tank	796.2	3038
Strathmore	801.0	3032
Cheadle	809.4	3189
Summit, grade	815.0	3306
Langdon	819.5	3292
Summit, grade	824.8	3373
Depression, grade	828.2	3334
Shepard	830.1	3370
Summit, grade	832.9	3409
Bow River, grade	836.8	3377
Elbow River, water, 3394; grade	839.2	3411
Bow River at the mouth of Elbow River, water	839.2	3390
Calgary	840.1	3421
Keith	849.4	3547
Cochrane	862.9	3743
Radnor	873.1	3876
Morley	881.6	4061
Kananaskis River, bed	892.0	4149
Kananaskis	894.1	4214
The Gap, station	901.9	4225
Bow River here, at point of issue from the mountains, water, about	901.9	4215
Branch of Bow River, water	902.3	4220
Canmore	907.2	4278
Bow River, water	914.5	4359
Duthil	914.8	4380
Devil's Head Creek, water	916.1	4436
Anthracite	917.3	4484
Banff (new station)	921.8	4515
Forty Mile Creek, water	922.0	4505
Cascade	927.9	4531
Bow River, water	934.2	4586
Castle Mountain station	938.6	4653
Eldon	946.3	4804
Baker's Creek, water	948.6	4852
Lion Creek, water, 4949; grade	954.2	4970
Laggan	956.2	5029
North branch of Bow River, water	956.2	5020
South branch of Bow River, water	957.8	5049
Bath Creek, water	961.3	5263
Summit of grade crossing Rocky Mountains, Wapta or Kicking Horse pass	962.2	5323

	Miles from Winnipeg.	Feet above the sea.
Stephen	962.7	5313
Summit Lake, water	962.7	5308
Hector	965.0	5197
Kicking Horse Lake, water	965.0	5190
Kicking Horse River, first crossing, water	966.2	5184
Mount Stephen tunnel, grade	970.4	4335
Field	973.2	4058
Muskeg summit, grade	975.7	4164
Ottertail Creek, water, 3746; grade	978.4	3856
Ottertail	980.2	3689
Kicking Horse River, water	981.4	3665
Leanchoil	986.4	3570
Summit grade	988.6	3669
Kicking Horse River, fourth crossing, water	992.7	3287
Palliser	994.2	3275
Kicking Horse River, sixth crossing, water, 2666; grade	1003.5	2682
Golden	1006.7	2570
Columbia River here, at the mouth of Kicking Horse River, water	1006.7	2557
Arm of Columbia River, water	1008.7	2538
Moberly House	1013.4	2537
Blueberry Creek, water	1016.7	2544
Donald	1023.6	2565
Columbia River, first crossing, grade	1024.4	2544

c. Main line through British Columbia, from Donald to Vancouver.

From H. Abbott, Superintendent of the Pacific Division, Vancouver, whose figures, referred to the level of the Pacific Ocean, are given without change in the first column of these elevations, showing at Donald a discrepancy of 39 feet above the preceding series from Winnipeg, Lake Superior, and the Atlantic. In the second column these figures are revised by subtraction of 39 feet from the east end of the series for agreement at Donald; by comparison with a profile from Donald to Sicamous, supplied by P. A. Peterson, engineer, Montreal, which indicates that this correction should be reduced to 30 feet at Glacier House and onward, and to 20 feet at Twin Butte and onward; and by comparison with elevations supplied by Dr. G. M. Dawson, copied from profiles in the office of Collingwood Schreiber, engineer of government railways, Ottawa, which seem to require the continuance of this subtraction of 20 feet west to Notch Hill and Shuswap, beyond which they indicate that the elevations received from Mr. Abbott are probably correct. This line, however, needs verification by levelling from Donald to Lytton, about 300 miles, within which distance the discrepancy of 39 feet at Donald can probably be eliminated. At Lytton, and through the remaining distance of about 150 miles to Vancouver, these elevations agree with those published by Dr. Dawson in advance sheets of the second edition of Macfarlane's *American Geological Railway Guide*, and with the blue-print condensed profile prepared in the engineers' office of this railway, Montreal.

	Miles from Winnipeg.	Feet above the sea. (Abbott.)	Feet above the sea. (Revised.)
Donald	1023.6	2604	2565
Beaver	1035.6	2453	2414
Six Mile Creek station	1041.0	2633	2594
Bear Creek station	1050.0	3680	3641
Rogers Pass station	1055.0	4222	4183
Summit grade in Rogers Pass, crossing the Selkirk Mountains	1056.5	4366	4327
Glacier House station	1059.0	4102	4072
Ross Peak Siding	1065.5	3471	3441
Illecillewaet	1074.5	2740	2710
Albert Canyon station	1081.0	2244	2214
Twin Butte station	1091.0	1918	1898
Revelstoke (at the second crossing of the Columbia River)	1103.0	1515	1495
Summit grade in Eagle Pass, crossing the Gold range	1111.0	1848	1828
Clanwilliam	1112.0	1827	1807
Griffin Lake station	1120.0	1537	1517
Craigellachie	1130.5	1259	1239
Sicamous bridge, crossing narrows of Shuswap lake, 1173 (1153); Sicamous station	1147.0	1171	1151
Salmon Arm	1166.0	1175	1155
Tappen Siding	1173.5	1168	1148
Notch Hill station (Shuswap summit)	1183.0	1708	1688
Shuswap	1198.5	1173	1153
Duck's	1214.5	1150	....
Kamloops	1231.5	1153	....
Tranquille	1239.5	1134	....
Cherry Creek station	1245.5	1134	....
Savona's	1256.5	1158	....
Penny's	1262.5	1252	....
Ashcroft	1276.5	996	....
Spatsum	1291.5	854	....
Spence's Bridge station	1303.5	768	....
Drynock	1309.5	752	....
Lytton	1325.5	687	....
Cisco	1331.5	558	....
Keefer's	1341.5	555	....
North Bend	1352.5	487	....
Spuzzum	1367.5	394	....
Yale	1379.5	217	....
Hope	1393.5	208	....
Ruby Creek station	1401.5	94	....
Agassiz	1411.5	52	....
Harrison	1420.5	38	....
Nicomen	1429.5	23	....

	Miles from Winnipeg.	Feet above the sea. (Abbott.)	Feet above the sea. (Revised.)
Mission	1439.5	33	....
Wharnock	1449.5	14	....
Hammond	1457.5	19	....
Port Moody	1469.5	5	....
Hastings	1478.0	22	....
Vancouver, 2904.8 miles from Montreal	1482.0	3	....

d. Emerson Branch.

From Collingwood Schreiber, engineer of government railways, Ottawa.

It agrees with the Saint Paul, Minneapolis & Manitoba Railway on the international boundary.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Red River, grade on Louise bridge	0.8	752
Winnipeg Junction (of this branch with the main line)	2.0	752
Saint Boniface, 429.6 miles from Port Arthur	3.0	754
River Seine, high water	10.5	760
Saint Norbert	12.0	767
Niverville	23.5	774
Rat River, low water, 752; high water	30.0	763
Otterburne	30.6	779
Dufrost	39.0	791
Arnaud	47.0	794
Roseau River, low water, 761; high water, 1880	54.5	779
Dominion City	55.0	785
Joe River, low water, 756; extreme high water	62.6	785
Emerson, 391.1 miles from Saint Paul	65.0	790
Grade on the international boundary, connection with the St. P., M. & M. Railway	65.1	790

e. Southwestern Branch.

From R. M. Pratt, engineer, Winnipeg; and west of Manitou in part from profile in the office of P. A. Peterson, engineer, Montreal.

The profile requires an addition of twenty-four feet, which is made here. It agrees near Gretna and at Emerson with lines of the Saint Paul, Minneapolis & Manitoba Railway on the international boundary, and at Thornhill with levelling from Park River, North Dakota, in the survey of the beaches of Lake Agassiz.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg, 1422.8 miles from Montreal	0.0	757
Junction of this branch with main line	1.1	760
Saint James	3.6	764
Assiniboine River, ordinary low and high water	3.7	736–754

	Miles from Winnipeg.	Feet above the sea.
La Salle (or Stinking) River, ordinary low and high water	18.3	737–750
La Salle station	18.5	770
Scratching River (R. aux Gratias), low and high water	42.0	744–770
The upper part of this stream, above the marshes in which it is lost in T. 7, Rs. 2, 3 and 4, is called Boyne River (R. aux Iles du Bois).		
Morris	42.8	772
Rosenfeld, junction of lines to the south and west	56.2	796
On the line south from Rosenfeld:		
Gretna	70.1	829
Grade on the international boundary, connection with the Neche line of the St. P., M. & M. Railway	70.4	830
On the line (abandoned) from Rosenfeld to Emerson:		
Crossing the first initial meridian, grade	62.1	794
Marais River (R. aux Marais), bed	68.9	781
West Lynne	75.7	790
Red River, low and high water	77.0	750–787
Emerson	77.2	790
On the line west from Rosenfeld:		
Morden	80.6	978
Thornhill	87.9	1314
Summit, grade	94.4	1588
Darlingford	95.9	1560
Summit, grade	99.4	1618
Manitou	102.4	1586
In the descent from the top of the bluff of the Pembina River valley at 106 miles (grade, 1552) to its bottom at 112 miles, the profile is very irregular, with frequent cuts 10 to 50 feet deep and fills of 10 to 30 feet.		
La Riviere	112.5	1304
Pembina River, water, 1287; grade	112.7	1304
Ascending from the Pembina valley, the profile is broken by many ravines to 119 miles, where grade at the top of the bluff is 1547. The width of this valley is one to two miles.		
Pilot Mound	125.2	1549
Summit, grade	125.9	1555
Crystal City	130.0	1513
Crystal Creek, water, 1474; grade	130.6	1500
Summit, natural surface and grade	132.2	1519
Clearwater, water of Clearwater (Cypress) Creek, 1426; grade at station	134.1	1498

LIBRARY
NAT. RES. INTELL. BR.

	Miles from Winnipeg.	Feet above the sea.
Smoothly undulating contour reaches from 137 to 141 miles, with grades from 1515 to 1532; also between 141 and 147 miles, with grades from 1525 to 1535 feet.		
Cartwright	144.9	1533
Badger Creek, water, 1476; grade	147.6	1509
Moderately undulating surface extends thence to 156 miles, the highest grades being 1535 to 1551 feet.		
Holmfield	155.4	1551
Long River (White Mud River), water, 1541; grade	155.7	1551
Thence the line rises gradually westward to 169.4 miles, where the natural surface and grade are 1649 feet.		
Killarney	164.1	1625
Little Pembina station	169.7	1649
Pembina River, water, 1605; grade	170.3	1645
The valley here is only 40 feet deep and about 40 rods wide.		
Lake, water, 1636; grade	171.7	1641
Lake, water, 1645; grade	172.2	1648
Summit, level grade	181.1–181.7	1690
Boissevain	182.7	1683
Whitewater Lake, low and high water	192.7	1632–1637
Deloraine	202.7	1644
The last twenty-five miles of this line lie near the northern base of Turtle Mountain.		

f. Manitoba & Southwestern Railway.

[Operated by the Canadian Pacific Railway Company.]

From R. M. Pratt, engineer, Winnipeg, and west of Elm Creek in part from profile in the office of P. A. Peterson, engineer, Montreal.

With uniform addition of twenty-four feet.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Junction with Canadian Pacific Railway	1.2	760
Colony Creek, bed	2.8	758
Sturgeon Creek, low water	7.5	756
Assiniboine River, low and high water	14.0	754–764
Headingly	14.2	776
La Salle River, low and high water	26.8	766–774
Starbuck	27.2	781
Elm Creek station, junction of Carman branch	45.0	819
On the Carman branch:		
Maryland (on the Burnside beach of Lake Agassiz)	47.5	844
Barnsley (end of track)	51.0	854

	Miles from Winnipeg.	Feet above the sea.
End of grade, one mile north of Carman..........	56.0	861
Boyne River (R. aux Iles du Bois), low and high water....................................	56.5	842–854
On the main line west from Elm Creek junction:		
Burnside beach of Lake Agassiz, crest, 845; grade..	46.1	841
The descent from the crest eastward is ten feet in 25 rods, and westward seven feet in an equal distance.		
Slough, water, 965; grade........................	57.8	967
Slough, water, 1016; grade........................	63.0	1018
Slough, water, 1043; grade........................	66.0	1045
Boyne River, low water, 1034; grade..............	68.9	1047
Norcross beach *b* of Lake Agassiz, crest, 1167; grade	75.2	1162
The descent from the crest eastward is 15 feet, and westward 10 feet.		
Norcross beach *a*, crest, 1195; grade...............	75.7	1191
Herman beach *dd*, crest, 1211; grade..............	76.0	1206
The descent from the crest eastward is 15 feet, and westward 7 feet.		
Summit, on the Herman beach *d*, natural surface and grade....................................	76.2	1217
Little Boyne River, low water, 1169; grade........	77.3	1209
Treherne	77.6	1212
Boyne River, low water, 1166; grade..............	78.4	1222
Herman beach *bb*, crest, 1252; grade..............	80.6	1247
The descent from the crest both to the east and west is about ten feet.		
Summit, natural surface and grade the same, being the highest grade on this profile............	84.8	1248
Holland..	85.9	1237
Cypress River station............................	95.0	1232
Cypress River, low water.........................	95.7	1214
Glenboro (end of track, 1886)....................	105.0	1231
Summit in sec. 4, T. 6, R. 16....................	.....	1489
Divide between Souris River and Pelican Lake, in Lang's Valley (the channel of a glacial river that flowed southeast to the Pembina River) ..	.....	1364
Prairie west of Lang's Valley	.....	1524
Souris River at Souris City......	.....	1164
" " at Milford	.....	1114

The following branches of the Canadian Pacific Railway, running northward from Winnipeg on the west side of the Red River, receive an addition of twenty-four feet, like the main line from Winnipeg west :—

g. West Selkirk Branch.

From profile in the office of P. A. Peterson, engineer, Montreal.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Junction with main line	1.5	759
This branch is very nearly level, ranging from 760 to 750 feet, between Winnipeg and Lower Fort Garry (also called the "Stone Fort").		
Lower Fort Garry	19.5	754
West Selkirk	23.5	736
End of the "river track"	24.1	724
Red River, ordinary stages of low and high water	24.1	712–725

h. Stonewall Branch.

From R. M. Pratt, engineer, Winnipeg.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Air Line Junction, with main line	1.9	761
Stony Mountain station	13.3	773
Stonewall	19.8	810

WINNIPEG & HUDSON BAY RAILWAY.

From Collingwood Schreiber, engineer of government railways, Ottawa. With addition of twenty-four feet, as before explained.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Junction with the Canadian Pacific Railway	4.7	780
Burnside beach of Lake Agassiz about three miles south of Shoal Lake, crest and grade the same	31.0	860
Lowest natural surface crossed by the railway beside Shoal Lake, 852; grade	38.2	855
Shoal Lake, five to fifteen feet deep, surface at ordinary low stage, 850; low and high water	....	849–853

MANITOBA & NORTHWESTERN RAILWAY.

From profiles in the office of George H. Webster, engineer, Portage la Prairie.

These profiles are referred to the Canadian Pacific Railway station at Portage la Prairie, which is called 100 feet. The original figures accordingly receive here a uniform addition of 754 feet to refer them to mean sea level.

a. Main line.

	Miles from Portage la Prairie.	Feet above the sea.
Portage la Prairie, Canadian Pacific Railway station, 1478.8 miles west from Montreal, 56 miles west from Winnipeg	0.0	854
Portage la Prairie, Manitoba & Northwestern Railway station	0.0	856
Channel by which the Assiniboine River overflowed into Lake Manitoba, May 3-15, 1882, bed, 850; grade	2.9	859
Macdonald	9.8	837
Westbourne	16.9	831
White Mud River, first crossing, bed, 812; grade	17.4	831
Burnside beach of Lake Agassiz, crest, 860-862; grade at switch of spur track to gravel pit	21.8	860
Woodside	26.8	858
White Mud River, second crossing, bed, 849; grade.	27.3	859
Summit, grade (one foot above natural surface)	32.2	878
Depression, filling 3 feet; grade	34.0	876
Gladstone beach, natural surface at crest, 878; grade	34.3	880
Verge of plain of Gladstone, natural surface, 882; grade	34.5	884
Gladstone, section house and tank, grade	34.7	884
" passenger station	34.9	883
White Mud River, third crossing, bed, 871; grade	35.7	889
Gopher Creek, bed, 876; grade	36.5	888
Secondary Emerado beach, forty rods wide, crest, 916; grade	39.1	917
Depression west of this, 914, marking the beginning of a more rapid ascent westward.		
Emerado beach, about thirty rods wide, crest, 927-929, wind-blown in hollows one to two feet below the crest	39.9	927-9
Depression west of this, 925.		
Third Blanchard beach, crest and grade alike	42.4	969
This beach ridge is thirty rods wide, with descent of five feet both to the east and west from its crest.		
Midway	43.3	975
Second Blanchard beach, crest, 979; grade	43.9-44.1	980
This deposit is almost flat, not having the usual ridged form. It is nearly a quarter of a mile wide, and is bordered on the west by a depression of two feet, to 977.		
First or upper Blanchard beach, another tract nearly like the last, natural surface, 994; grade	45.3-45.4	995
Depression, natural surface, 991; grade	45.5	993

	Miles from Portage la Prairie.	Feet above the sea.
Level grade (½ to 2 feet above the natural surface).	45.7–46.1	1004
Lower McCauleyville beach, crest and grade alike..	46.4	1016
Depression west of this, 1014.		
Middle McCauleyville beach, crest, 1029; grade.....	47.0	1025
Descent of three and five feet, respectively, to the west and east from the crest.		
Stream, bed, 1018; grade........................	47.1	1027
Upper McCauleyville beach, crest, 1039; grade......	47.6	1035
Descent of four and six feet, respectively, to the west and east from the crest.		
Lower Campbell beach, crest, 1061; grade..........	48.2	1056
This beach ridge is twenty rods wide, with descent of eight feet east and five feet west.		
Slight beach mark, natural surface................	48.6	1070
Beginning of nearly level grade on the east margin of the Arden beach ridge (two feet above the natural surface)...........................	48.7	1079
Arden......................................	51.6	1086
Upper Campbell beach ridge, excavated for ballast, crest, 1089; grade........................	51.8	1084
Snake Creek, bed, 1061; grade....................	52.0	1079
Lower Tintah beach ridge, crest and grade alike....	55.4	1111
This has a width of about thirty-five rods, with a descent of four feet to the east and three feet to the west.		
Beach ridge associated with the preceding, crest, 1115; grade..............................	55.7	1116
Dune crossed on steep grade, crest, 1133; grade....	56.9	1134
Depression west of this, 1131.		
Dunes three to five feet high occur at 57.15, 57.2, and 57.3 miles, with crest and grade alike in each, respectively 1150, 1152½, and 1154 feet.		
Level grade (0 to 7 feet above the natural surface)...................................	57.3–57.7	1154
Upper Tintah beach, crest, 1158; grade............	57.8	1157
This has a descent of eleven feet in fifty rods east, and three feet in six rods west.		
Nearly level natural surface, 1174–1172; grade...	58.1–58.8	1174–1177
Ridge of dune sand, crest, 1177; grade............	58.9	1178
This has a descent of five feet to the east and three feet to the west.		
Ridge of dune sand, crest, 1179; grade............	59.3	1180
This likewise has a descent of five feet to the east and three feet to the west.		
Dunes at the level of the Lower Norcross beach occur at 60.1, 60.2, 60.25 and 60.3 miles, with their crests successively at 1192, 1192⅓, 1192½, and		

	Miles from Portage la Prairie.	Feet above the sea.
1193½ feet. The intervening hollows are two, four, and five feet deep in order from east to west, i.e. at 1190, 1188½, and 1187½ feet. Grade here	60.1–60.5	1193
From the dunes at 58.9 miles and 59.3 miles to 60.5 miles the surface is wind-blown sand with hollows two to four feet deep. The railway bed, formed of this sand, is somewhat insecure, because of its liability to be channelled by the wind.		
Neepawa	61.0	1206
Upper Norcross beach, crests successively 1223½, 1225, and 1225; grade	61.45–61.6	1227–1232
The descent westward from each crest is only one foot.		
Eroded escarpment, base, 1225; crest, 1240; grade	61.6–61.7	1232–1239
Herman beach *bb*, crest, 1304; grade	64.0	1305
This ridge has a width of forty rods, with descent of seven feet both to the east and west from its crest. It is found to consist of sand and gravel suitable for ballast, nearly like that of the Arden ridge, and has been purchased by the railway company for this use.		
Herman beach *b*, crest, 1323; grade	64.7	1320
This ridge descends seven feet from crest to base in fifteen rods, the amount of descent and length of slope being nearly alike on the east and west.		
Stony Creek, bed, 1359; grade	66.3	1373
Bridge Creek station	70.3	1600
Summit grade (two feet above natural surface)	76.0	1798
Little Saskatchewan River, bed, 1654; grade	78.4	1669
Minnedosa, junction of Rapid City branch	78.5	1670
Summit, grade (two feet above natural surface)	83.0	1928
Depression, filling eight feet; grade	83.9	1906
Summit, grade (three feet above natural surface)	87.0	1956
Basswood	88.5	1949
Outlet from Basswood Lake, bed, 1932; grade	88.6	1950
Summit, highest grade on this railway	92.8	1983
Newdale	96.8	1975
Grade and natural surface	100.0	1972
Grade and natural surface	103.0	1950
Strathclair	106.1	1901
Salt Lake, bed, 1855; water, 1860; grade	108.3	1867
Summit, cutting four feet; grade	109.0	1879
Shoal Lake station	114.9	1812
Oak River, bed, 1791; water, 1794; grade	115.0	1811

	Miles from Portage la Prairie.	Feet above the sea.
Shoal Lake, about a third of a mile south; water, approximately	115.0	1793
Summit, cutting two feet; grade	117.0	1830
Kelloe	123.2	1814
Solsgirth	129.8	1789
Grade (eight feet above the natural surface)	132.0	1697
Ravine, bottom, 1596; grade	132.8	1648
Birdtail Creek, bed, 1538; water, 1540; grade	134.5	1558
Summit, grade (one foot above the natural surface)	137.0	1704
Birtle	137.6	1703
Summit, cutting one foot; grade	138.0	1706
Stony Creek, bed, 1683; grade	139.0	1701
Summit, grade (one foot above the natural surface)	144.0	1747
Foxwarren	145.2	1742
Summit, grade	149.0	1772
Silver Creek, bed, 1631; water, 1632; grade	153.9	1704
Binscarth, junction of Shell River branch	154.9	1713
Two miles northwest of Binscarth, natural surface and grade	157.0	1654
Three miles farther northwest, natural surface, 1515; grade	160.0	1521
Johnson's Creek, bed, 1350; grade	161.8	1408
Old bed of the Assiniboine River, bed, 1317; stagnant water, 1319; grade	162.7	1349
Assiniboine River, bed, 1309; water, 1314; grade	162.9	1342
One mile northwest of Assiniboine River, natural surface, 1405; grade	164.0	1408
Two miles farther northwest, natural surface and grade	166.0	1533
Harrowby	167.6	1593
Grade and natural surface	173.0	1638
Langenburg	180.1	1681

b. Rapid City Branch (Saskatchewan & Western Railway).

	Miles from Portage la Prairie.	Feet above the sea.
Minnedosa	78.5	1670
Little Saskatchewan River, first crossing, bed, 1643; water, 1645; grade	80.2	1658
Riverdale	87.1	1636
Little Saskatchewan River, second crossing, bed, 1569; water, 1570; grade	92.4	1579
Rapid City	93.9	1579
A survey from Rapid City westward supplies the following:		
Surface, S. E. ¼ of sec. 19, T. 13, R. 20	101.5	1701
" W. ½ of sec. 16, T. 13, R. 21	105.5	1734

	Miles from Portage la Prairie.	Feet above the sea.
Oak River, sec. 23, T. 13, R. 22, water, 1668; proposed grade	109.2	1703
Surface on line between secs. 28 and 33, T. 14, R. 25	132.0	1688
Surface, S. W. ¼ of sec. 6, T. 15, R. 25.	135.5	1623

c. Shell River Branch.

Binscarth	154.9	1713
Four miles north of Binscarth, grade and natural surface	158.9	1791
Four miles farther north, grade (three feet above natural surface)	162.9	1797
Russell	166.2	1830

d. Line surveyed west from Langenburg to the south side of the Beaver Hills.

	Miles from Portage la Prairie.	Feet above the sea.
Red Deer Horn Creek, bed	185.0	1721
Surface	188.0	1729
Surface	195.0	1726
Big Cut Arm Creek, bed	198.5	1651
Surface	203.0	1720
Surface	210.0	1709
Crescent and Leech lakes, a few miles north of this line, approximately	....	1679
Surface	220.0	1763
Surface	230.0	1816
Surface	234.0	1863
Ravine, bottom	236.0	1882
Surface, end of survey	237.5	1919

This line ends in the west part of T. 23, R. 7 W. from the second initial meridian, between the Beaver Hills on the north and the Pheasant Hills on the south, and about fifteen miles east of the File Hills.

e. Line surveyed northwest from Langenburg, passing northeast and north of the Beaver Hills.

	Miles from Portage la Prairie.	Feet above the sea.
Summit	194.0	1774
Surface	212.0	1721
Armstrong's Coulée, first crossing, bed	213.9	1686
" " second crossing, bed	217.4	1652
Yorkton	222.5	1633
Mill Creek (South branch of White Sand River), bed	223.3	1585
Surface	226.0	1620
Summit	231.0	1697

	Miles from Portage la Prairie.	Feet above the sea.
Creek, bed	233.1	1654
Big Bone Creek (or Little White Sand River), bed	233.5	1651
Surface	238.0	1690
Owl Creek, bed	240.2	1683
Surface	243.0	1709
Clair Creek, bed	244.5	1691
Small lake	245.7	1711
Surface	252.0	1747
Chippewa Creek, bed	253.8	1736
Surface	256.5	1770
Fern Creek, bed	258.3	1747
Surface	260.0	1781
Bear Creek, bed	262.7	1762
Spring Creek, bed	265.3	1785
Surface	270.0	1820
Water-course, bed	272.5	1813
Surface	273.0	1825

Along its last forty miles this line lies from two to seven miles southwest of White Sand River. It terminates near the north side of T. 30, R. 10 W. from the second initial meridian, a few miles north of the Beaver Hills and about twenty-five miles east of the Big Touchwood Hills.

REGINA & LONG LAKE RAILWAY.

From R. M. Pratt, engineer, Winnipeg.

	Miles from Regina.	Feet above the sea.
Regina, junction with the Canadian Pacific Railway, 356.6 miles from Winnipeg	0.0	1885
Qu'Appelle River, low water, 1595; grade	21.4	1609
End of track	22.2	1606
Arm of Long Lake here, in sec. 23, T. 20, R. 21, water	22.2	1598

[Longlaketon, at the southeast end of the main lake, is about three miles farther northwest.]

NORTHWEST COAL & NAVIGATION COMPANY'S RAILWAY.

From Dr. George M. Dawson, of the Geological and Natural History Survey of Canada.

	Miles from Dunmore.	Feet above the sea.
Dunmore, junction with the Canadian Pacific Railway, 652.8 miles from Winnipeg	0.	2405
Bull's Head Creek, grade on bridge	2.	2314
Seven Persons River, grade on bridge	16.	2446
Crossing the west line of T. 11, R. 8, a summit of grade	27.	2772

	Miles from Dunmore.	Feet above the sea.
Entering the northeast corner of T. 10, R. 11	40.	2592
Depression, grade	49.	2562
Crossing the west line of T. 10, R. 12	53.	2614
" " T. 10, R. 14	65.	2609
" " T. 9, R. 16	78.	2677
" " T. 9, R. 17	84.	2707
" " T. 9, R. 18	90.	2768
Depression, grade	91.	2751
Crossing the west line of T. 9, R. 19	96.5	2806
" " T. 9, R. 20	103.	2877
Summit of grade	106.	2999
Lethbridge	109.	2954

This elevation proves the approximate correctness of that barometrically determined by Dr. Dawson, before this railway was built, for the Belly River (2717 feet) at the "Coal Banks," about a mile southwest of Lethbridge. The general surface of the country here is 250 to 300 feet above the river.

DRAINAGE SYSTEM OF THE RED RIVER OF THE NORTH.

From levelling by U. S. engineers, under the direction of Major C. J. Allen, of Saint Paul; from railway surveys; and from the U. S. Geological Survey of Lake Agassiz.

a. Red River.

	Feet above the sea.
Lakes on the Otter Tail River in Becker county, Minnesota	1500–1400
Otter Tail Lake	1315
Red River in Fergus Falls, descending 80 feet, approximately	1210–1130
Mouth of Pelican River, about	1115
Mouth of the Bois des Sioux River, Breckenridge and Wahpeton	943
Mouth of the Bois des Sioux River, highest flood, about	958
Lake Traverse, head of the Bois des Sioux River, low and high water	971–976
Red River at McCauleyville and Fort Abercrombie	910
Red River at McCauleyville and Fort Abercrombie, highest flood, about	934
Surface of ground at Fort Abercrombie	937
Red River at Moorhead and Fargo, bed, 862; ordinary low and high water, 870-885 or 890; extreme low and high water (range, 32 feet)	866–898
At Belmont (formerly Frog Point), extreme low and high water (range, 50 feet)	797–847
Mouth of Red Lake River, Grand Forks, bed, 779; extreme low and high water (range, 44 feet)	784–828
Mouth of Pembina River, Pembina and Saint Vincent, bed, 739; ordinary low and high water, 753–782; extreme low and high water (range, 40 feet)	748–788

	Feet above the sea.
At Emerson, on the international boundary, ordinary low water and extreme high water	750–787

The following elevations of the Red River at Winnipeg and northward are derived from surveys for the Canadian Pacific Railway, being in considerable part from the published report of Sandford Fleming, engineer in chief, 1880, p. 269, from which a uniform subtraction of six feet is here made to accord with the revised profile of this railway.

Mouth of Assiniboine River, Winnipeg, extreme low water, 724; ordinary summer stage, 730; ordinary spring floods, 740-745; high water, 1882, 750; do., 1860, 759; do., 1852, 761; do., 1826, 763; general level of the land surface, 758; extreme low and high water (range, 39 feet)	724-763
At the Louise bridge, Winnipeg, extreme low water, 723; ordinary spring floods, about 740; high water, 1882, 749; do., 1826, 763; general level of the land surface, 756; extreme low and high water (range, 40 feet)	723–763
At Saint Andrew's church, extreme low water, 715; ordinary spring floods, about 735; high water, 1852, 745; do., 1826, 753, nearly the same as the general level of the land surface; extreme low and high water (range, 38 feet)	715–753
At Lower Fort Garry (the "Stone Fort"), extreme low water, 711; ordinary spring floods, about 730; high water, 1852, 736; do., 1826, 746; general level of the land surface, 752; extreme low and high water (range, 35 feet)	711–746
At West Selkirk, extreme low water, 710; ordinary spring floods, about 720; high water, 1852, 726; do., 1826, 732; general level of the land surface, 739; extreme low and high water (range, 22 feet)	710–732
At Saint Peter's church, general level of the land surface, 730; extreme low and high water (range, 15 feet)	709–724
Lake Winnipeg, mean, 710; extreme low and high water, approximately	708–713

b. Pembina River.

Whitewater Lake, low and high water	1632–1637
At bridge of the Manitoba & Southwestern Railway, near Little Pembina station	1605
Divide between the Souris and Pembina Rivers, in Lang's Valley	1364
Bone Lake in Lang's Valley	1357
Grass Lake and Pelican Lake	1355
(Range of Pelican Lake from low to high water, 3 feet.)	
Lakes Lorne and Louise, about	1345
Rock Lake, about	1335
At the Marringhurst bridge, about	1330
Swan Lake, about	1310
At bridge of the Manitoba & Southwestern Railway, La Rivière	1287

	Feet above the sea.
At the Mowbray bridge, on the line between secs. 21 and 22, T. 1, R. 8, about	1235
On the international boundary, about	1125
At the "fish trap," seven miles west of Walhalla, North Dakota (fall, 7 feet in an eighth of a mile), estimated about	1050–1043
At the Walhalla bridge, low and high water	934–943
At the Saint Joseph bridge, seven miles east from the last	865
At Neche, bed, 810; low and high water	813–832
Mouth of Tongue River, about	770
At bridge of the Duluth & Manitoba Railroad	757
Junction with the Red River, Pembina, extreme low and high water	748–788

c. Assiniboine River.

At bridge of the Manitoba & Northwestern Railway, bed, 1309; water	1314
Mouth of the Qu'Appelle River, about 17 miles south of the foregoing	1264
At bridge of the Canadian Pacific Railway, 1¾ miles east of Brandon	1161
Mouth of the Souris River, approximately	1100
At outcrop of Niobrara limestone in sec. 36, T. 8, R. 11, about 3½ miles east of the mouth of Cypress River, approximately	1000
At Portage la Prairie, ordinary low and high water, two miles southwest from the town, near the former site of the Hudson Bay Company's fort	842–850
At Portage la Prairie, extreme high water, May 3–15, 1882, when the river overflowed here, sending part of its waters north to Lake Manitoba	854
This rise was caused by an ice jam a few miles farther east. It is said that the river had previously overflowed here to Lake Manitoba about twenty years before (probably in 1860).	
Big Slough, occupying a deserted channel of the Assiniboine close south of Portage la Prairie, ordinary stage of water, 849; in ordinary spring floods, 850; in the great flood of May, 1882, 854; range, 5 feet	849–854
At Pratt's Landing, 2½ miles southeast from Portage la Prairie, ordinary low and high water, 840–849; lowest and highest stages	837–852
At centre of lot 142, Baie St. Paul, near the southeast end of Long Lake	796
In lot 230, Baie St. Paul	779
At St. Francois Xavier church	765
At crossing of the Winnipeg meridian, in Headingly	757

	Feet above the sea.
At Headingly, 1½ miles farther east, ordinary low and high water	754–764
Mouth of Sturgeon Creek	745
At Saint James, ordinary low and high water	736–754
Junction with the Red River, ordinary low and high water, 728–742; extreme low and high water	724–763

d. Lakes on the Qu'Appelle River.

From H. Y. Hind; referred to sea level approximately by comparison with elevations determined by levelling.

	Feet above the sea.
Sand Hill Lake	1685
Divide in glacial water-course between the Elbow of the South Saskatchewan and this lake	1704
Buffalo Lake	1635
Qu'Appelle River at bridge of the Regina & Long Lake Railway	1595
Long Lake, tributary to the Qu'Appelle River	1598
Fishing Lakes	1504–1500
Crooked Lake	1389
Round Lake	1364
Junction of the Qu'Appelle with the Assiniboine	1264

e. Souris or Mouse River.

On the international boundary, crossing from Assiniboia into North Dakota, 215 miles west of the Red River, about	1650
At Minot, North Dakota	1535
At Towner, North Dakota	1445
Crossing the international boundary 170 miles west of the Red River, about	1400
At Plum Creek, Manitoba, about	1335
At the Elbow west of Lang's Valley, 21 miles east-southeast from the last, about	1265
At Gregory's mill, in sec. 34, T. 6, R. 18, five miles north from the last, head 8 feet, about	1210–1202
At Souris City	1164
At Milford	1114
Junction with the Assiniboine, about	1100

ALTITUDES ON THE CANOE ROUTE FROM LAKE SUPERIOR TO LAKE WINNIPEG, BY WAY OF THE KAMINISTIQUIA RIVER.

Determined by levelling by S. J. Dawson in 1857 and 1858, and published in Hind's *Narrative of the Canadian Exploring Expeditions*, London, 1860, vol. ii, pp. 399–402; corrected approximately by comparison with the survey of the Canadian Pacific Railway.

a. From Lake Superior to the Lake of the Woods.

	Miles from Lake Superior.	Feet above the sea.
Mouth of the Kaministiquia River, Lake Superior	0.0	602
Mountain portage (Kakabeka Falls), Kaministiquia River, 248 rods, ascending 119 feet (including 14 feet of rapids below the alls)	29.2–30.0	681–800
Rocky portage (or Ecarté portage), 148 rods, ascending 63 feet	30.2–30.7	800–863
Nine portages, ascending successively 6½, 12½, 7, 19, 10, 3, 3, 3, and 15 feet, intervene between the last and Little Dog Lake.		
Little Dog Lake, 1.2 miles across on this route	52.3–53.5	1002
Great Dog portage, 1⅔ miles, ascending 348 feet, to Great Dog Lake	53.5–55.2	1002–1350
Summit of this portage (a broad and massive sand ridge)	54.0	1470
Highest part of this sand ridge, east of the portage path, about	54.0	1500
"The great falls of Little Dog River are surprisingly beautiful. The difference in level between Little and Great Dog Lakes ...... is descended by the foaming torrent in six successive leaps."		
Great Dog Lake, 90 feet deep, crossed 10¾ miles on this route to the mouth of Dog River	55.2–66.0	1350
Mouth of Prairie River, tributary to Dog River	98.8	1378
Cold Water Lake, crossed 0.2 mile on this route	101.9–102.1	1381
Prairie portage, 2½ miles, ascending 157 feet, to Height of Land Lake	102.1–104.6	1381–1538
Summit of this portage, about	....	1570
The highest land there within view is about	....	1600
Height of Land Lake, crossed 0.2 mile on this route	104.6–104.8	1538
The portage from this to Savanne Lake "passes over a low sandy ridge supporting small pine."		
Savanne Lake, crossed 1½ miles on the route	105.4–106.9	1522
Great Savanne portage, 1½ miles, descending 32 feet to the Savanne River	106.9–108.4	1522–1490
Thousand Lakes (Lac des Mille Lacs), 21¾ miles on the route	121.6–143.4	1485
Thousand Lakes (Lac des Mille Lacs), low and high water, approximately	....	1483–1488
The Seine River, outflowing from this lake to Rainy Lake, has a total descent of 368 feet, approximately. Hind states that it "falls 350 feet by twenty-nine steps vary-		

	Miles from Lake Superior.	Feet above the sea.
ing in altitude from three to thirty-six feet."		
Baril Lake, on the head stream of Sturgeon River, crossed 8 miles on the route	143.6–151.6	1487
Brulé portage, 84 rods, descending 47 feet	151.6–151.9	1487–1440
Upper Brulé Lake (or Cannibals' Lake), 8 miles on the route	151.9–159.9	1440
Lower Brulé Lake, 4¼ miles on the route	159.9–164.1	1437
Great French portage, 1¾ miles, descending 100 feet to French Portage Lake	164.1–165.8	1437–1337
French Portage Lake, 1½ miles on the route	165.9–167.4	1337
Pickerel Lake, 13 miles on the route	169.9–182.9	1336
Pickerel portage, 104 rods, descending 7 feet to Doré Lake	182.9–183.2	1336–1329
Doré Lake, 1¾ miles on the route	183.2–185.0	1329
Deux Rivières portage, 128 rods, descending 117 feet to Sturgeon Lake	185.0–185.4	1329–1212
Sturgeon Lake, 23¼ miles on the route	185.4–208.6	1212
First Sturgeon rapids, descending 4 feet in 44 rods	208.6–208.7	1212–1208
Second Sturgeon rapids, portage 12 rods, descending 6 feet	209.0	1208–1202
Island portage, 12 rods, descending 10 feet	221.2	1197–1187
Nequauquon Lake (or Lac la Croix), 8 miles on the route	225–233	1186
Rattlesnake portage, Namekan River, 20 rods, descending 12 feet	235.2–235.3	1184–1172
Crow portage, 32 rods, descending 10 feet	238.6–238.7	1171–1161
Grand Falls portage, 24 rods, descending 16 feet	245.2–245.3	1158–1142
Foot of Grand rapids, Namekan River	248.8	1127
Lake Namekan, 6½ miles on this route	251.3–257.8	1126
Rainy Lake, 38 miles on this route	263.3–301.3	1117
" low and high water, approximately		1115–1120
Rapids, Rainy River, ½ mile, descending 3 feet	301.3–301.8	1117–1114
Chaudière Falls, close east of Fort Francis, portage 32 rods, descending 23 feet	303.3–303.4	1114–1091
Manitou rapids, descending 2½ feet in 60 rods	336.2–336.4	1081–1078½
Long Sault, descending 3 feet in ¼ mile	342.9–343.1	1075–1072
Lake of the Woods, crossed 72 miles on this route	381.1–453.1	1060

b. Winnipeg River.

The difference in elevation between the Lake of the Woods and Lake Winnipeg determined by this survey agrees exactly with that found by the railway survey.

	Miles from the Lake of the Woods.	Feet above the sea.
Lake of the Woods, low and high water, 1057–1063; mean	0.0	1060
Rat Portage, 52 rods, descending 16 feet	0.0–0.2	1060–1044
Les Dalles rapids, descending 3 feet in ¼ mile	8.25–8.5	1043–1040
Grand Décharge, descending 6 feet in ¼ mile	33.55–33.8	1038–1032
Terre Jaune portage, 20 rods, descending 22 feet	35.7–35.8	1029–1007
Charette Décharge, descending 3½ feet in 8 rods	36.5	1006½–1003
Terre Blanche portage, 40 rods, descending 8 feet	37.5–37.6	1002–994
Cave rapids, descending 2½ feet in 8 rods	38.0	993½–991
Mouth of English River, approximately	54.0	987
De l'Isle portage, 8 rods, descending 3½ feet	57.0	986½–983
Chute à Jacques portage [Jack's Falls], 12 rods, descending 13 feet	80.1	979–966
Point des Bois portage, 52 rods, descending 10½ feet	89.7–89.9	964½–954
Point aux Chênes portage [the Upper Falls], 20 rods, descending 20 feet	90.0–90.1	954–934
Roche Brulé portage, 12 rods, descending 8 feet	91.1	933–925
Slave Falls, portage 120 rods, descending 20 feet	95.5–95.9	924–904
Barrier Falls, portage 8 rods, descending 5 feet	102.0	902–897
Otter Falls, descending 3 feet in 4 rods	107.0	895–892
Seven portages, successively 10, 8, 5½, 8, 3, 8, and 4¾ feet, follow.		
Foot of the seventh portage	116.2	826
Bonnet Lake, 4½ miles across on this route	127.6–132.1	823
Bonnet portage, 4 rods, descending 7 feet	132.2	823–816
Cap de Bonnet portage, 16 rods, descending 5 feet	132.85–132.9	814–809
Big Bonnet portage, 200 rods, descending 34 feet	136.2–136.8	805–771
Petit Roche portage, 52 rods, descending 8 feet	137.1–137.3	770–762
White Mud portage, 60 rods, descending 13 feet	140.7–140.9	758–745
Silver Falls [or Lower Falls], two portages, 92 rods, descending 22 feet	144.4–144.7	744–722
Pine portage, 48 rods, descending 8 feet	150.25–150.4	720–712
At Fort Alexander	161.4	710
Mouth of River, Lake Winnipeg, mean, 710; low and high water, approximately	163.2	708–713

There are thus twenty-seven portages (the two décharges being included) between the Lake of the Woods and Lake Winnipeg.

SASKATCHEWAN RIVER.

From surveys of the Canadian Pacific Railway; of the Geological and Natural History Survey of Canada, by Dr. G. M. Dawson, R. G. McConnell, and J. B. Tyrrell; and of the Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind.

	Feet above the sea.
Bow River at the Gap, where it issues from the Rocky Mountains, about	4215
Bow River at Calgary, mouth of the Elbow River	3390
" at the Blackfoot Crossing, near the centre of T. 21, R. 21	2595
Belly River at the "Coal Banks," Lethbridge	2717
Confluence of the Bow and Belly Rivers, forming the South Saskatchewan	2212
South Saskatchewan River at Medicine Hat, low and high water	2137–2154
South Saskatchewan River at mouth of Red Deer River	1958
" in T. 22, R. 18, long. 108° 27′	1782
" at the Elbow	1619
North Saskatchewan River at Rocky Mountain House and mouth of Clearwater River, about	3150
North Saskatchewan River at mouth of Brazeau River	2637
" at big coal seam (27 feet thick, but including two feet of shale), Goose Encampment, long. 114°30′	2307
North Saskatchewan River at proposed crossing of the original line of the Canadian Pacific Railway, long. 114°	2136
North Saskatchewan River at Edmonton, about	2000
Edmonton, 200 feet above high water level of the river, about	2210
North Saskatchewan River at Victoria, near mouths of Egg and Smoky Creeks	1871
North Saskatchewan at Fort Pitt	1722
Junction of the South and North Saskatchewan Rivers, estimated	1200
Cedar Lake	824
Cross Lake	818
Head and foot of Grand rapids of the Saskatchewan, extending from about four and a half to two miles above its mouth (fall stated by Hind to be 43½ feet in these two and a half miles, the upper 28½ feet being passed by a portage a little more than a mile long), approximately	765–720
Lake Winnipeg, mean, 710; low and high water, approximately	708–713

NELSON RIVER.

The following estimated elevations of points on the Nelson River are by Dr. Robert Bell (*Reports of Progress, Geol. Survey of Canada*, 1877-79).

	Feet above the sea.
Lake Winnipeg	710
Great and Little Playgreen Lakes, also	710
Sea River Falls, seventeen miles below Norway House, about	705–700
Pipestone and Cross Lakes, on the Nelson River at the north end of Ross Island, about	665
Sipi-wesk Lake on Nelson River from lat. 55° to 55°20′, about	565
Grand rapid, "a descent of about fifteen feet in the form of a steep chute," four miles south of Split Lake, about	460–445
Split Lake, in lat. 56°15′ to 56°35′, about	440
Gull Lake, eighteen miles below (east-northeast of) Split Lake, about	420
Twelve-feet chute, forty-three miles below (east of) Gull Lake, about	200–188
Foot of Broad rapid, "two miles wide, and full of knobs and little ridges of gneiss," extending five miles next below the Twelve-feet chute, or 116 to 111 miles from the mouth of Nelson River, about	125
Foot of First or Lowest Limestone rapid, about ninety miles by the course of the river above its mouth, probably about	50

ALTITUDES ON THE INTERNATIONAL BOUNDARY FROM LAKE SUPERIOR TO THE ROCKY MOUNTAINS.

From reports of N. H. Winchell, H. Y. Hind, G. M. Dawson, R. G. McConnell, and the U. S. Northern Boundary Commission; referred to sea level by comparison with railway surveys.

	Feet above the sea.
Lake Superior, mean, 602; extreme low and high water, approximately	599–604
Mountain Lake, at head of Pigeon River	1652
South Lake, at head of Arrow River	1535
Water divide on the boundary, between South and North Lakes	1573
North Lake, at head of waters draining to Rainy Lake	1535
Gunflint Lake	1530
Saganaga Lake	1368
Otter Track Lake	1326
Knife Lake	1322
Basswood Lake	1244
Lac la Croix (or Nequauquon Lake)	1186
Namekan Lake	1126
Rainy Lake, mean, 1117; low and high water, approximately	1115–1120

	Feet above the sea.
Lake of the Woods, mean, 1060; low and high water, approximately	1057–1063
Ridge twelve miles farther west, forming the divide on the boundary between the Lake of the Woods and Roseau Lake	1088
Pine River	1047
Roseau Lake, about	1040
Ridge three miles west of Pine River	1070
Roseau River at Pointe d'Orme	976
Ridge twenty miles east of the Red River	1016
Ridge twelve miles east of the Red River	848
Emerson	790
Red River, ordinary stage, 752; low and high water	747–787
Gretna	829
Pembina Mountain, base and top	1030–1500
Pembina River, approximately	1125
General level of the adjoining country, about	1540
Lac des Roches in North Dakota, and divide between this lake and Badger Creek in Manitoba, about	1520
Turtle Mountain, according to Dr. G. M. Dawson's map	2150
" according to profile in report of the U. S. Boundary Commission	2000–2534
Souris River, first crossing, about	1400
" second crossing, about	1650
Coteau du Missouri, base and crest	1900–2140
Wood Mountain, highest portion on the boundary	2950–3075
" north of the boundary	3350
White Mud River	2550
Boundary Plateau	3000–3250
East fork of Milk River	2790
Wild Horse Lake	2850
Milk River, probably about	2600
West Butte, the highest of the Sweet Grass Hills or Three Buttes	6483
East Butte	6200
Trail from Fort Benton to Fort MacLeod	3548
North Branch of Milk River one mile north of the boundary, long. 113°	4173
Eastern base of the Rocky Mountains, long. 113°25′, about	4500
Waterton Lake (or Chief Mountain Lake), crossed by the boundary in long. 113°52′, in the east edge of the Rocky Mountains	4245
Rocky Mountains, summits in the vicinity of this lake, on the continental water-shed	7,500–10,500

ADDITIONAL ALTITUDES IN MANITOBA AND ADJOINING PORTIONS OF CANADA.

Mostly from reports of the Geological and Natural History Survey of Canada; in part corrected approximately by comparison with the Survey of the Canadian Pacific Railway.

	Feet above the sea.
Lake Nipigon (540 feet deep near Echo Rock)	915
Depressions in the line of water-shed northwest of Lake Superior	1500–1750
Lonely Lake (Lac Seul)	1232
This altitude, determined independently, probably requires some subtraction, for the description of the canoe route from Lonely Lake to Lake Saint Joseph shows that the latter is the higher, the difference being apparently twenty feet or more.	
Lake Saint Joseph (mean of ten barometric observations on as many days)	1172
Lake Lansdowne, near the head of the Attawapishkat River, about	960
Lake Saint Martin	794
Lake Manitoba (determined by levelling by H. S. Treherne, of Saint Paul, Minn.), mean, 809; low and high water, approximately	805–813
Lake Winnipegosis, mean, 828; low and high water, approximately	825–831
Lake Dauphin	839?
Swan Lake, about	860?
Divide between Lake Winnipegosis and Cedar Lake	875?
Cedar Lake, on the Saskatchewan	824
Pembina Mountain, crest of the escarpment	1400–1500
Tiger Hills	1500–1600
Big Tiger Hill, north of Lang's Valley, about	1640
Brandon Hills	1550–1600
Riding Mountain, about	2000
Duck Mountain	2300–2700
Thunder Hill	1900
Churchill River, 105 miles from its mouth, in the direction S. 33° W. (astr.), at the mouth of the Little Churchill River	705
Was-kai-ow-a-ka Lake, at the head of the Little Churchill River	936
Churchill River, 23 miles above the mouth of the Little Churchill	878
Frog portage, from the Churchill River to the Lake of the Woods, at the head of a chain of lakes and streams flowing southward to the Saskatchewan, estimated	1200

The following altitudes, from Isle à la Crosse Lake to Lake Athabasca, which are here noted as determined by Sir John Richardson (*Arctic Expedition in Search of Sir John Franklin*), probably require an average addition of about 200 feet.

	Feet above the sea.
Isle à la Crosse Lake, on the Churchill River...............	1300

Thence southward to Carlton House on the North Saskatchewan, about seventy miles above the junction of the South and North Saskatchewan Rivers [estimated 1200 feet above the sea], Richardson reports a descent of about two hundred feet, across "an undulating country, but without any marked acclivity."

Professor Macoun states that Isle à la Crosse, Clear, and Buffalo Lakes "are on the same level," being stagnant water filled with green scum in summer.

Methy Lake or Lac la Loche..................................	1490
" " (according to Captain Lefroy, cited by Richardson)..................................	1500
Summit of Methy portage (also called Portage la Loche and the Long Portage), on the water-shed between the Churchill and Athabasca Rivers..........................	1556
The "Cockscomb," on this portage at the crest of the bluff descending to the Clearwater River, tributary to the Athabasca..	1534
Clearwater River at the north end of this portage..........	900
Lake Athabasca..	600

Altitudes determined by Dr. G. M. Dawson show the present height of the glacial lake bed now drained by the Peace River, and of its probable first avenues of outflow southeast to Lake Agassiz, as follows:

Peace River at Dunvegan................................	1300
Top of river-bluff one mile from Dunvegan................	2100
General level of the country in this vicinity...............	2200
Area of lacustrine silt in the basin of the Peace River.......	2000–2500

The valley of this part of the river, eight or nine hundred feet deep, is eroded in a vast plain, from which, according to Richardson, "the Rocky Mountains are not visible, and no range of hills meets the eye."

Water-shed between Peace River and Lesser Slave Lake...	2430
Water-shed between Tow-ti-now River, a tributary of the Athabasca, and the North Saskatchewan, on the trail from Athabasca Landing to Edmonton................	2485

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

MINERAL RESOURCES

OF THE

PROVINCE OF QUEBEC.

BY

R. W. ELLS, LL.D., F.G.S.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
WILLIAM FOSTER BROWN & CO.
1890.

To Alfred R. C. Selwyn, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

Sir,—I have the honour to forward my report on the "Mineral Resources of the Province of Quebec." In this report I have endeavoured to present, as clearly and concisely as possible, a history of the several Mining industries from their inception to the present time, and have availed myself of all the information, not only to be found in the reports of the Geological Survey, but from leading articles and reports by experts in the different branches of mining, and published in the scientific journals, both in this country and in England. For much information, also, I am indebted to gentlemen, at some time connected with the mining industries of the province, the names of some of whom have been mentioned in the Report, and to all of whom I beg to tender my sincere thanks for the assistance afforded in such cases. Where mines have been closed for a number of years, it has been found impossible to obtain all or the latest information relating to the subject. The report must, therefore, of necessity be imperfect on these points.

I have the honour to be, Sir,

Your obedient servant,

R. W. ELLS.

Geological Survey Office,
May 10th, 1890.

THE

MINERAL RESOURCES

OF THE

PROVINCE OF QUEBEC.

By R. W. ELLS, LL.D., F.G.S.A.

In preparing a history of the mineral resources of the province of Quebec it may be premised that a very large part of the material is necessarily derived from the publications of the Geological Survey, which has, for nearly fifty years, been working in this field. I am further indebted for information to the many valuable papers which have been published in one or other of the scientific journals of Canada and the United States, during the same period, by gentlemen connected with the mining industry, among whom may be mentioned Dr. James Douglas, Mr. H. S. Williams, M.E., Mr. James Douglas and Mr. W. Chapman. As, however, many of these publications—notably "The Geology of Canada, 1863," which contained a summary of nearly all the previous reports of the Survey—are long since out of print, and the valuable information they contain is not now easily accessible to the general public or to those especially interested in the development of the mineral wealth of the province, it has been thought desirable to reproduce certain portions of these publications in order to render the present report as complete as possible; the object being thus to present in an accurate and concise form a sketch of the rise and development, as well as of the present status of the leading mining industries; while the mode of occurrence and probable importance of the various sources of mineral wealth will be indicated as clearly as the available information will permit. **Sources of information.**

Among those who have furnished valuable information bearing on these subjects, and to whom thanks are due, I may mention Messrs. W. S. Hunter, of Belleville; C. H. Miller, Drummondville; Dr. James Reed, Inverness; Capt. Wm. Warne, Eastman; J. S. Ross, of Beauce; and Thos. Macfarlane, M.E., of Ottawa. **Assistance.**

In order to render more intelligible the statements, about to be made, regarding the distribution of the several mineral deposits, a brief sketch of the geological systems and formations is requisite; especially as the labours of the Geological Survey since 1869 have resulted in producing very considerable changes in the geological lines as laid down on the geological map of Canada, published in 1866; and as regards some districts have resulted in an almost entire change of opinion as to the age and relations of the formations over very large areas. These changes of the last fifteen or twenty years affect more especially that part of the province east of the St. Lawrence River, occupied by the crystalline schists and associated rocks, which are of special importance from their constituting the great mineral-bearing belts of the region from Vermont to Gaspe.*

Geology of the province.

Of the several geological formations now known to exist in Quebec, the oldest and the most important are those known as Metamorphic, Archæan, or Pre-Cambrian, consisting of the Laurentian* and Huronian systems. The first of these, the Laurentian, extends the entire length of the province from the Ottawa River to Labrador, and is confined to the north side of the St. Lawrence. From the vicinity of Montreal to Cape Tourmente, twenty miles below Quebec, it is separated from the river by a belt of irregular width, consisting of overlying, mostly undisturbed, formations which pertain to the Cambrian and Cambro-Silurian systems, and include the Potsdam, Calciferous, Chazy, Trenton, Utica and Hudson River. Below Cape Tourmente some of these formations re-appear, but only at the following widely separated points, viz.: Murray Bay, Bay St. Paul, Mingan Islands, and the Strait of Belle Isle. Except as sources of lime and building stone, mineral waters and small quantities of natural gas, they are not of economic importance, but in the wider parts of the belt they form considerable tracts of level and fertile country.

North side of the St. Lawrence River.

Minerals of the Laurentian system.

Except a few basin-shaped areas occupied by outliers of lower palæozoic rocks, as at Lake St. John and Lake Temiscamingue, the whole of the northern part of the province is, so far as at present known, occupied by the crystalline rocks of the Laurentian system, which as productive of economic minerals, are of great importance, furnishing, as they have done where explored, large deposits of iron ore, graphite, apatite, mica and zinc blende; also, veins containing gold and argentiferous galena. There are also extensive strata of quartz rock and orthoclase felspar, suitable for the manufacture of glass and porcelain, while serpentine and marble occur in considerable variety.

Huronian.

The rocks of the second or Huronian division of the Archæan are almost equally important as regards the economic minerals associated with them. They differ in many respects from those of the

* The term Laurentian was first officially used in the Geol. Survey Report for 1852–53.

Laurentian above described, and are confined to that portion of the province which lies to the south and east of the St. Lawrence River and Gulf and the great St. Lawrence and Champlain fault.

For the purposes of the present report they may be considered together with the immediately succeeding lower Cambrian and Cambro-Silurian systems, from which they are not everywhere easily separable, and together with which they have been greatly disturbed and altered, giving rise to conditions that do not occur in the rocks of nearly the same age to the north and west of the great fault. **Cambrian and Cambro-Silurian.**

They consist of schists of various kinds, chloritic, talcose, micaceous and hornblendic, with crystalline limestone, dolomites, great masses of dioritic rock, agglomerates, serpentines, and, in some places, imperfect gneisses and granitoid rocks.

The copper ore which has for so many years been mined in the province is found in this area. There are also extensive beds of iron ore, magnetite, hematite and chromite. In the copper lodes gold and silver occur, the latter often in sufficient quantity to be of economic importance. Antimony ore, argentiferous galena, asbestus and roofing slates also occur; the two latter already constituting important industries. **Minerals east of the St. Lawrence.**

In connection with the great exhibitions held from time to time at London, Paris and Philadelphia, between the years 1851 and 1886, the Geological Survey took a prominent part in collecting, arranging and forwarding as good a representation as possible of the mineral wealth of Canada. In the catalogues which accompanied these several exhibits the various minerals have been described according to a certain well arranged scheme which places those adapted to certain purposes under their proper heading, and in now describing the mineral resources of the province of Quebec we can probably adopt no better course than to follow the scheme laid down in these publications. According to it the classification of the various sources of mineral wealth is arranged as under:— **Arrangement of the subject.**

I. Metals and their ores.
II. Materials used in the production of heat and light.
III. Materials applicable to certain chemical manufactures, and their products.
IV. Mineral manures.
V. Mineral pigments.
VI. Salt, brine and mineral waters.
VII. Materials applicable to common and decorative purposes.
VIII. Refractory materials.
IX. Materials for grinding and polishing.
X. Minerals applicable to the fine arts and jewelry.
XI. Miscellaneous.

I.—Metals and their Ores.

Iron Ore.

Of the various ores which come under division I. we may perhaps first consider those of iron, both on account of their great economic importance and their widespread distribution; and, of these, the most prominent are the magnetites, hematites and limonites or bog iron ore.

Early history of iron mining.

The history of iron mining in the province extends back for many years, but presumably the earliest operations of any importance were those in connection with the limonite or bog iron ore deposits in the district of Three Rivers. These were described as far back as the latter part of the seventeenth century, and in 1737 a blast furnace was erected, and smelting operations undertaken, which have been carried on more or less continuously to the present time. In the Ottawa district the iron deposits were first opened in 1854, near Hull, while those of R. Haycock's location were not mined till nearly twenty years later. The lack of deposits of coal has interfered very largely with the successful smelting of the iron ores, more especially of the magnetites and hematites, and other causes have seriously influenced the practicability of shipping these ores to the American market in the raw state.

Magnetic ores.

The magnetic ores of iron are found at many points, not only among the rocks of the Laurentian system in the vicinity of the Ottawa River and along the north side of the St. Lawrence, but in beds and veins, often of large size, in connection with the metamorphic series of the eastern townships of Quebec. There is, however, at times a marked difference in the character of the ores from the two series of rocks, though this difference is not constant. Thus the ores of the Laurentian, near Ottawa, are remarkably pure and rich, containing a large percentage of metallic iron, while those found along the lower St. Lawrence, below Quebec, often contain a very considerable percentage of titanic acid, and the ore passes into a true ilmenite.

Magnetites of Hull.

In the publications of the Geological Survey of Canada, the first reference to the presence of magnetic iron ore is found in the report for 1845-46, where the great ore bed near Hull is described. A brief notice of this deposit, however, appeared in a paper read by Lieut. Baddeley, R.E., before the Literary and Historical Society of Quebec, in 1830, in which it is said "to form a vein or bed from ten to twelve inches thick, and appears to traverse the mountain in a south-west course, having a vertical position as regards the walls of the vein. On the opposite side of the mountain, at the distance of upward of a mile, and in the direction of the vein, ore was again in great abundance." The presence of plumbago in the ore was also pointed out; the associated rocks being stated to be friable white marble.

In the Geological Survey Report for 1845, the ore bed at this place is stated to have a thickness of twenty feet, and to be traceable for about a mile, with a course of N.N.W. and S.S.E., and to occur on the southern half of lot eleven, concession seven of Hull, on the property of Mr. Wright, as well as on the twelfth lot of the same concession, the containing rock at this place being syenitic gneiss and crystalline limestone. The ore is described as coarse granular, and as carrying in places disseminated scales of graphite, while other portions are comparatively free from this mineral. An analysis by Dr. Hunt of an average specimen gave **Analysis.**

Magnetic oxide of iron	96.09
Silica and graphite	3.18
Metallic iron	69.65

In the report for 1847 the width of this deposit is stated as 40 feet, while the scales of graphite are said to sometimes form a vein of an inch or two in thickness.

This bed of iron ore was opened and mined in 1854 by Messrs. Forsyth & Co., of Pittsburg, with the intention of supplying the ore to their own works. In 1855, about 5,000 tons were raised, which were forwarded by the Rideau Canal to Kingston, and thence by lake vessel to Cleveland; but the discovery of the great Newboro' ore bed, in South Crosby on the canal, from which the ore could be mined and shipped at a cheaper rate than from the Hull deposit, acted disadvantageously to the latter, and its mining was for a time abandoned.

Subsequent exploration on the Hull bed showed it to have an entire thickness of about ninety feet, presenting a dome-shaped structure with gneiss on both sides and a mass of crystalline limestone protruding from below through the summit. The amount of iron ore taken from it up to 1858 is reported to be about 8,000 tons, containing 60.70 per cent. of metallic iron.

The Newboro' ore bed in South Crosby, was reported to have a thickness of 200 feet. It was mined by the Chaffey Bros., by whom some thousands of tons were extracted and forwarded to Kingston for shipment. The Hull deposit, in consequence, remained unworked for some years, but in 1867, a blast furnace was erected for the purpose of reducing the ores on the spot, which was kept in blast for a portion of 1867 and 1868. In the report by Dr. Hunt, on "The Iron Ores of Canada," in the Geological Survey Report for 1866-69, a very full account of the operations of this furnace is given. **South Crosby.**

Two kinds of ore were obtained from the Hull bed, a black magnetite and a red hematite. The analysis of these, given by Dr. Hunt,* is as follows:—

* Geo. Survey Report, 1866-69, p. 255.

In the hematite

Peroxide of iron	66.20	Metallic iron	58.78
Protoxide of iron	17.78		
Silica	10.44		

Analyses of Hull ore.

In the magnetite

Magnetic oxide of iron	73.99
Metallic iron	53.20
Silica	20.27

Both contained very small quantities of phosphorus and sulphur.

Smelting operations at Hull.

The results obtained while the furnace was in blast from the 27th of April to the 5th of October, 1868, as quoted by Dr. Hunt, were as follows :—

Ore from Hull and Arnprior	1,896	tons
Scrap iron	$7\frac{1}{5}$	"
Limestone	211	"
Charcoal, both soft and hard	242,782	bushels
Wood	$25\frac{1}{2}$	cords
Peat and coke	$21\frac{13}{20}$	bushels
Resulting pig iron	$1,040\frac{3}{20}$	tons
Cost per ton	$26.50	

The yield per ton of ore from these experiments is $54\frac{1}{2}$ per cent. The amount of charcoal used per ton was 235 bushels, and of peat and coke 47 lbs. Leaving out the amount of peat and coke, the quantity of charcoal per ton of ore was $37\frac{3}{4}$ cwt.

This amount of fuel is excessive as shown by Dr. Hunt, from a comparison with furnaces smelting similar ores in Sweden, where the average weight of the charcoal required, per ton, is for white or mottled pig iron but sixteen to seventeen cwt., while for gray metal for foundry purposes or for Bessemer steel from twenty-one to twenty-two cwt. On the assumed weight of charcoal at 18 lbs. per bushel, this saving, at 8 cents per bushel, would effect a reduction on the cost per ton of pig iron of seven to eight dollars. At Port Henry, on Lake Champlain, according to the same authority, where magnetic ores, similar to those of Hull are smelted with anthracite coal, the average consumption is from 1.10 to 1.14 tons, equal to 22 or 23 cwt. of anthracite to the ton of pig iron. He further remarks that the lack of profit in smelting the Hull ore is due to excess or wastefulness in use of fuel and to the useless or unnecessary addition of sand and clay in the charge.

So much for the experience of twenty years ago. Probably the most important paper that has been published since then on the subject of iron manufacture in Canada is that by Mr. John Birkenbine on

"The Possibilities of Iron Manufacture at Ottawa." The remarks in reference to Ottawa are equally applicable to many other portions of Canada. This paper was read before the Institute of Mining Engineers at the Ottawa meeting, in October, 1889. From it we learn that anthracite is laid down at the furnaces on Lake Champlain, at $4.25 per ton and probably could be supplied at the furnaces in Ottawa at something under $5 per ton, so that the cost of the fuel necessary to produce a ton of pig iron from the Hull ores should not now exceed $6. Under the old process with charcoal, the cost of the fuel was from $12 to $14 per ton, so that a saving of $6 to $8 per ton in this item alone could now be effected. From the figures given by Mr. Birkenbine, who is a leading authority on the manufacture of iron, we may quote the estimated cost of producing pig iron in Ottawa as follows :—

Mr. John Birkenbine quoted.

Cost of pig iron at Ottawa.

Fuel, Anthracite..........................	$6.50	
" Charcoal, estimate................	7.00 to $8.00	
Ore..	4.25	
Flux..	.50	$11.25
Labor and other expenses connected with production......................		2.75
		$14.00

The above figures, compared with those of the cost of production while the Hull forges were in operation, show a saving of $12.50 per ton. In smelting the ores at Hull, a great advantage is derived from having the ores and the flux in close proximity, and the only thing lacking is the fuel supply. At the Londonderry Mines in Nova Scotia, the disadvantage arising from a lack of fuel and flux on the spot is very great; the former having to be brought either from Spring Hill in the raw state and coked at the mines or as coke from Pictou, about eighty miles distant; while the latter is brought from Brookfield, a distance of forty-four miles. In addition to this, the ordinary Londonderry ores are not nearly so rich in metallic iron as those of Hull, and for some years a considerable portion of the supply of ore has been obtained from Pictou or Brookfield; while during the past year a further supply has been contracted for from the county of Annapolis, which will entail a railway haul of not far from two hundred miles.

Londonderry Mines compared.

Mr. Birkenbine also makes a strong point in regard to iron smelting in Canada, by showing that pig iron is protected to the amount of $5.60 per gross ton by bounties and duties, so that, at the figures quoted for manufacture, the real cost of pig iron to the manufacturer in Canada is only $8.40 per ton, or, making due allowance for profit and other items, foreign foundry pig would need to be laid down in Ottawa at a cost of $11.00 per ton to compete successfully with the home manufacture. He also thinks it very possible that much of the enormous waste of sawdust and mill refuse could be utilized in connection with some of the processes of manufacture, as is the case in Sweden.

Haycock's location.

About six miles from the Hull deposit, on the other side of the Gatineau River, may be mentioned that on the Haycock location. The ore is a mixture of hematite and magnetite, and occurs in a series of beds associated with red and grey felspathic gneiss. The deposit has been only partially opened up, and further developments may prove it to be of some importance.

At the Bristol Mines, thirty-five miles up the Ottawa River from Hull, a very extensive deposit of magnetite also occurs. The first reference to this is in the Report of the Geological Survey for 1845-46, pp. 77-78; as well as to the extension of the same ore into McNab on the west bank of the river. In the report for 1873-74 Dr. Harrington gives some important details regarding this ore. He says: (p. 196)

Dr. Harrington on the Bristol deposit.

"During the winter of 1872-73 several openings were made in deposits of magnetic ore on lots twenty-one and twenty-two, range two, Bristol, Pontiac county, Quebec. The ore here forms a series of beds, interstratified with reddish syenitic gneiss and glistening, micaceous and hornblendic schists. The thickness of what appeared to be the uppermost and most important bed could not be ascertained...... Judging, however, from the quantity of ore taken out, the thickness must be considerable. Besides this bed, three others had been exposed. One of them was two feet thick, another only a few inches, while the fourth appeared to be about nine or ten feet thick, so far as the small amount of work done enabled one to judge."

In the same report, page 208, the analysis of this ore is given as under:—

Specific gravity		4.32
Peroxide of iron	65.44	
Protoxide "	14.50	
Bisulphide "	2.74	
Protoxide of Manganese	0.11	
Alumina	0.60	
Lime	3.90	
Magnesia	0.45	
Silica	11.45	
Carbonic acid	1.64	
Phosphoric acid	traces	
Titanic acid	none	
Water	0.14	
		100.97
Iron as peroxide	45.81	
" protoxide	11.28	
" bisulphide	1.28	
Total metallic iron		58.37
Sulphur		1.46

"Combining a sufficient quantity of the peroxide of iron with the protoxide to form magnetic oxide, we find the ore to be a mixture of magnetite and hematite in the proportion of 46.72 of the former to 32.22 of the latter" (1.40 : 1.)"

Mr. Birkenbine on the Bristol deposits.

Mr. Birkenbine describes the Bristol ore as a rich dense magnetite, with a very small percentage of phosphorus, but with so much sulphur as to render roasting necessary. He says that the mine has been opened to a depth of 150 feet, and with drifts along the strike for 150 feet and across the bed for 50 feet in one place, and from 50 to 60 feet in another, so that the deposit promises to be extensive. The ore is now being extensively shipped to the States. The quantity of sulphur which necessitated roasting the ore from the upper benches has become so much diminished in that from the lower workings as to render roasting no longer necessary. In the vicinity also, on the other side of the Ottawa, in Renfrew and Lanark, beds of both limonite and magnetite occur, which carry a large percentage of iron, and are in such close proximity to those of Hull that if any central location in the vicinity of Ottawa should be selected for smelting operations the supply of ore from many available points could be secured at very cheap rates, either by rail, from the localities up the Ottawa just described, or by canal, from the great ore bed of South Crosby on the Rideau, as well as from the great deposits of bog iron ore, presently to be described.

Ores of Grenville.

The occurrence of magnetic ores in Grenville, on the south half of lot three, range five, was pointed out by Sir William Logan in the Geological Survey Report for 1853, p. 38. The breadth of the vein was estimated at from six to eight yards. This was traced for 150 yards in a westerly and south-westerly direction, the country rock being a micaceous gneiss, interstratified with many beds of quartzite. The assay of a specimen by Dr. Hunt gave metallic iron 52.23 per cent.

Ores of Ottawa county.

Indications of similar ore are found on the adjacent lot, in the fourth range, the beds, however, being generally thinner. No attempt has yet been made to work the ores in this area. In addition to the localities just mentioned north of the Ottawa, there are doubtless others in which ores may be found in the area drained by the Gatineau and the Lièvre Rivers. Reference is made by Mr. Vennor, in the Geological Survey Report, for 1876-77, p. 298, to the occurrence of iron ore in Cameron township, near Post Creek, about fifty-four miles in a direct north line from the Ottawa River. It was traced, by frequent exposures, southward to the mouth of the Kasabasua, between the townships of Aylwin and Hincks; and was considered to be an extension of the horizon of the Hull ore bed. More recently, deposits of iron ore have been discovered in Templeton and in the adjacent townships.

Along the north side of the St. Lawrence beds of magnetite have been reported at many points. Here, the ore is found in two forms, viz., as massive beds interstratified with the gneiss and limestone of the Laurentian, or as beds of iron sand along the beaches, often of considerable thickness and of great extent. These ores, while carrying a large percentage of magnetic oxide of iron, also frequently contain a considerable amount of titanic acid, so much so, as in many cases to entitle them to be classed as ilmenite. Of these iron deposits probably the most important, as well as the largest known, occurs at Bay St. Paul, about fifty-four miles below the city of Quebec. Here an immense bed, having a thickness of ninety feet, has been traced for some hundreds of yards. This great bed has a historic interest, having been discovered in 1666 by Sieur de la Tesserie, and some explorations were carried on in the following year by Colbert's orders under the sanction of the King of France. In spite, however, of the great quantity of ore at this point, it has never been found possible to carry on smelting operations with any measure of success, owing to the large percentage of titanic acid contained in the ore, as seen by the analysis of Dr. Hunt,* thus:—

Bay St. Paul.

Peroxide of iron	10.42
Protoxide of iron	37.06
Titanic acid	48.60
Magnesia	3.60

Two furnaces were, however, built at this place in 18 by the Canadian Titanic Iron Company. The undertaking, proving unprofitable, was discontinued in 1880.

Similar magnetic iron ore is found at different points along the north shore. Near the mouth of the Rapid River, which flows into the Bay of Seven Islands, a great mass of magnetite is found in the labradorite rocks of that place. The ore is reported by Dr. Hunt to have a breadth on the stream of about 500 yards from east to west, and to extend some distance north and south. Assays of it have given:—

Bay of Severn Islands.

Protoxide of iron	49.77
Metallic iron	38.70
Titanic acid	34.30

Moisie River.

On the beach at the mouth of the Moisie River there are also great deposits of iron sand interstratified with beds of nearly pure silica. Smelting works were erected there in 1867, which continued in operation for several years, being finally dismantled in 1876 or 1877. Similar deposits in greater or less quantity occur on the shore at Mingan,

* Geological Survey Progress Report, 1869.

Bersimis, Tadousac and at other points along the north side of the St. Lawrence. While these vary somewhat in composition, by far the greater part are titanic ores. In the preparation of these sands for the blast furnace, a large percentage of the magnetic portion can be separated by an arrangement of magnets, and the titaniferous portion, which interferes with the easy reduction of the ores, eliminated.

North of Montreal, deposits of ilmenite, very similar in character to those just described, also occur, notably at St. Jerome and near St. Lin. These have been examined by Dr. Harrington, and that from St. Jerome was found to contain:— St. Jerome and St. Lin.

Metallic iron	24.65
Titanic acid	32.36

while that from St. Lin had:—

Metallic iron	38.27
Titanic acid	33.67

Large deposits of similar ores are also reported as occurring along the Saguenay River; at Lake Kenogami and on islands at the outlet of Lake St. John. Saguenay.

In the country east and south of the St. Lawrence considerable beds of magnetite occur in places. Some of these are titaniferous, but others are remarkably pure and contain no titanic acid.

The presence of magnetite and hematite ores in Templeton, Buckingham and Hull is referred to in the Geological Survey Report of Progress for 1866, pp. 20-21. In Buckingham, on lot seventeen, range nine; and on lot twenty-six, range twelve; a vein of felspar cuts the gneiss and contains large cleavable masses of the magnetite, some of which are four inches thick. The felspar vein is about thirty paces wide, but the ore does not appear to be economically valuable, according to the observations then made. Buckingham.

On lot twenty-eight of the sixth range of Templeton deposits of hematite of considerable extent occur along with the orthoclase gneiss, but these masses, scattered through the rock, do not appear to be of any special value, though subsequent explorations may result in finding deposits of greater extent. A similar ore occurs on the adjoining lot in Hull, but has not yet been developed to any extent. Templeton.

Among other localities on the north side of the St. Lawrence River yielding iron ores, of which assays have been made, may be mentioned a magnetic ore from the Leduc Mine, lot twenty-three, sixth range of Wakefield, Ottawa county; the size of the deposit is not, however, stated. The assay by Mr. Kenrick of this Department gave:— Wakefield.

Metallic iron	69.185
Phosphorus	0.012
Titanium dioxide	Trace
Sulphur	......
Insoluble matter	1.551

St. Jerome.

An ore from the county of Terrebonne, two miles and a half south of the village of St. Jerome, on the west side of the North River, assayed by Mr. F. D. Adams, of this Department, gave :—

Metallic iron	62.191
Phosphorus	0.007
Sulphur	0.001
Titanium dioxide	Trace
Insoluble matter	9.897

Brome, Sutton and St. Armand.

In the Geological Survey Report for 1847, page 59 *et seq.*, attention was directed to the presence of beds of iron ore at various places in the townships; more especially in those of Brome, Sutton and St. Armand. These were for the most part stated to be situated chiefly in the vicinity of two dolomitic belts, ocupying the two sides of a ridge which traverses the two first mentioned townships, and in all, the ores are more or less titaniferous, sometimes strongly so. "The specific gravities of the ores in consequence frequently appear disproportioned to their produce in metallic iron, the specific gravity of the different varieties of titaniferous iron or ilmenite being as great or greater than that of the pure peroxide of iron; and from the presence of different varieties of ilmenite or their unequal mixture in the ore, it sometimes happens that a light ore will have a greater percentage of metallic iron than a heavy one. The produce of many of the beds will be found too low to render them available for economic purposes, but the ore being unequally mixed with chlorite and epidote, different samples from the same bed occasionally give different results, and, in any trial of the beds, with a view to turning them to practical account, great care should be bestowed on an effective test of them for considerable distances on the strike."

East St. Armand.

Among the localities mentioned in the Géological Survey Report for 1847, and which may be here referred to as of prospective value, are the following:—The forty-fifth lot, East St. Armand, in the south-east corner of the township, where five feet of ore, mostly red hematite or specular schist, are exposed on the west half of the lot, the limits not determined; the rocks of the vicinity are chloritic and epidotic slates. The ore is mixed with chlorite to some extent, and on assay gives 34.73 per cent. of metallic iron. A later assay gave a mean of thirty-seven per cent. of metallic iron. On the seventh lot of the ninth range of Sutton, similar ore was observed, in apparently much greater quantity, the quality varying, however, in different parts of the bed, the percentage of metallic iron by assay ranging from 15.91 to 27.53. The beds are here kept near the surface by a series of folds, so that a considerable thickness of ore is exposed. The ore bed, however, is said to be from five to eight feet thick. A continuation of possibly the same bed is seen in the south-eastern corner of lot six of the same range. Here a similar folded structure is apparent, and the bed is about seven feet thick. Another ore bed in the south-west corner of the same lot is six feet thick, and the percentage of metallic iron ranges from 22.98 to 23.86. On the fifth lot, range nine, a few yards from that just mentioned, a smooth vertical bluff of ore having a length of twenty feet and fifteen feet high is said to occur. The assay of this ore gives 48.60 of pure iron, and on lot four of the same range, a bed of one to two feet occurs, yielding 22.68 per cent. of metallic iron.

On the north half of lot nine, range nine, Sutton, magnetite grains occur in bands of limestone, in quantity sufficient to constitute more than half of the mass, and making an ore which would yield 38.76 per cent. of metallic iron ; and in the tenth range, two beds of specular ore are found, one of a foot in thickness on the seventh lot, the percentage of iron varying from 19.07 to 39.06, the other seven feet thick and yielding from 19.42 to 32.13 per cent. of metallic iron. Sutton.

On the ninth lot, eleventh range, a seven feet bed of peroxide of iron was found; the assays of two samples gave 21.78 and 39.90; and on the seventh lot another bed of unknown thickness gave 28.63 per cent. of metallic iron.

In Brome, lot one, range three, a very considerable deposit of iron ore is found in several parallel bands, varying from three to ten feet in thickness. A quantity from one of these bands was shipped at one time to the smelting works at Troy, Vermont; a distance of nearly forty miles. The assays of these ores are not given, but in the second lot of the same range a five feet bed occurs, which yielded 28.63 per cent. metallic iron. It is probably an extension of one of those just mentioned. On the Yamaska River also, on the fifth lot, range four, a little below the bridge, an eight feet bed occurs, which gave upon assay 24.08 metallic iron. Brome.

On the sixth lot, between ranges three and four, a bed of specular ore was mined and shipped to Troy. It is supposed to be three to four feet thick, though possibly more. Several other thin beds, interstratified with chloritic rocks, also occur in the vicinity; while on the fourth and fifth lots of the same range, beds of similar ore occur, having a thickness of five feet and with a percentage of metallic iron ranging from 30.97 to 37.91.

In Bolton magnetic iron is found on lot two, range fourteen, two miles east of Orford Pond. The size of the bed could not be ascertained. It was visited last season, and the pit was found filled with water. The assay of the ore by Dr. Hunt, given in the Geological Survey Report for 1847, was 37.79 metallic iron. This bed is apparently continued in the twenty-second and twenty-first lots of range fifteen, Orford. Bolton.

The associated rocks in Bolton are the diorites of Orford Mountain; the mine being a short distance north of the C. P. R. near Miletta Station.

Probable future value.

From the foregoing list of localities it will be seen that the deposits of iron ore in this district are not only numerous, but, from the assays and the extent of the beds, should be of considerable economic value. But little development has, however, been carried out in these areas, and the dimensions of the beds, as given above, cannot be taken as fully determining their extent, since much of the surface was at that time (1847) covered with forest and soil. It is very possible, as in the case of the Hull and Bristol mines, more especially of the latter, which, when discovered, were supposed to be of small extent and but little value, but which have since been found to be of great importance, some of these will also, upon closer examination, be found to be of much greater importance than at first regarded.

Titanic ores of Sutton and Brome.

The presence of titanic acid in considerable quantity in some of these ores tends to exert a prejudicial influence on their value as easy smelting ores. The percentage in some cases has been determined, and is given by Dr. Harrington in the Report of the Geological Survey for 1873-74. Thus the ore from lot nine, range eleven, gives:—

Metallic iron	40.87
Titanic acid	27.20

From lot eight, range eleven, Sutton:—

Metallic iron	39.14
Titanic acid	29.86

And from lot one, range three, Brome:—

Metallic iron	41.46
Titanic acid	24.16

Titanic ores of the Chaudière River, Beauce.

A great bed of magnetic iron ore, or more properly ilmenite, forty-five feet thick, occurring on the Colway River, about four miles north of the Chaudière, in connection with serpentines, is described by Dr. Hunt as being separable with the magnet, after crushing, into two portions; about two-thirds of the whole being a magnetic oxide of iron; the remaining third being an ilmenite which contains 48.60 per cent. of titanic acid and 40.70 per cent. of peroxide of iron. The smelting of such ore is difficult from the great amount of fuel necessary to overcome the resistance offered by the titanic acid. These ores give, generally, a brown streak, and are but slightly affected by the magnet as a whole. Other deposits in the townships are not so highly titaniferous. Thus Dr. Hunt* mentioned that some of these from Brome and Sutton contain only two hundredths of titanic acid. Assays of

* Geology of Canada, 1863, p. 501.

these ores have not, however, been made for some years, nor have tests for the quantity of titanic acid been made except in the few cases quoted.

Other deposits of magnetic ores, however, exist in the eastern townships, which are apparently entirely free from titanic acid, and which form rich and valuable ores of iron. Among these may be mentioned that on lot seven, range five, Leeds. This locality was examined by Mr. Charles Robb, who reported the presence of three tolerably regular beds of ore of six, four and three feet in width respectively, separated by bands of chloritic slates. The ore is a fine grained magnetite, more or less mixed with micaceous iron ore. Similar ore occurs in the adjoining township of Inverness. The assay of the Leeds ore gave:— **Leeds.**

Metallic iron	67.099
Phosphorus	.206
Sulphur	.038

Several assays of this ore showed the percentage of phosphorus to be variable, ranging from .025 to .335; the average for the three specimens being .188.

An assay of the Inverness ore gave:— **Inverness.**

Metallic iron	65.433
Phosphorus	.193

Neither of these ores contained titanic acid. The deposit was examined by the writer in 1887, and the principal bed was found to be from five to six feet thick, between green chloritic and micaceous schists on the upper side, having a north-west dip, and crystalline dolomite beneath. This ore has lately been mined to some extent and shipped to the Harvey Hill copper mines, where it is used as a flux in smelting the copper ores. The site of the mine is from ten to twelve miles from Robertson station on the Quebec Central railway.

A large and apparently excellent vein of magnetic ore is found on lots nineteen and twenty of the Gore, west side of Nicolet Lake, township of South Ham. The vein occurs in serpentine with a width of six feet at the surface, increasing to eleven feet in a shaft twelve feet deep. It was opened by Mr. Colombe in 1881, by whom about one hundred tons were extracted. From a partial assay made by Mr. Nagant of Quebec, and kindly furnished me by Mr. Obalski, G.M.E., this ore contained a small quantity of chromic acid. The locality is from eight to ten miles distant from the Quebec Central railway at Garthby station. **Nicolet Lake, South Ham.**

In the vicinity of Sherbrooke several deposits of magnetite occur, which, from their excellent quality and their convenience to lines of railway, should be of economic importance. Of these, the largest is on lot eight, range nine, Ascot, near the summit of the ridge lying south of the city of Sherbrooke and to the east of the Belvidere road, at an elevation of 1000 feet above the St. Francis River at that city. The magnetite here is in irregular veins in chloritic schist, distributed over several acres and ranging in thickness up to ten or twelve feet. Some portion is a hematite. Assays by Bartlett of Portland gave 49.48 of metallic iron, but the quality differs at various points; since an assay in the laboratory of the Geological Survey gave only 28.39 metallic iron, insoluble matter 45.794. It showed no trace of titanic acid. No determinations for phosphorus or sulphur were made.

Sherbrooke, Clarke's mine.

Smith's mine.

Adjoining and opposite the city of Sherbrooke, on lot twenty-one, range six, Ascot, about three quarters of a mile from the Grand Trunk railway station, on the property of Mr. Stephen Smith, is another apparently large deposit of magnetic ore. The containing rocks here are also for the most part chloritic schists of the Sherbrooke anticlinal, along with jasper, which was referred to in the earlier reports of the Geological Survey. Precisely similar rocks are found in the city of Sherbrooke itself, and on the road south towards Capelton, near the fork of the road to Belvidere. The thickness of the ore and its extent on Mr. Smith's lot are unknown; but it is evidently quite extensive, and a considerable quantity of ore has been extracted. An analysis by Mr. Hoffmann gave:—

Metallic iron	54.074
Phosphorus	.660
Sulphur	.024

with no trace of titanium.

McVeity's mine, Leeds.

An ore from one of the beds near Kinnear's Mills, Leeds, gave:—

Metallic iron	37.23
Titanic dioxide	trace
Insoluble	44.31

Ore from the specular schist bands on lot nine, range nine, Sutton, gave:—

Sutton.

Insoluble matter 40 per cent., with a strong reaction for titanic acid. The percentage of iron is not stated.

The iron ores of the eastern townships present the same difficulty as regards fuel as do those near Ottawa. The erection therefore of smelting works at some central point, as at Sherbrooke or Magog, to which the ores from the various mines could be readily brought, would be desirable, since the railway facilities are at present so great, that nearly all the most important deposits can be readily reached. Fuel suitable for smelting can be laid down in Sherbrooke at a cost for anthracite of probably not more than $5.50 to $6.00 per ton, and for coke from $4.00 to $4.50 per ton; and with the facilities presented as regards labour and shipment, the cost of smelting should not greatly exceed that given for the district of Ottawa. Probable cost of smelting at Sherbrooke.

The bog iron ores or limonites found in Quebec occur in beds which are both numerous and extensive, and have, as already stated, been worked for many years, more particularly in the district of Three Rivers. A good description of the smelting works was given by Lieut. Baddeley,* but a specially valuable paper on the history of the enterprise, by Mr. F. C. Wurtele, librarian of the society just mentioned, is contained in the Trans. Royal Society of Canada, 1886, from which we have obtained a brief abstract of the inception and history of the smelting operations at this place. The discovery of the bog ore deposits in the district of Three Rivers dates as far back as 1667. The place was visited by the Sieur de la Potardiere, who reported the deposit as of no value either in quality or quantity, and it was not until 1733 that any attempt to work it was made. From a letter of Frontenac, 1672, however, the importance of these deposits as a source of supply for iron was clearly pointed out, and plans were suggested for the erection of forges at some central point between Cap de la Madeleine and Champlain, where the deposits of ore are very extensive. They were also favorably reported on to the French Government by Denonville in 1681 and 1686, but no action was taken in the matter. In 1733, a company was formed consisting of Francheville, Peter Poulin, Gamelin and Cugnet, by whom forges were erected, but the first operations were unsuccessful; and Francheville having died, his widow and the company surrendered the forges and rights to the Crown in 1735. In 1737, however, a new company, formed the preceding year, and composed of Francois Etienne Cugnet, Pierre Francois Taschereau and several others, obtained from the king the privilege of working these ores, and this company acquired, in addition to the property on which the ore beds were more specially known to be situated, the adjoining fief of St. Etienne for the purposes of a fuel supply. Work was at once commenced, and a skilled artizan was obtained from France to conduct the operations in 1739. In 1740, the company having expended all their capital in the erection of the forges and various buildings, were compelled to return their charter to the Government of Three Rivers, and in 1743 the king ordered the furnaces to be repaired and work to be

Bog iron ores.

History of the Three Rivers forges.

* Trans. Quebec Lit. and Hist. Soc., vol. ii, 183).

resumed and conducted in his own name. This was done by the importation of skilled laborers from France, and the furnaces erected in 1737 have been in use from that date down to the present time, or to the cessation of operations on the original site a few yêars since.

Changes of ownership.

During the period between 1743 and 1863 the Three Rivers and St. Maurice forges changed hands several times, but were in almost constant operation or with occasional intervals of but short duration, necessary for repairs or during changes of ownership or management. In 1847, the property was leased to the late Hon. James Ferrier, of Montreal, for a term of four years, by whom the works were carried on very successfully, but the lease was not renewed. A lack of success apparently attended the operations of the company who succeeded him, and in 1862, the entire property was sold by the Crown Lands Department to Mr. Heroux for $7,000, by whom in turn, in 1863, the forges, water power, etc., were sold to Messrs. John McDougall & Sons, of Three Rivers, for £1,700 currency. This firm carried on smelting operations on this spot till 1876, when the property passed into the hands of Mr. George McDougall, by whom the forges were worked till 1883, when they were shut down owing presumably to the exhaustion of the supply of ore and fuel within convenient distance to be profitably handled. Charcoal alone was used throughout the whole time in which the forges were in operation, and the iron produced, for the most part, enjoyed an excellent reputation, especially for certain lines of manufacture, such as car wheels, etc.

In the report by Dr. Harrington on the iron ores of Canada,* particulars of the blast furnace so long in active operation at this place are given, p. 247, as follows :—

Smelting works, Three Rivers.

" The internal dimensions of this furnace are :—

Height	30 feet
Diameter at hearth	2½ "
" " boshes	7 "
" " throat	3½ "

" There are two twyers, and the blast, produced by water, is cold and has a pressure of one pound to the square inch. The usual charge was :—

Bog ore	600 lbs.
Limestone	45 "
Charcoal	16 bushels (French†)

* Geol. Survey Report, 1873-74,

† The French bushel weighs two pounds more than the English.

"Forty-five charges are made in the twenty-four hours, and the furnace tapped at intervals of from twelve to eighteen hours. The daily production is four tons, of which ten per cent. is white and ten per cent. mottled iron. The charcoal required per ton was about 180 bushels, weighing from eleven to twelve pounds, and costing about six cents, per bushel." The yield of the bog ore in the furnace was from thirty-three to thirty-five per cent. of iron; and the cost of the ore at the furnace was about $2.50 per ton, and sometimes rather more. The resulting pig of late years was largely used for the manufacture of car wheels. In addition to the cast iron from the blast furnace, a small quantity of iron was also produced direct from the ore by the old fashioned hearth-finery. This was employed in the manufacture of axes, and was found to be of excellent quality, not at all cold short, and showing only traces of phosphorus. From the figures given of the cost of the raw material, the cost of pig ranged from $19.50 to $20.00 per ton; the fuel itself costing nearly $11.00. Attempts made to smelt the magnetic ores of Leeds in these furnaces were not attended with success, doubtless owing to the unsuitable size and shape of the furnace for these harder varieties of ore, and similar poor results have attended the attempt to smelt the Sherbrooke magnetites in the bog ore furnaces now located at Drummondville. From the report of Dr. Harrington, above cited, as well as from an excellent and comprehensive paper by Mr. J. H. Bartlett, Montreal, "On the Manufacture of Iron in Canada," read before the American Institute of Mining Engineers at the Halifax meeting, 1885, we are able to present some details of the several blast furnaces and forges which have been worked from time to time, some of which are still in operation and using the bog iron ores of Quebec.

Cost of production.

Furnaces not suited for smelting magnetites.

Mr. J. H. Bartlett quoted.

The Batiscan iron works were erected about 1798, comprising a blast furnace, casting house, two forges, mills and other buildings on the east side of the Batiscan River, about six miles from its mouth, in the seigniory of Batiscan, Champlain Co. They were similar to those of St. Maurice, and were in operation for several years till the death of the proprietor, when the works were closed. Ore and wood are both reported as plentiful at this place.

Batiscan forges.

The Radnor forges, situated at Fermont, seigniory of Cap de la Madeleine, Champlain Co., on the River Lard, were erected in 1860, by Messrs. Larue & Co. The works comprised a blast furnace, forge and rolling mill, with a car wheel foundry at Three Rivers, about ten to twelve miles distant. The product was manufactured into car wheels principally, which had an excellent reputation. The rolling mills and forges were destroyed by fire some years ago, but the blast

Radnor forges.

furnace is still in operation, the probable output for 1887, according to Mr. Obalski, being 1,000 tons, employing forty workmen. Work at the Radnor furnace was suspended in the fall of last year. Mr. Bartlett says: "The ore is taken up from Lake Tortue. The iron manufactured is used for car wheels in the foundry of Mr. George McDougall at Three Rivers. A large sum of money has been spent on this Radnor industry."

L'Islet forges.

The L'Islet blast furnace was built by Messrs. McDougall, the proprietors of the St. Maurice forges, about four miles further up the river, north-west of the St. Maurice works, where the same conditions prevailed. These have not been in operation for some years. The Yamaska works were erected by the St. Francis River Mining Co. in 1869, on the River Aux Vaches, Yamaska county, on the east side of the St. Lawrence, and near the St. Francis River. This furnace was completed in 1869, and worked by the company till 1873, making in that time 5,520 tons of charcoal pig iron. It was then sold to Messrs. John McDougall & Co., of Montreal, who worked it till 1880, when it was closed, owing to the exhaustion of the ores in the vicinity.

Yamaska.

Drummondville.

The works at Drummondville were erected in the township of Grantham, county of Drummond, on the River St. Francis, in 1880-81, by Messrs. John McDougall & Co., of Montreal. They consist of two blast furnaces, each thirty-four feet high, with a diameter at the boshes of eight and ten feet respectively. They are worked by hot and cold blast, the motive power for the air-pump being the St. Francis River. The fuel used is charcoal. The supply of ore is obtained in part from beds of bog ore in the vicinity, and in part from Vaudreuil, near the St. Lawrence, above Montreal. The ore contains from forty to forty-four per cent. of iron; and the annual capacity of the furnace is about 4,000 tons of pig iron. It is principally used for car wheels, which are made at the foundry in Montreal.

Localities for bog iron ore.

Bog iron ores are distributed at many points throughout the province of Quebec. The deposit at Vaudreuil, now being worked for the Drummondville furnace, was referred to in the Report of the Geological Survey for 1845, as occurring on a number of lots, and having, in Côte St. Charles as well as in the Petite Côte in the same seigniory, a thickness of four feet. Near Ottawa, deposits of bog iron ore are mentioned as occurring in several places, among which are the Blanche River in Templeton, above McArthur's Mills; the fourteenth lot, concession seventeen, Hull; Eardley; at Upper Rocky Point in March; in Constance Lake and in the vicinity of the Chats. Analyses of some of these will be found further on.

Ireland.

Among other deposits referred to in the Geological Survey Report for 1849-50, are the twelfth lot, fourth range, Ireland, where an area of two yards by fifteen, in a bed about fifteen inches thick, was noted; also a bed at St. Lambert, on the west side of the Chaudiere, in the seignory of Lauzon, about twenty inches thick, but the area not ascertained, though apparently of considerable extent. In the seigniory of St. Vallier, one mile above the forks of the River Sud, two considerable areas were noted; one of which had a breadth of twenty-eight yards and a length of three hundred and eighty yards north-west from the mill, with a thickness of twenty inches; the other twelve hundred yards by twenty-four yards, and twelve to twenty inches thick; with others in the vicinity, sufficiently extensive to be of economic importance. Other deposits occur on the road between Ste. Anne des Plaines and St. Lin; and on the road between Rivière Ste. Marie and Achigan, the thickness being about six inches, but the area unknown. Considerable deposits of bog ore also occur in the township of Kildare, and the augmentation of the seigniory of La Noraye and Dautraye, near the River l'Assumption; but these areas have never been worked. They are situated on the north bank of the St. Lawrence, about midway between Montreal and Three Rivers.

St. Lambert, Chaudière district.

St. Vallier.

North side of the St. Lawrence above Quebec.

The areas from which the St. Maurice furnaces drew their supplies are for the most part entirely exhausted. They were very extensive, having furnished ore for nearly 150 years. Further to the north-east, in the seigniory of Champlain and Batiscan, large beds of this ore still exist, which, in the early part of the century, supplied forges which were operated on the Batiscan River. On the eastern side of this river, also, several areas of considerable extent occur in the vicinity of the road between the Batiscan River and the village of St. Prosper. The old forges on the Batiscan were apparently situated on the south side of the river about six to eight miles from the mouth.

Three Rivers and vicinity.

Further down the St. Lawrence, between Port Neuf and St. Basil, as well as on the Jacques Cartier, in Bois Brulé and Cap Sante, other deposits occur, the particulars of which are not to hand. The low grounds which flank the ranges of Laurentian hills along the north side of the St. Lawrence River seem to carry areas of this bog ore in great abundance, and would appear to point out the presence, at many points, of masses of pyrite or other forms of ore in the hills, not far from where these deposits are located, and from which these latter have been derived. Below Quebec similar ore is reported in small quantities in the east side of Ha Ha River, a branch of the Saguenay, and, though the quantity is not said to be very extensive, it was thought it might indicate more valuable ores in the vicinity; but on the south side of the lower St. Lawrence River, deposits have been noted and described by Mr. Richardson in several localities, which appear to possess economic values. Among these, are concession two

St Lawrence below Quebec.

Ha Ha River.

Green Island. of Green Island, where beds from ten to twenty inches thick and of considerable extent are found on ten lots, having a surface breadth of one hundred yards. In the seigniory of Cacouna, at the village of La Plaine, several small patches, with a thickness of four inches or so, were observed; and in the seigniory of Villeray, about three miles west of Green Island Seigniory, patches of ore of considerable extent, from six to twelve inches thick, occur on several of the farms in that vicinity. The ore-bearing belt here is stated to be comprised in an area of about twenty-four miles from east to west by four to six miles from north to south.

Cacouna.

Villeray.

Kamouraska. Small deposits are also reported from the seigniory of Kamouraska, near the road between that village and St. Paschal, one of which, with a thickness of six to eight inches, has an extent of three hundred by thirty paces.

St. Francis River. On the River St. Francis several areas of bog iron ore are found, one of which, near the River aux Vaches, which joins the St. Francis about ten miles from its mouth, was worked for some years and supplied the ore for the St. Francis furnace, the yield of iron obtained being about 36 per cent. At Drummondville, about twenty miles further up the stream, extensive deposits are now being worked for the furnaces at that place already referred to.

Memphremagog Lake, Hog's Back Mountain. A considerable deposit, lately opened up, occurs near the west shore of Memphremagog Lake, on the west side of the Hog's Back mountain, at Knowlton Landing, on lot twenty-eight, range nine, Potton. This ore overlies a heavy bed or vein of pyrites, carrying both copper and iron, and has a considerable surface area, with a thickness of from one to three feet. Its remoteness from smelting works and the consequent high rate of freight are at present a bar to its being profitably worked; but should furnaces be erected at some central point, as already suggested, this deposit could then be utilized, since it is within a short distance of shipment on Lake Memphremagog.

An analysis of bog ores from several localities is here appended. It will be seen that the percentage of iron varies very considerably in the ore from the different areas.

ANALYSES OF BOG IRON ORE

By Dr. B. J. Harrington.*

	I.	II.	
Peroxide of iron	40.96	69.64	No. I. is from Ste. Angelique, Vaudreuil (McGillis property).
Protoxide of iron	....	17.25	
Oxide of manganese	26.34	....	
Protoxide of manganese	....	0.05	
Lime	1.48	0.53	No. II. is from L'Islet forges, Three Rivers.
Alumina	....	.90	
Magnesia	Traces	Traces	
Phosphoric acid	0.60	Traces	
Sulphuric acid	Traces	0.05	
Silica	....	1.93	
Insoluble matter and silica	12.08	....	
Water and organic matter	17.97	22.04	
	99.43	102.39	
Metallic iron	28.67	54.34	

Analyses of bog ores.

ANALYSES OF BOG IRON ORES

By Dr. T. S. Hunt.†

	I.	II.	III.	IV.	V.	VI.
Peroxide of iron	74.50	76.95	....	77.60	74.30	64.80
Sesquioxide of manganese	....	....	....	0.30	Traces	5.50
Alumina	0.30	0.80	....	....	....	....
Silica	7.10	1.50	5.43	5.40	3.60	4.80
Phosphoric acid	....	....	1.52	1.81	1.80	Undet.
Volatile matters	18.95	19.80	19.70	17.25	22.20	23.65
	100.85	99.05	....	102.36	101.90	98.75
Metallic iron	52.15	53.86	....	54.32	52.01	45.36

I. From Petite Côte, Vaudreuil.
II., III. Côte St. Charles, Vaudreuil.
IV., V., VI. From the St. Maurice forges.

Dr. Harrington quoted.

Dr. Harrington remarks on the bog iron ores of the province, (Geological Survey Report for 1873-74):—"That they are mainly of recent age, occurring at or near the surface, and generally in sandy regions, ferruginous sands often being the source of the iron. The variety employed for smelting, concretionary lumps or massive, often

* Geol. Sur. Rep., 1873-74, pp. 236-37.
† Geol. Sur. Rep., 1873-74, pp. 236-37.

shows a curious cavernous structure, and is either dull and earthy or at times highly lustrous when fractured. The color is usually yellowish or reddish brown, and dark brown or black when much manganese is present. The proportion of iron obtained on analysis is variable, averaging about fifty per cent. In the blast furnace, however, the yield has usually been only from 30 to 40 per cent., as the ores contain a considerable quantity of silica in the form of sand, which is not easily removed even by washing. When sulphur is present it is usually only in very small quantity. The amount of phosphoric acid ranges from mere traces to nearly two per cent. The volatile matter (water and organic matter) averages about twenty per cent." The ore is easily reduced; and, judging from the iron made by Messrs. McDougall, produces, when rightly manipulated, a metal of uniform value.

Value of bog ores.

It is an important consideration in connection with the smelting of the iron ores of Eastern Quebec to ascertain to what extent the great deposits of peat already worked by several companies for the manufacture of fuel, can be utilized in the smelting of the ores of this section. In Europe, peat charcoal is largely employed in certain sections, but, owing to its friability, is unsuited for transportation to a distance or to withstand the pressure of the blast furnace. It also frequently contains a large quantity of ash. But in the Geological Survey Report for 1869, Dr. Hunt discusses the question of using peat, even in the wet state in peculiarly constructed furnaces, at some length, the feasibility of using such fuel, being demonstrated from experiments in this direction made in Sweden, where it was found practicable to use a fuel holding as much as forty-five per cent. of water in a furnace, specially adapted for this process. In this furnace not only peat but sawdust slabs and mill refuse can be used with success and economy. Dr. Hunt remarks that when such results can be obtained from the use of such materials as sawdust or with ordinary peat, the want of mineral coal need no longer be an obstacle to the development of the metallurgical industry of this country. In view of this statement by so eminent an authority, as well as of the fact that in Quebec, in the great extent of flat country east of the St. Lawrence, there are very extensive peat swamps, excellently suited for the manufacture of this form of fuel, it is certainly not unreasonable to expect that, with improved and economic methods of preparing and compressing, the peat of these great bogs may, at some time not distant, be extensively utilized for these purposes, and with results as satisfactory as have been obtained in other countries.

Dr. Hunt on peat for smelting iron ores.

From the great extent of many of the ore beds, both of the Laurentian rocks and of those east of the St. Lawrence, it appears very strange that they cannot be profitably utilised. The duty imposed by the United States Government, combined with the long carriage to the smelting works at Cleveland, or other points in the adjoining states, seriously affects their profitable export. From the figures given by Dr. Harrington in the Geological Survey Report for 1873-74, we find that no less than 47,200 tons were shipped for export in 1872-73, andabout 12,000 tons additional extracted. Lately, ore from the mines at Bristol is being shipped quite extensively, with every prospect of a profitable result.

Export of iron ore.

COPPER.

First reference to the copper ores of Quebec.

While we have seen that the presence of iron ores in workable quantities was known in eastern Canada more than two hundred years ago, and have been utilized for nearly a century and a half in the manufacture of metallic iron, the first reference to deposits of copper in the province of Quebec is apparently contained in the reports of the Geological Survey, 1847-48, where, on pages 26-27, the presence of copper pyrites is noted in connection with the limestones of Acton, Upton and Wickham, and further north in Inverness. Reference was, however, made in 1830 by Gen. Baddeley, R. E., to the copper ores of western Ontario, but at this date it does not appear that anything was known in relation to those of Quebec. As regards the deposits observed in Quebec, and referred to by Sir William Logan in the report just mentioned, the quantity was generally regarded at that time as unimportant; but several localities were recommended for trial. Among these was a quartz vein on lot four, range two, of Inverness, having a thickness of about two feet, with a course a little north by east, which, however, upon testing, although the quality of the ore was excellent, did not appear to contain sufficient to render its further exploration profitable.

Inverness.

A second area recommended for trial at the same time was the seventeenth lot, seventh range of Ascot, about one mile from Sherbrooke, on the road to Lennoxville. The thickness of the quartz vein carrying copper pyrites was from ten to twelve inches, cutting chloritic and talcose slates, and it carried, in addition to the copper ore, small quantities of gold and silver. The third locality recommended was in the fifty-first lot of the twenty-first range of Upton; the breadth of the lode, which is in a whitish gray massive limestone, being from twelve to eighteen inches, consisting of white quartz and calcspar, carrying pyrites also in small quantity. Assays of the ores from these three localities were made by Dr. Hunt. The percentage of metallic copper in the washed pyrites from Ascot was 30.34, or eighteen per cent. of

Ascot.

Upton.

the vein; from Inverness, 34.93, or seven per cent. of the unwashed ore, and from the Upton lode, from an average sample, 3.84 per cent.

St. Joseph, Beauce.

In the report of 1849-50, reference was made to traces of copper in the rocks of the Chaudière, in the seigniory of St. Joseph, where, in rear of the church at that place, spots of vitreous copper were found disseminated through quartz veins in red and green slate, and about one mile from the Chaudière River on the road to Frampton. Similar ore, in quartz veins in the red slates, was also at the same time noted as occurring in Ste. Mary's seigniory; but neither of these localities appeared to possess any special value. The deposit at Upton was opened up and found to consist of a series of bunches, following a bend in the stratification; but the opinion was expressed that their irregularity was such as to seriously interfere with their being successfully worked for copper.

The copper deposits of the eastern townships appear to have been entirely neglected for some years after this, but some examinations made about this time on the north side of the St. Lawrence, in the augmentation of Lanoraie and Dautraye, on the left bank of the River L'Assomption, showed the presence of a vein nine inches thick of calc- and pearl-spar, cutting gneiss, which carried copper and iron pyrites. On either side of the main vein, other veins were reported of an inch or more in thickness, also carrying copper pyrites, and the whole was comprised in a breadth of about nine feet. In this a shaft was sunk for sixteen feet, the vein, which had the aspect of a regular lode, appearing uniform throughout, though the quantity of copper it contained did not appear to be remarkably promising.

Lanoraie and Dautraye.

Upton.

A more detailed description of the Upton deposit appeared in the report for 1858. It is there stated to occur in a mass of greyish-white, sometimes reddish-grey limestone, compact sub-crystalline and yellowish weathering, reticulated by small veins of copper pyrites, as well as by others of quartz and various ores of iron, all of which were regarded as of segregation origin. This ore-bearing limestone was overlaid by a bed of breccia, or conglomerate, which also carried pyrites and was supposed to be underlaid by red-grey limestone, which, towards the bottom, became interstratified with red slates. No copper was found in the underlying limestone. The general dip of the measures was to the south-east at angles of 10° to 27°. The bands of limestone, carrying ore, extend through the northern part of Acton into Wickham, where, also, on the twenty-sixth lot of the last range of that township, they also carry similar ores. A second band to the south-east is seen at Acton on lot thirty-two of the third range, which extends approximately parallel to that just mentioned, and also at Wickham, and this was regarded as the equivalent of the Upton bands of rock coming to the surface on the south side of the synclinal.

Wickham.

The description of the rocks of this copper belt is considered of some importance, as illustrating a peculiar series, in which has occurred, more particularly at Acton, and presently to be described, one of the most productive copper mines ever worked in Quebec; a band entirely distinct in character from those which contain the copper deposits now so extensively worked in the townships. In order that the relations of the several ore belts may be better understood, we may here proceed to describe, before taking up the history of the several copper mines, which nearly thirty years ago were so prominently before the mining public, the views of structure of the several areas of cupriferous rocks, as stated in the Geology of Canada, 1863 and 1866, more especially since the new views of the structure and of the age of these rocks, as stated in the more recent reports, have modified the opinions there expressed to a very considerable extent. Acton.

The metamorphic rocks of eastern Quebec were, for many years, regarded as the altered equivalents of the fossiliferous and comparatively unaltered sediments of the St. Lawrence basin; and these were divided at first into two and subsequently by sub-division into three portions, viz.: The Levis, Lauzon and Sillery formations. Early views of the geology and structure of the copper-bearing rocks.

These were supposed to be arranged in a series of long and sometimes narrow folds, with many overturn dips, of which it was remarked that "the latter circumstance renders it difficult to determine which of these folds are synclinal and which anticlinal, inasmuch as the outcrop in both cases presents a similar arrangement." These metamorphic rocks, for the portion north of the Vermont boundary, considered to be specially cupriferous, were held to occur in three approximately parallel bands or areas. Thus the first area, or the most westerly, extended from Farnham, near Missisquoi Bay, to the seigniory of Lauzon, on the St. Lawrence. Where it is traversed by the St. Francis it was supposed to be nearly, or quite, separated into two parts by the appearance of what was then regarded as the underlying series of slates. In this supposed synclinal are found the deposits of Upton, Acton, Wickham, Roxton and Durham, while in the north-eastern extension are those of Wendover, Somerset, Nelson and St. Flavien. The second area, which was supposed to be divided into two parts by the ridge of the Sutton Mountain, extended from St. Armand to the seigniory of Ste. Mary, on the Chaudière. In this were the copper deposits of the townships of Sutton, Stukely, Melbourne, Cleveland, Shipton, and further to the north-east those of Halifax, Leeds, Inverness and Ste. Mary. Western area. Second or central area.

The western portion of this supposed synclinal occupied the Sutton valley; the eastern, the Potton and Bolton area along the valley of the Missisquoi River. The third area extends from the Owl's Head on Divided into two parts by the Sutton Mountains.

Memphremagog Lake to the township of Ham, and included the Stoke Mountains, while further to the north-east it was traced across the Chaudière into Buckland. It was supposed to be separated from the last by what were regarded for the most part as newer rocks, much of which were supposed to be of Upper Silurian age, although now known to belong, in great part, to much older horizons. In this area were included the deposits of Ascot, Ham and Garthby.

Eastern area.

Character of the copper-bearing rocks of the three areas.

The rocks of the first or most westerly area, extending from Farnham north-easterly, were regarded as belonging to the Lauzon and Sillery divisions of the Quebec group. They include slates, black, red, green and grey, with sandstones, diorites and dolomitic limestones; which are seen at many points. The outcrops at Upton and Acton appear to be very similar in character, and probably represent portions of the same series, brought to the surface by synclinal structure. Of the second main synclinal, as then considered, viz., that in which the Sutton mountain was supposed to occur, the rocks vary somewhat on either side of the mountain ridge; those on the west being, for the most part, schistose and crystalline, either talcose, micaceous or chloritic, while on the east side there is a large development of serpentines, diorites, slates and hard quartzite. The rocks which were found in the third area, or that of Ascot, were also largely schistose, resembling rather those of the western side of the Sutton mountain than of the eastern. It will be seen, therefore, that there is a manifest difference in character of rocks in the three areas, and, by a careful examination of the copper ores obtained from each of these, a corresponding difference in their character will also be observed; the ore of the Ascot belt being unlike that from the Potton area, while this in turn is of a different character from that of Acton or Inverness and Leeds.

Present view of structure.

The studies made of these several groups of strata during the past ten or fifteen years have led to an entire change of opinion regarding their relative age and structure from that expressed in the Geology of Canada, 1863. Instead of now regarding these different copper-bearing belts as synclinals in the Sillery or other divisions of the Quebec group, and all of Lower Silurian age, it is now very clearly established that, while the rocks of the first area are, in large part, of the age and character of what have been described as the Sillery formation, and which is now held to form the lowest member of the fossiliferous Quebec group, as developed along the south side of the St. Lawrence River, those of the second and third areas, or of Sutton and Ascot, belong, for the most part at least, to the pre-Cambrian horizon; while the slates and serpentinous or dioritic portions may probably, with more propriety, be classed in the lower portion of the Cambrian system, the slate rocks of which flank the pre-Cambrian schists on either side, and that the greater part at least of these crystalline schists really occur as anticlinal axes instead of as synclinals of altered Lower or Middle Silurian rocks.

As just stated, the character of the ores in the different copper-bearing belts,—for it is scarcely necesssary to maintain the use of the term synclinal in view of the change of opinion expressed—varies greatly when contrasted. Thus, from the more westerly belt the ores are largely yellow sulphurets, though occasionally variegated sulphurets are found mostly in a dolomitic limestone. In the township of Roxton the principal deposit was on lot twenty-three, range three, where the ore, according to the late Mr. Charles Robb, M.E., who had great experience in the mines of this section of Quebec, appeared to be disseminated through a band of this rock for a breadth of fifty feet, but was more particularly concentrated into a breadth of about one foot near a band of diorite. From the west half of this lot, belonging to Lord Aylmer, there had been obtained in January, 1864, fifty-six tons of three and a half per cent. ore, sixteen tons of five per cent. and two tons of twelve per cent.; and from the eastern half, eight tons of eight per cent. and fourteen of three and a half per cent. were taken. In the adjoining township of Ely, though indications of ore are found at a number of points, the principal deposit was on lots nine and ten of the second range, owned by the Ely Copper Mining Co., where the ores were the yellow and variegated sulphurets in a crystalline limestone. In Upton mining was carried on at four places, viz. 1st, on lot forty-nine of range twenty, called the Bissonette mine, where there was a yellow sulphuret in a thickness of three feet and a half of dolomite, yielding from 10 to 15 cwts. of 10 per cent. ore per fathom. 2nd, at the Prince of Wales Mine, on lot fifty-one of the same range, (the ore being scattered through about twenty feet of the same band as the last,) from which about forty tons of twelve and a half per cent. were obtained from open cuttings. 3rd, on lot forty-nine, range twenty-one; the ore and rock being similar to the last, and owned by Col. McDougall, by whom, from open cuttings also, about twelve tons of twenty per cent. ore and eight tons of twelve per cent. were obtained; and 4th, the Upton Mine, on lots fifty and fifty-one of the same range, where two shafts were sunk to a depth of forty-two and twenty-five feet respectively, which yielded a considerable quantity of ore, the amount, however, not being stated.

Different character of ores in the several areas.

Roxton.

Lord Aylmer's mine.

Ely Copper Mining Co.

Upton. Bissonnette mine.

Prince of Wales mine.

McDougall's mine.

Upton mine.

In the township of Acton several mines were located and worked to some extent about this time, but of all these, that known as the Acton Mine, situated on the thirty-second lot of range three, and about half a mile south of Acton station on the Grand Trunk railway, was the most important.

The Acton mine.

Early history.

The discovery of this mine is said to have been made by Mr. H. P. Merrill, but the date of this discovery is not mentioned. In a paper by Mr. Robert Williams, for many years connected with copper mining in eastern Quebec, read before the Lit. and Hist. Soc. of Quebec, 1865, we learn that in the autumn of 1858, operations were commenced by Mr. Sleeper; and "that although the discovery of copper ore of very rich quality was known some years previously, so incredulous appeared the human mind on the subject that the property was purchased by Mr. Davis, of Montreal, from the owner, Mr. Cushing, of Actonvale, for a very insignificant sum and a royalty, but that gentleman had so little faith in his purchase, that he at once leased it to Mr. Sleeper on tribute, at two-thirds of all the ore that he could obtain from it for a period of three years."

It was largely in consequence, apparently, of the great results obtained by Mr. Sleeper at this mine, that the great boom in copper and copper explorations took place in the townships, which resulted in the finding of the ore in greater or less quantity at hundreds of places throughout the areas already outlined, and of which a full list of localities will be found in the report of the Geological Survey for 1866, by Mr. James Richardson.

Description of the Acton mine.

The peculiar character of the deposit at this place, and the great importance which for some years attached to this mine renders it worthy of a somewhat detailed description. When first found "the surface presented an accumulation of blocks of copper ore, evidently in place, and covering an area of about sixteen paces in length by ten in width. These masses consisted of variegated sulphuret of copper, intermingled with limestone and a siliceous matter, without anything like veinstone, and evidently constituted a bed, subordinate to the limestone, whose strike was about north-east, and with a dip to north-west at an angle of about forty degrees. In continuation of this bed for about seventy paces in either direction the limestone was observed to hold little patches and seams of variegated ore and yellow pyrites, with stains of the blue and green carbonates of copper. The limestones in the immediate vicinity presented several veins of quartz crossing the strike, but containing only traces of copper."*

Change of owner.

The mine was worked by Mr. Sleeper to September, 1861, when it reverted to the proprietors, Messrs. Davis and Duncan, of Montreal, by whom it was sold, in October, 1862, to the Southeastern Mining Company of Canada. The enormous masses of rich ore-bearing rock gradually became exhausted, though no attempt at any very deep exploratory works appears to have been undertaken. According to Mr. Richard-

* Report Geol. Survey, 1858, pp. 57, 58.

son's notes, the mine produced, during the period in which it was worked, 16,300 tons of 12 per cent. ore, sent to market, besides a great amount of lower grade left at the surface.*

Mr. Macfarlane's notes.

The ore at this mine, from a number of sections furnished by Mr. Thos. Macfarlane, who was in charge of operations there for some time, and who published an exhaustive paper on the subject in the Can. Nat., 1863, is apparently for the most part confined to a bed of dolomitic limestone interstratified with dark grey shales, a considerable thickness of which lies between the copper limestone and a great mass of another limestone band, which forms a prominent ridge to the south of the workings. Between the copper limestone and the shale beneath, intrusions occur, often of considerable size, of a greenish, fine-grained diorite which are also at times found above the limestone band. The strata, both above and below the limestone band, also contains small strings of copper pyrites, but the workable deposits are for the most part confined to the calcareous portion. The cupriferous rocks appear to be bent in an anticlinal fold, and are, to some extent, affected by faults; these being probably due to the diorite intrusions.

The bed of limestones, which appears to have carried the bulk of the ore, in places appeared as a solid mass, at others as a brecciated rock or conglomerate; those which consisted of the pyritous, the variegated and the vitreous, being disseminated through the brecciated bed, constituting, to some extent, with silica, the paste of the mass. The ore deposit at Upton presents a somewhat similar set of conditions, with this important difference that, while at Acton the prevailing ores were vitreous and variegated, at Upton the ore was mostly a pyritous sulphuret.

Probable age of the rocks and origin of copper at this place.

If the two localities of Upton and Acton should be the outcrop of the same beds on the two sides of a synclinal it is very possible that other large deposits of similar ores may occur other than already worked. To test this point at Acton would, however, require considerable expense of shafting. Several bore-holes have been put down, but the results obtained have not been made available. From the fact that red slates of the Sillery formation cross the Grand Trunk railway a short distance east of this mine, and appear, also, near the village of Acton, as well as in the lower beds of Upton, it is probable, that this unusual development of copper is in rocks of this age, and that its presence is due to the intrusion of dioritic matter at this point, since at other localities in this formation, as at Nelson, St. Apollinaire, &c., though the amount of copper is not so large as at Acton, the presence of diorite masses at these places, in somewhat similar rocks, has apparently produced similar effects, though on a much more limited scale.

* See Geol. Can. Supplement, 1866.

The Vale mine. Among other localities in this township, where exploratory work was carried on about this time, were lot thirty-one, range four, called the Vale mine, the results from which were of little value; and the White Horse mine on lot twenty-nine of range six, and on lot thirty-one, range three, the ores being very similar to those of the Acton mine, and, as at that place, occurring in dolomite. It is probable, that the diorites were absent from these localities, no mention being made of them at either place. In Wendover, in the diorites which cross the St. Francis from the town of Drummondville, several shafts from 30-40 feet in depth were sunk between 1860 and 1863 by the Drummondville Mining Co. of Canada, but without finding copper in any quantity, though just before the suspension of the company a large vein was reported to have been struck. Since the failure of this company no further attempt has been made to ascertain its value.

The White Horse mine.

Wendover. The Drummondville Mining Co.

Wickham. In Wickham but two mines were located. The first, and most important, was styled the Wickham mine, on lot fourteen, range ten; the ores being yellow and variegated sulphurets in dolomite. Here a shaft was sunk to a depth of thirty feet and a few tons of ore removed. The Toomey mine, on the third lot of the eleventh range, was similar in rock and character of ore, but the work done was merely exploratory and confined entirely to the surface.

The Toomey mine.

Durham. In the township of Durham, adjoining Acton, the same character of ores is found. Two mines were here started, of which that on the twenty-first lot of the seventh range, styled the Durham mine, was apparently the more important. Shafts were here sunk on three veins, varying from three to twelve inches in thickness, the deepest of which was eighty-four feet, ending in black slate. The ore obtained amounted to ten tons of five per cent., 110 tons of three per cent., and 300 tons of one per cent., consisting of yellow sulphuret in a calcspar vein cutting dolomite. On lot nine, range six, a shaft was also sunk to a depth of sixty-four feet in similar ore, but no returns are given; and on the south-west half of lot nine, range four, a shaft was sunk to a depth of forty feet, showing good specimens of the variegated and yellow sulphurets, while a second shaft of sixty feet was sunk on the north-east quarter of the same lot, in green and black slates, for which no returns are available.

The Durham mine.

Somerset. In Somerset, near the northern portion of this area, small quantities of the yellow sulphurets have been observed in beds of limestone conglomerates near diorites; and in Nelson, on lot eight of range eleven, the yellow and varigated ores are disseminated through limestone, also near diorites, from which about ten tons were extracted by a company formed in Boston, the width of the ore-bearing bed being about thirteen feet. At various points along this line, also, indications

Nelson.

of ores, for the most part similar to those already described, but presumably in even smaller quantity, were observed. In the county of Lotbiniere, near St. Apollinaire, indications of the yellow sulphuret are found in amygdaloidal diorite; and in this vicinity the St. Flavien mines were worked about thirty years ago. Since that time no attempt at exploration in all this area appears to have been made. St. Apollinaire. St. Flavien mine.

Throughout the rocks of the western division the workable deposits of copper also appear in all cases to have been associated with masses of intrusive diorite, which have penetrated the red and green slates and limestones of the Sillery formation, now regarded as forming the upper portion of the Cambrian system. The want of success which has attended many of these workings is due largely to decline in the price of the copper, and also to a lack of concentration of the ore in the cupriferous beds, since the quality of much of that obtained is excellent, and, in some cases, peculiarly rich as seen in the Actonvale deposits. Diorite intrusions in the Sillery formation.

Of the mines found in the second belt, beginning at St. Armand, it may be remarked that the ores here observed differ somewhat both in character and mode of occurrence, and, as already pointed out, in the nature of the containing rock. In this area, at the time of the great copper excitement, several localities were indicated in which traces of copper, both the sulphurets and the carbonates, the latter in green chloritic and epidotic rock, were found, but none were at that time shewn to be of much importance. In 1882, however, a vein of yellow and variegated ore was opened on the south side of the Pinnacle Mountain, St. Armand, in greenish micaceous and chloritic schist, which was worked for some time, and at first promised well. Crushing and concentrating works were erected, and a considerable quantity of the ore extracted and prepared for market, but the works were shortly after abandoned, and no returns from this location are to hand. In the township of Sutton, adjoining, copper mining was carried on at a number of points; indications of the presence of the ore being frequent. These ores were mostly the yellow sulphuret, but green carbonate of copper, with deposits of the variegated and vitreous ores, are frequently observed. Among the most important of these in this township, and which have been opened up to some extent, may be mentioned the following:— St. Armand. The Pinnacle Mountain mine. Sutton.

Sweet's mine, on the west half of lot eight, range ten, where variegated and vitreous sulphurets occur in a bed of nacreous schists from one to four feet and a half wide, which, for the whole breadth, yielded four and a half per cent. of copper. A band of dolomite occurs in the vicinity, but the ore is confined principally to the schists; differing in this respect from those of the first belt, of which the Acton mine may be taken as the type. This mine was one of the Sweet's mine.

first opened in this portion of Quebec; samples being displayed at the International Exhibition in London, 1862. The schists in which it and the mine on the Pinnacle are located belong to a distinctly lower geological horizon than that of the belt just described from Farnham, north. A considerable quantity of ore was raised from the Sweet mine, but probably the limited size of the lode interfered with its successful development.

North Sutton Mining Co.

The works of the North Sutton Mining Co. were located on the north half of the eleventh lot in the tenth range, on a bed from eight inches to two feet thick, in talcose slate, near black plumbaginous slate. Three shafts were sunk, one of which was twelve feet deep and about two tons of five per cent. ore obtained. Explorations were also carried on by this company on a seven foot vein in nacreous slates, on the west half of lot twelve, range eleven, carrying yellow sulphuret with iron pyrites, but no returns are at hand from this exploration. Two shafts of a depth of fourteen and nineteen feet respectively, were sunk.

Brome Mining Co.

On the east half of lot nine, range eleven, the Brome Mining Co. also sank a shaft sixty feet deep on a bed of variegated and vitreous ore in similar nacreous slates, of which it was supposed three feet of the rock would carry three per cent. ore. From this also no returns are available, and in the south-east half of lot seven, same range, explorations on a four feet band in chloritic slates yielded, according to Mr. Chas. Robb, a considerable quantity of ore.

Brome.

In the adjoining township of Brome, mining was carried on at several points. On the east half of lot five of the fifth range, the yellow and variegated sulphurets were found in three bands, varying from two to thirteen feet thick, supposed to be repetitions of one and the same bed through undulations of the strata. Three shafts were here sunk by the Canada Copper Mining Co. to a considerable depth, and a large quantity of ore, estimated at three per cent., extracted. Machinery for crushing and concentrating was erected, but the company soon ceased operations. On lot six, range six, considerable exploratory work was carried on by the Bedford Mining Co., but with no satisfactory result. On the west half of lot twelve, range seven, the Tibbets mine, owned by Messrs. Ball and Morell, consisting of a shaft to the depth of eighteen feet, was sunk on a band of yellow sulphuret in nacreous and chloritic schist. On lot six, range seven, the variegated ore was found in two bands, one of which, two to three feet thick, was estimated to carry one per cent. copper, the other band of five feet was supposed to carry one and a half per cent. ore.

Canada Copper Mining Co.

Bedford Mining Co.

The Tibbets mine.

On lot eighteen of range eight variegated and vitreous ores were observed to occur in four bands in nacreous, chloritic and epidotic slates, and dolomite, in a breadth of several yards, and a small excavation, not sufficient for a test, was made. These ores were continued on lot nineteen, same range, and on lot twenty-one, range nine, but no returns as to value or output from any of these are to hand.

In the township of Shefford, mining was carried on at two places only, viz.: by the Glencoe Mining Co., on lot seventeen, range two, where the different ores occur with quartz and calcspar in four separate bands in micaceous and chloritic slate, and on lot twenty-eight, range three, by the Waterloo Mining Co., in similar ores, and with similar country rock, where a shaft was sunk to a depth of sixty feet, but no returns are available. Shefford. Glencoe Mining Co. Waterloo Mining Co.

Further north in Stukely, the Grand Trunk mine was situated in the south-east quarter of lot six, range one. A shaft was here put down to a depth of sixty feet on a band of yellow and variegated sulphurets, in micaceous and chloritic slates, with dolomite of the usual character. The same bed with a thickness of three feet was found on the lot adjoining; some good ore was obtained, but the quantity is unknown. A trial shaft, twenty-one feet deep, was also sunk by Messrs. Lambe and Shepherd in the south half of lot seven, range two, on a band of fifteen to twenty feet of dolomite, carrying disseminated yellow ore with pyrites. On the south-east quarter of lot nine and the south-west quarter of lot ten, range six, vitreous sulphuret occurs in chloritic sandstone associated with quartz, felspar and chlorite; masses of pure ore being obtained of from three to twelve pounds weight. On the latter area the Logan mine was located, in which from four to five tons of twenty per cent. ore were obtained. Stukely. The Grand Trunk mine. Lambe & Shepherd's mine. The Logan mine.

On lot seven, range eight, two parallel bands of dolomite carrying vitreous sulphuret occur, with a breadth of twenty-three and thirty-six feet respectively, separated by about a hundred and seventy-five yards of micaceous and chloritic slates. The ores are intimately associated with veins and strings of quartz, calcspar, chlorite and epidote. A shaft was sunk for sixty feet and a cross-cut driven twelve feet across toward the vein to the west, but did not reach the ore. On the north-east half of lot six, range nine, a shaft was sunk for one hundred and forty-two feet in a slate band, carrying similar ore to the last, without satisfactory results, and on the south half of lot four, tenth range, a shaft twenty-two feet deep was sunk in order to cut a band of eighty to ninety paces, in which four cupriferous bands occur. No returns from any of these are available.

Tracing this belt to the north, we have, in Melbourne, several deposits of copper ore, for the most part in green chloritic rocks and micaceous schists. On these deposits three mines have been in operation, viz., the Ryan Hill, the Cold Spring and the Balrath. The first is situated Melbourne. The Ryan Hill mine.

on lot two, range two; the ore is the variegated and vitreous sulphuret in chloritic slates; the size of the band not being stated. At the Cold Spring mine, lot six, range two, some shafting was done; the ore occurring in narrow bands over a considerable breadth, but presumably not in sufficient quantity to be economicably valuable. At the Balrath mine, on lot two, range four, the ore, which is of the kind just described, is said to occur in a series of bands, eight in number, ranging from one and a half to five feet in width, in one of which a shaft was sunk, which disclosed some rich bunches of ore. Considerable exploratory work was also done on lot eight, range one, in the shape of pits and trial shafts, on a deposit of yellow sulphuret; the copper being mixed with magnetic and specular iron ore, in a gangue of quartz and calcspar, cutting quartzite and talcose slates. None of these areas appear to have yielded very much copper.

The Cold Spring mine.

The Balrath mine.

Cleveland.

In Cleveland, across the St. Francis River, variegated and vitreous ores also occur, with similar chloritic rocks, at a number of places. The only locations worked to any extent, however, were on lot twenty-five, range twelve, at the St. Francis mine, and at the Jackson mine, on the south-west quarter of lot twenty-six of range thirteen. At the former place, in addition to the usual ores already mentioned, green and blue carbonates are said to occur with a little native copper; the whole contained in a lode three feet thick. A shaft was here sunk for 195 feet, and levels and other works driven for 513 feet along the lode, from which a large quantity of ore was taken, which, according to Mr. Bennett, the manager, ranged from six to twenty-six per cent. At the Jackson mine a shaft was sunk to a depth of twenty feet, the ore being found in a lode of a foot in width, with other larger veins carrying ore in smaller quantity at no great distance. The amount of ore extracted from either of these places is not known.

The St. Francis mine.

The Jackson mine.

Shipton.

Halifax.

In Shipton, copper ores are comparatively rare, at least in so far as known, and not in quantity apparently sufficient to warrant mining operations; but in Halifax the variegated and vitreous ores are again quite extensively distributed, the rocks being of the same character of schists as in Melbourne. Mining was carried on at two places, viz., by the Halifax Mining Co., on lot ten of range three, where a considerable admixture of different ores was found in a vein from eight inches to three feet in width, on what is known as the Halifax mine, and visible gold was reported in a quartz vein which was cut. Considerable work was done here by shafts and adits, but no returns as to the amount of ore obtained are to hand, though no large bodies of ore were found. At the Black Lake mine, on lot nine, range nine, some exploratory work was also done by Dr. James Reed and others, but nothing of importance was encountered.

The Halifax mine.

The Black Lake mine.

In Chester, although exploratory work was carried on at a number of points, the most important location probably was that in the S. E. half of lot eight, range six, known as the Viger mine. Here the ore was principally the yellow sulphuret in quartz veins, and vitreous ore in the slates. The veins were scattered through a width of 170 feet and were opened at a number of points, from which a considerable quantity of ore was extracted, but involving a large outlay and much work. No deposits of large size were met with, and the explorations, after a very thorough trial, were found to be unprofitable. The metalliferous veins on this property extend across into the adjoining lot, but their size was insufficient to pay for the labor involved in their opening. On lot nineteen, range ten, the Austin Mining Co. made a couple of openings, one on a two-feet vein, the other on one of six feet, but the ores were found to be not sufficiently concentrated in the gangue to pay for extraction. Explorations were also made on lots eleven and fourteen of Craig's Road range, in variegated and vitreous ores in limestone, but without success, as well as on lot five, range six, where a quartz vein from two to four feet thick was observed, which presented some good specimens of ore, but the quantity was too small for successful mining.

Chester. The Viger mine. Austin Mining Co.'s work. Craig's Road range.

Ores similar to the last are found at several points in Inverness, occurring in micaceous, chloritic and nacreous slates or schists, but, in so far as known, no attempt at mining these was made, though one of these localities was among the first recommended for trial in 1847. In Leeds, however, in addition to the great Harvey Hill mine, very fully described in the Geol. Can., 1863, several other deposits were worked, notably that on the fifteenth lot of the fourteenth range, in close proximity to the Harvey Hill deposit, the ore veins and beds from which were supposed to be continuous in this direction. The ores are all vitreous, variegated and yellow sulphurets occurring in beds or veins, in what have been styled nacreous slates, and, on the lot just mentioned, were owned by the English and Canadian Mining Co. Native gold was found in one of the ore veins. Not far distant from this, to the north-east, in that part of the seigniory of St. Giles known as the Handkerchief, the Chaudière Mining Co. opened up several quartz veins, of which eight were exposed in a breadth of 1,100 feet, two of which had a thickness of two to three feet, and could be traced for 1,200 to 1,500 feet. About $5,000 were spent in these explorations, but owing to difficulties of various kinds, the work was shortly abandoned. Fine specimens of ore were obtained here, and the quartz is reported by Dr. Reed to have yielded him native and visible gold.

Inverness. Leeds. Harvey Hill mine. St. Giles. Chaudière Mining Co.

What was regarded as the eastern limit of the second belt was the seigniory of Ste. Mary, where ores similar to those just described

Ste. Mary.

occur in red and green slates near ferruginious dolomite, not far from Ste. Mary's Church. From the aspect of the strata, it would, however, almost appear as if this deposit should be more closely related to the red slates and dolomite of the first area. Another mine at St. Sylvester, referred to in the report of the Geol. Survey for 1866, was that of Ste. Margaret. It was opened by the late Thos. Glover of Quebec, by whom a company was formed in New York, styled the Ste. Margaret Mining Co. Several shafts were sunk with an expenditure of about $5,000, the amount of ore obtained being about fifty tons. The ore was mostly the variegated sulphuret, the country rock consisting of purple slates, green grits and quartzites. The mine was owned by Mr. Cromwell, but the ore appeared not to be in sufficient quantity for profitable extraction.

St. Sylvester. Ste. Margaret's mine.

The Harvey Hill mine.

The most important of the mines in this section is that so widely known as the Harvey Hill, now the Excelsior, on lot seventeen, range fifteen of Leeds. This location, according to a paper by Mr. Herbert Williams read to the Literary and Historical Society, Quebec, 1865, was the second discovered in the province as carrying copper, the first found having been at Inverness. These discoveries did not appear to awaken very great interest for sometime, and Dr. James Douglas seems to be the first who appreciated their value, and through his agency the Megantic Mining Co. was formed for the purpose of exploring and working the copper deposits of Megantic county. Upon the discovery of the Harvey Hill deposit, the location was secured by this gentleman and his associates, who organized a company under the name of the Quebec and St. Francis Mining Co. But little further investigation was, however, undertaken by any others than by this company, who explored the Harvey Hill property in such a way as to bring it prominently to the notice of English capitalists, and by these a new company was formed in 1858, under the name of the English and Canadian Mining Co., by whom operations were commenced and carried on with varying success for a number of years. The history of the workings of this celebrated mine for some years is given in the Geol. Can., 1863, with considerable detail. From this we learn that the ores occur in two ways, first as a series of interstratified beds, of which three were clearly recognized, varying in thickness from six inches to six feet, or possibly more, and second, in quartz lodes or veins, composed of quartz, calcite, pearl-spar and chlorite, some of which carried the variegated and vitreous ores, others carried copper pyrites, in places in very rich pockets. The veins, which sometimes cut across the bedding, were exceedingly rich in certain parts, and in others comparatively barren, so much so that in actual value as a source of supply for copper, the beds were con-

Discovery and early history.

Mode of occurrence of the copper.

sidered the more important. In these the various ores were disseminated through the body of the slates, generally in lenticular masses, running with the bedding. These masses were generally small and thin, sometimes having a thickness up to three-fourths of an inch, with a length of six to twelve inches, in addition to scattered grains of the ore through the slate bed; the amount of copper in all being estimated at from three to five per cent.

Workings.

The hill upon which this mine is situated was pierced by a number of shafts from twelve to forty-five feet deep, as well as by an adit and tunnels; the whole forming a very extensive series of workings. The principal adit was driven into the hill across the measures to a distance of 1,488 feet and intersected the several ore beds, the upper one of which had a thickness, when first worked, of three feet, which, in the lower workings, increased to ten feet and was estimated to carry five per cent. ore. From a prospectus issued by the Consolidated Copper Co. of Canada, limited, in 1872, the subsequent history of this mine is given to that date. The surface works of the company, including much of the plant, were destroyed by fire in 1866, with an estimated loss of £20,000, owing to which, operations were suspended till 1870, when Mr. James Douglass, one of the proprietors, took over the work again and resumed operations in the mine. The quantity of ore raised from the commencement of operations in 1858 to the end of 1862 was 322 tons of thirty per cent. copper, in addition to 1,000 tons at the surface of two and a half per cent. and 500 tons of four to five per cent. from the upper bed. The figures as to the output for the different years, as given by Mr. H. Williams, the manager, are as follows:—

Later history of the mine.

Output.

Mr. H. Williams quoted.

	Tons.	Cwts.	Qtrs.	Lbs.	
1858........	9	15	0	2	of 30 per cent. copper.
1859........	43	7	0	21	
1860........	104	5	3	0	
1861........	70	4	1	6	
1862........	94	17	2	21	
1863........	113	20	3	14	of 26 per cent. copper.
1864........	235	12	3	4	of 20 per cent. copper.

The mining ton=21 cwts., or 2,352 lbs.

Character of the ore beds.

The falling off in the value or percentage is attributed to the fact that during the last years the mining was confined principally to the beds and not to the quartz leads. The ore in these beds was found by Mr. Williams, upon careful examination, to occur in lenticular masses, as already stated, varying in thickness from one-sixth of an inch to two or three inches, and in length from three to eighteen and even twenty-four inches. These masses overlapped each other and were disseminated throughout a thickness of five to six feet. This refers to the overlying or upper bed, which appears to be the one principally worked. For 1865 the figures for the output appear to be wanting, but from the report of Mr. Harrold Douglas, superintendent of the mine, as given in the prospectus of the Consolidated Co. mentioned, it appears that for a part of 1866, in which year the works were destroyed, 265 fathoms of ore were taken from the bed, dressed to twenty-four per cent. and sold in Liverpool for $35,420, at an average of fifteen shillings per unit. From a paper by James Douglas, jr., of Quebec, in the Lit. and Hist. Soc. of that city, 1870, in discussing the several beds from which the supply of ore had been principally derived, he considers that "there is no likelihood of these beds being of such great extent or of such uniform richness as was at one time attributed to them."

Mr. H. Douglas quoted.

The work of Capt. Williams on the main or upper beds showed that where quartz lodes cut the beds, deposits of ore, often of considerable size and great richness, were struck; that the beds gradually became less rich in copper as they were worked away from the lodes which had all along been supposed to derive their supply of ore from the beds with which they were associated; but certain features observed in driving an inclined shaft on a lode, reached from the Kent shaft, induced a change of belief in this respect, the evidence there presented going to show that the beds derived their supply of copper from the lodes by percolation into the contiguous slates, and subsequent operations appear to have confirmed this view.

Origin of the copper in the beds.

The most important probably of the different lodes struck in the several shafts is that known as the "Fanny Eliza." This entered the bed near the intersection of the Kent shaft, and on this lode the greatest amount of work appears to have been expended. Where first struck, near the shaft, it was of small size, but rapidly widened as it was opened. Mr. Douglas says of it: "The lode is from twenty to twenty-four inches in width, and very regular, both in dip and strike, which is slightly to the west. The ore, as it comes to the surface, yields from eight to twelve per cent. copper. It separates in crushing, very perfectly from the gangue, and is therefore easily concentrated to from forty to fifty per cent. It consists of a mixture of grey and purple sulphurets. When the lode enters the bed it carries a good deal of yellow and no grey ore, but the yellow entirely disappears in depth. The ore occupies the centre of the lode, whose matrix consists of calcspar, some quartz and a good deal of bitter spar, in the composition of which iron replaces part of the magnesia."

The "Fanny Eliza" lode.

"Tracing the lode upward, but beneath the bed and beyond the spot where it first attracted attention, it is seen, in the thirty feet cross cut, as a well defined lode of about eight inches wide, but carrying very little copper, and has been reached by a level driven upon it from the bottom of Kent's shaft, where, however, it is thin and irregular, though highly charged with copper." From Mr. Douglas's paper we learn, further, that to the east of the Fanny Eliza two lodes enter the bed, on one of which some work was done. The lode runs parallel with the Fanny Eliza, and like it increases in size in the direction of the dip, but diminishes towards the rise." He says, also, that "the beds gradually decrease in richness in proportion to their distance from the lode." Mr. Douglas also maintains that the Fanny Eliza is a true lode maintaining its width and direction for forty fathoms with a regular dip, and holds that the veins which take their rise in the roof of the bed are also lodes and not lenticular masses. The vicinity of the lodes is indicated by an increase in the richness of the slates and the kind of ore which they carry. These mines, after having been idle for some years, have lately changed hands and are now being worked by the Excelsior Copper Co. From the notes of Mr. C. W. Willimott, who visited the spot in 1882, we learn that the mine closed work in 1879; operations being confined principally to the Fanny Eliza lode, or vein, and in the level and incline which had been sunk to a distance of 600 feet some rich pockets of ore had been found. The mines, in 1882, were owned by a New York company, but no work, other than taking the water out of the shaft, was going on. The Excelsior Copper Co. have been carrying on work during the last two years, but have not extended their underground operations to any great distance, having cleared the shafts of water, repaired the timbering and the buildings and erected a smelter, in which a considerable quantity of the ore lying about had been reduced, the coke for this purpose being obtained from Nova Scotia, the limestone from Dudswell, and the iron from McVeity's mine near Kinnear's Mills, but no returns of output nor of other results are to hand. The present manager is Col. Drew Gay.

The Excelsior Copper Co.

On lot sixteen, range fourteen, adjoining the Harvey Hill property to the north, the Leeds Mining Co. began operations in 1863. These were carried on for a couple of years, in anticipation of meeting the extension of the rich lodes and beds of the Harvey Hill mine, but in this their expectations were not realized, since the extension of these beds to this property was not found sufficiently rich in copper to pay for mining. These works were suspended in 1865. They were under the general supervision of Mr. Herbert Williams, and no attempt has since been made to develop the property.

The Leeds Mining Co.

The second range of mines in what was, in 1863, regarded as the eastern portion of the second synclinal, or that area east of the Sutton Mountain ridge, included those of Potton, Durham, Brome, Bolton, Oxford and Brompton. The rocks here, in places, differ markedly from those of the area just described, being very frequently black and other colored slates, with great areas of serpentines and diorites, but

Area east of Sutton Mountain.

the character of the ore is, in some cases, similar to those from the west side of the Sutton ridge, though in certain of the mines, some features which are different are presented.

Potton.

In the township of Potton, the yellow sulphuret is the most abundant ore, the vitreous being rarely found. The rocks here are mostly slates and diorites with serpentines; the copper pyrites are largely mixed with iron pyrite, much of which is the magnetic variety or pyrrohotite. In no case yet observed in this township is the quantity of ore sufficient to warrant any great outlay in exploration, except, possibly, at the recently discovered mine on lot twenty-eight, range nine, on the west side of the Hog's Back Mountain, owned by the Memphremagog Mining Co. This mountain is a mass of diorite, rising to a height of about 800 feet above Lake Memphremagog, and surrounded on both sides by black and bluish grey slates. The deposit of ore, which is principally a pyrrohotite with a small quantity of copper pyrites, occurs on the west side, at the contact of the diorite and slates, in a bed of fifteen to eighteen feet thick, which extends along the side of the mountain for several hundred yards. It dips north-west at an angle of about forty degrees, having the diorite for its foot wall, and the surface above the vein and for some distance beyond is covered with a heavy bed of bog iron ore. The ore, in places, contains a considerable quantity of a dark colored or almost black calcite. On this vein several pits have been sunk at intervals along a distance of 1,000 feet, and, according to the manager, an inclined shaft has been put down on the vein for eighty-five feet. A cross cut has also been driven with the vein, so as to drain the pits. About 800 tons of the ore have been extracted and piled, waiting for shipment. From several assays by Dr. Wyatt of New York, and by Torrey and Eaton, the ore contains from different samples.—

The Memphremagog Mining Co.

Iron	30 to 50 per cent.
Copper	2·80 to 5 "
Sulphur	37·75 to 42 "

A peculiarity of this ore is the readiness with which it spontaneously ignites when piled in heaps exposed to the weather; a feature not common to the ores from most of the other locations.

This mine is situated at 700 feet above the lake, connected by a good road of a mile in length with landing-stage, and good facilities for shipment, either to Magog or Newport.

Bolton. The Huntingdon mine.

In Bolton, the township adjoining to the north, the extension of the slates and serpentines is found, and mining operations were carried on quite extensively for some years at several points. Probably the most important of these was the celebrated Huntington mine, on lot eight, range eight, and the Ives mine, a couple of miles further to the north, on lot two, range nine, and lot four, range eight. In the former, the ores are mostly copper pyrites, mixed with the magnetic pyrites or pyrrohitite, a large deposit of which occurs in chloritic slates in contact with serpentine and diorites. A band of more than three feet of solid granular copper ore occurs near the serpentines of the west side of the vein. A section of the metalliferous portion, going eastward from the western wall of serpentine is as follows:—

Section of ore beds.

	Feet.
* 1. Greenish diorites, with disseminated masses of copper pyrites and magnetic iron pyrites	2·0
2. Compact granular copper and iron pyrites with disseminated masses of quartz	1·4
3. Magnetic iron pyrites, interstratified with thin leaves of chloritic and mica schist	0·9
4. Greenish diorite with disseminated copper and iron pyrites	1·0
5. Compact granular iron pyrites, with disseminated small masses of quartz	2·6
6. Green chloritic slate, with disseminated masses of copper pyrites, mingled with iron pyrites	8·0

History of the mine.

Work was begun on this property in August, 1865. From notes kindly furnished me by Capt. W. Warne, the present manager of the Memphremagog Mining Co's. works, the management was in the hands of Capt. Bennett of Lennoxville, who controlled operations till 1870-71, when the mine was sold to a Glasgow company and the name changed to the Huntington Copper and Sulphur Co., under the management of Mr. John Rudda, of Cornwall. The output under the old company's management is stated to have been from 200 to 300 tons of ten per cent. ore per month, part of which was shipped to England and part to the United States. Extensive buildings, etc., were erected, and under Capt. Rudda's management, the output was increased to 400 to 500 tons per month of seven per cent. ore.

In 1872, works were erected for carrying on the Longmaid or Henderson process, by which the ore was burnt in retorts to drive off the sulphur, but the process did not apparently meet with much success. The ore was then crushed, mixed with common salt, and calcined in furnaces and placed in vats with hot water and acid from the tower, and run off into other vats containing scrap iron, by which the copper was precipitated. Hundreds of tons of precipitate, containing 65 to 75 per cent. of copper, are said to have been made in this way.

In 1873, the works were destroyed by fire with a loss of $75,000.

* Geol. Rep. 1866, p. 35.

They were partially rebuilt, and mining was carried on in a desultory fashion for several years, and the company finally closed operations in 1883. During the past year the property has passed into the hands of Messrs. G. H. Nichols & Co., of Capelton.

Extent of the workings.

In the working of this mine two deep shafts were sunk, one to the depth of between 500 and 600 feet, called the Huntington shaft, the other known as the Wright shaft, 200 feet deep. North of the Huntington mine, on lot six, range eight, were the works of the Canadian mine, presumably on an extension of the vein just described. Two shafts were here sunk, one to a depth of 100 feet, the other 50 feet, and some ore shipped to Capelton. The mine subsequently passed into the hands of the Eastern Townships Bank and has not been worked for some years.

The Canadian mine.

The Ives mine.

Further north, on lot two, range nine, Bolton, the Ives mine was situated. Two shafts were here sunk, the Ferrier and the Galt, the former to a depth of about sixty feet, the latter for 100 feet. This mine was opened in 1866, and worked for ten years, and a large quantity of from 10 to 14 per cent. ore was extracted and shipped to England. These three mines are situated on the east side of the Missisquoi River, south of what is now known as Eastman, and are all probably located on the same belt of ore. The serpentine rock is found at all these mines, with slates of various colors, differing, in this respect, from the rocks of the second area or that west of the Sutton Mountain. Very favorable reports on these deposits have appeared by Dr. T. Sterry Hunt and others, but the presence of the magnetic pyrites serves to distinguish the ores as a class from those already described.

Orford.

The copper deposits of Orford township were mined at several points. On lot nine, range A, yellow sulphuret occurs in a dioritic rock, near serpentine, of which six veins are found in twenty-five feet. This was exploited by Messrs. McLeod and others. On the third lot of range F, and on the eighth lot of the same range, similar ores, with a like association of rock matter, were found, but at none of these does systematic mining seem to have been carried on.

McLeod's mine.

The King mine.

At the King mine, on the third lot, range thirteen, variegated ore, associated with magnetic oxide of iron, occurs in a four-foot band of dolomite and serpentine; and on the west side of Brompton Lake, on the east side of a high hill, called the Carbuncle, composed of diorite and serpentine, several small openings were made, from which in all about twelve tons of twelve per cent. ore are said to have been obtained. The difficulties of working this deposit, from its comparative inaccessibility, must have been very great, and the quantity of ore in the rock appears at present very limited, although a five foot vein of

The Carbuncle Hill mine.

solid yellow sulphuret is reported to occur there. This mine was styled the Carbuncle Hill mine and was located in the second lot of the fourteenth range of Orford. In the township of Brompton the only mine worked was on lots twenty-eight and twenty-nine of range nine, where the ores, which were of the variegated and vitreous varieties, were found in serpentine. According to Mr. Chas. Robb, the principal deposit was in a five foot vein, containing, according to his report, a promising quantity of ore. It has, however, long since been abandoned. The Robinson mine.

In what we have styled the third area, viz., that of Ascot and Hatley, we find a great series of deposits which have of late years proved to be among the most valuable in eastern Quebec, not probably so much for the amount of copper contained as for their adaptability for the manufacture of sulphuric acid. In this respect the ores of this most easterly belt differ widely from those of the two areas already described. Mines of the third or most easterly area.

The variegated and vitreous ores are, for the most part, wanting; the bulk of the ore being a chalcopyrite, with much iron pyrites. The amount of copper contained is not high, averaging, for the great bulk of the production, from four to five per cent., while in most of the ore there is an appreciable quantity of silver, reaching, in some portions, as much as twenty-five to forty dollars per ton of ore, but yielding, on the average, from four to five dollars. A certain amount of gold is also present, but, as no attempts have yet been made to save this, the quantity is unknown. Character of the ore.

These mines are situated in what we now regard as the Sherbrooke and Stoke mountain anticlinal, and the rocks are chloritic, micaceous and talcose schists, with diorites. On this belt of rocks, southwest of Sherbrooke, and extending to the north line of Hatley, a large number of mines have been located, some of which have been worked for many years, while others, although containing valuable bodies of ore, have been idle for some time. In the township of Hatley the deposits appear to be much less numerous; the belt of schists becomes narrower, probably in part owing to the overlap of the black slates of the Cambrian system. The most southerly deposit of copper ore in this direction is near the upper end of Massawippi Lake, on the west side, on lot nine, range six. At this place there appears to be two kinds of rock, the soft blackish and bluish pyritous slates being in contact with the hard quartzo-felspathic rocks of the mountain series. The contact is probably along a line of fault, and the ore, which is scattered through a width of eight to ten feet, is in the form of the yellow sulphuret, but the shaft being filled with water, the quantity could not be ascertained; a large amount of iron pyrite appears to be mixed with the copper ore. This is the Parnell mine. The only other mine located in this town- Situation and kind of rocks. Hatley. Hatley. The Parnell mine.

The Reid Hill mine.

ship is that on lot twenty-eight, range one, known as the Reid Hill mine. It has an elevation of 500 to 600 feet above the Massawippi River, and presents the appearance of six beds of the yellow sulphuret, with iron pyrite, in a space of a fourth of a mile in breadth. Similar ores appear on the lots to the west on ranges two, three and four adjoining. Considerable exploratory work was done at this place, and a level was driven in about 200 feet below the outcrop of the bed, but no details of the workings or subsequent exploration are to hand.

Ascot.

Beginning with this mine and passing into Ascot, there appears to have been an unusual development of this variety of ore, more particularly in that portion to the south-west of the St. Francis River, though large and very valuable deposits have also been discovered in the extension, to the north-east, of this anticlinal. The ores are apparently yellow sulphurets, and no less than fifty-five localities were at one time reported as copper-producing or giving good indications of the ore. In all, up to 1865, thirteen mines were operated, of which the localities may, for the sake of reference, be briefly noted as follows, but since that date several others have been opened:—

Mines south of Sherbrooke.

The Clark mine—Lot eleven, range seven.
The Sherbrooke mine—Lot twelve, range seven.
The Albert mine—Lot three, range eight.
The Eldorado or Capel mine—S.E. ¼ lot four, range eight.
The Victoria mine—N.E. ¼ lot four, range eight.
The Ascot mine—W. ½ lot eight, range eight.
The Parks mine—W. ½ lot twelve, range eight.
The Short mine—Lot fourteen, range eight.
The Lower Canada mine—Lot three, range nine.
The Marrington mine—N.E. ¼ lot 6, range nine.
The Hill mine—E. ½ lot eight, range nine.
The Belvidere mine—Lot ten, range nine.
The Magog mine—Lot eleven, range nine.
The Griffith mine—Lot three, range eleven.

Suffield, Howard, Hepburn and Moulton Hill mines.

These are the mines mentioned in the report for 1866, and in addition, several other areas, not distinguished by any particular names, occur, on which a greater or less amount of development work has taken place. Several mines have also since been opened, which promise well in view of the great present demand for sulphur ores. Among these may be mentioned the Suffield mine, on lot three, range eleven; the Cillis, now the "Howard," on lot five, range eleven; the Hepburn mine, on lot seven, range nine; and the Moulton Hill mine, north of the St. Francis River, on lots twenty-three and four, range three. The width of the ore lodes, or beds, in this section is very great, in places being considerably over fifty feet, and the breadth of the ore-bearing rocks, south of Sherbrooke, is about three miles, while from the

Parnell mine, on the south, to the Moulton Hill mine, on the north, the distance is about twenty miles. Still further to the north, again, in Garthby, large deposits of similar ore have been reported.

The first reference to the copper ores of this section is found in the report of the Geol. Survey for 1847, where an outcrop of a vein in the fifteenth lot of the seventh range, is mentioned as worthy of trial, which was found to contain, in addition to copper, small quantities of silver and gold; the latter, however, not in quantity to be of economic importance, but of interest as showing the possible presence of the precious metal in greater quantity in other veins of the vicinity. On the thirteenth lot of the same range, the continuation of this deposit carried copper pyrites in veins, distributed throughout a belt of thirty feet of chloritic slates. This lode, on lot fifteen, was at the time traced for a distance of about fifty yards, but further to the south, from half to one-third of a mile, could not be found. When first opened it had a breadth of from ten to twelve inches. Up to 1858 no further interest appears to have been taken in these deposits, only two places being referred to in the report for that year, viz., that just mentioned and on lot nineteen, same range, where a small vein of copper pyrites was seen in a railway cutting near Sherbrooke station on the Grand Trunk railway. In 1859 the Ascot mine was discovered by Thos. McCaw of Montreal, at Haskill Hill, and found upon examination to consist of a bed of copper pyrites mixed with iron pyrites, with a thickness of five to six feet, in a matrix composed of impure limestone and chloritic schist. This mine was, in the fall of 1863, purchased by an American company, who erected furnaces for smelting the copper ore at Lennoxville. In the Geology of Canada, 1863, reference is made to but three mines in this vicinity, viz.: the Ascot, or Haskell Hill, the Belvidere and that first discovered and already described. The ore was similar throughout, and the breadth in the Belvidere lode was estimated at six feet. What was afterwards the Marrington mine on lot six of the ninth range, shewed a vein of from two to three feet at the surface, with a large proportion of iron pyrites. During the next two years a very extensive development in mining took place; a large number of mines were opened and a very considerable quantity of ore extracted.

Early history of the Sherbrooke mines.

The Ascot mine.

The Belvidere.

The Marrington mine.

From notes kindly furnished me by Mr. T. Macfarlane and by J. S. Hunter, now of Belleville, I am able to present a few items in regard to some of these, not already generally made public.

The Clark mine.

The Clark mine is situated one mile and a half from the Lennoxville station, G. T. R., on lot eleven, range seven, Ascot. This was first opened in 1863, by Mr. Wm. Clarke, and was worked with more or less vigor for several years, principally by an American company, who took out a large quantity of ore. The work was carried on for the most part by means of open cuttings upon a vein said to have a thickness of eighteen feet, (?) and containing three and a half per cent. metallic copper. This estimated thickness of ore bed is, however, doubtless exaggerated, since, on the most reliable authority, the thickness never exceeded seven to eight feet, and gradually decreased to eighteen inches. In addition to surface workings, a pit was sunk to a depth of forty feet and a shaft for seventy-three feet. Further explorations were carried on in 1866, but without success, and in that year the mine was sold at sheriff's sale. No returns as to quantity or quality of output are to hand, and the mine has apparently remained idle since the date mentioned.

The Sherbrooke mine.

The Sherbrooke mine immediately adjoins that just described, to the south, and is traversed by the same lodes as are found in the Clark mine. It has been quite extensively explored on the surface, though not yet opened up by underground exploration. Several valuable deposits of pyrites are reported on this property; one of which is said to have a thickness of eight feet, while another was stated to be no less than seventy feet in width. (?) Assays by several parties give from $4.00 to $5.00 of gold, $11.00 per ton of silver, and from 30 to 40 per cent. of sulphur.

The Capelton mines.

A group of three mines, situated on lots three and four, range eight, and lot three, range nine, are worthy of special notice, not only from their early history, but from their great and growing importance at the present time. These comprise what were formerly known as the Lower Canada, or Hartford, now the Eustis or Crown mine, the Capel or Eldorado, and the Albert; the latter being now owned by the firm of G. H. Nichols & Co.

Their early history.

The Capel mine was so called from the name of the original owner of the property, Mr. Geo. Capel, and in 1863, chiefly through the agency of Mr. W. S. Hunter, three men, Mr. Hunter. Mr. Pierce and Mr. Capel, formed a company to develop the property on lots three and four of range eight. These gentlemen spent from eight to ten thousand dollars in exploratory work, and, finding the results satisfactory, divided the property into two portions; the eastern area, on range nine, being styled the Prince Albert mine. The property was soon acquired by Montreal capitalists, by whom mining operations were commenced, and have been carried on to the present day, though under change of ownership and management.

Changes of ownership.

From the Montreal firm the property passed into the hands of Taylor and Sons of London, who adopted the Henderson process for the extraction of the metallic copper. This, however, after a thorough trial, failed to give satisfaction, and the mine was closed. The property subsequently changed hands, and was finally purchased by Messrs. G. H. Nichols & Co., an American firm of ability, by whom the ores have, for the most part, been shipped to the sulphur works at New York or vicinity, for the manufacture of acid. Within the last three years, however, a somewhat extensive plant has been erected at the mine for the manufacture of sulphuric acid on the spot as well as for that of superphosphate. Smelting works have also been still more recently started for the production of matte. The success of the present company is no doubt largely due to the saving of the sulphur and other by-products of the ore, in which the profit consists. The depreciation of the copper market at the time of the former management, combined with the loss of the sulphur, was such, that expenses apparently could not be met. The deposits at the Albert and Capel mines are doubtless a continuation of that found to the south-west at the Crown mine, formerly the Lower Canada. There the ore bed is an immense, but somewhat irregular deposit of chalcopyrite, with much iron pyrites, yielding an average of four to five per cent., some of the ore being very rich, and in addition contains an appreciable amount of silver; the lode varies in width from four to over fifty feet, and has been worked to a depth of over 1,600 feet. At the Eustis or Crown mine also, smelting works have been erected, in which a large amount of matte is made, the sulphur in this case being wasted, but a very large proportion of the ore still goes in the raw state to the sulphuric acid works in the vicinity of New York, while the residue is treated for copper at the smelting works at Bergenport, New Jersey. The owners of the latter are the Eustis Mining Co. The ore at this mine apparently occurs conformably with the bedding; the irregularities in size being due to local thickening of the ore mass. Dykes of diorite are met with in the different under-ground workings, and can also be seen at the surface in the immediate vicinity of the mines. The rocks containing the lode are schists, often highly micaceous and talcose, but generally chloritic, which are traversed by numerous quartz veins. The ore is delivered on the railway, about half a mile distant from the Albert mine, by an elevated cable tramway, carrying the ore buckets and from the Eustis property by a gravity tramway to the track, where it is dumped directly into the cars. From several assays of this ore the quantity of sulphur is found to vary somewhat, but averages 38 to 40 per cent.:—

Messrs. G. H. Nichols & Co.

The Albert and Capel mines.

The Eustis or Crown mine.

Iron	35
Copper	4 to 5

Silver, about one ounce per unit of copper, say 4 ounces per ton.

The Lower Canada mine, or the Crown mine now so called, was discovered in 1865. For two or three years thereafter it was worked for copper alone, but subsequently for copper and sulphur. This mine is well described in the Geological Survey Report for 1866, from which the following abbreviated extract may be made as illustrating the character of the workings and of the ore at that date.

Character of the ore at the Crown mine.

Earlier workings.

The strata for a distance of 1,600 feet dip S. 30°-40° E. $<$ 40°-60°, and in this distance five shafts have been sunk in micaceous schist, to the south-east of a dolomite band, and to all appearances in the same bed of ore. In shaft No. 1, the ore is ten feet thick, the lower four feet of which is apparently an almost compact mass of the yellow sulphuret of iron and copper, with a yield from this portion probably of eight per cent. of copper. Upon this are two feet of similar character, but yielding only about five per cent. of copper, and the upper four feet contain iron pyrites alone. No. 2 shaft is 125 feet south-west of this, sixty feet deep, and the ore bed is four and a half feet thick; the lowest part is similar to that in the first shaft, but said to yield fifteen per cent. copper, while the remainder yields only three per cent. The ore bed as shewn in the shafts Nos. 3 and 4, sunk to a depth of 75 and 132 feet respectively, is similar to that in No. 2, but in No. 5, sunk 90 feet, the bed is six and a half feet thick and vertical for eighty feet from the surface, thence dipping S. 40° E. $<$ 40°-50°. In the vertical part it contains only iron pyrites, but below this sufficient copper pyrites becomes mixed with it to cause the bed to yield between three and four per cent. of metallic copper. Other bands of copper ore occur in this lot, on both sides of shaft No. 1.

Subsequent operations.

Subsequently to the date of this report mining operations were vigorously carried on, and in addition to the copper, which was originally the sole object of the enterprise, the large amount of sulphur contained in the ore was utilized for the manufacture of sulphuric acid, both in Canada and the United States. Up to June, 1869, about 20,000 tons were smelted to 40 per cent. regulus on the spot. A very large quantity was shipped to acid works, the amount of sulphuric acid obtained being stated at one ton of 66° acid to each ton of ore.

Output.

The yield of ore from these mines at present is very large and apparently annually increasing. The output for 1889, taken from the returns of the Mining Review, was, from the Eustis mine, 34,089 tons, including 1,773 tons matte, and from G. H. Nichols & Co. 36,000 tons.

Undeveloped conditions of certain locations.

Of some of the other mines alluded to in the list given in a preceding page, but little can here be said. On some of these a considerable amount of exploratory work was done and the promise of good sized ore beds seemed good, but, in most cases, this exploration was not pushed to a depth sufficient to decide as to the actual value of the property. This can be easily seen by reference to the great mines of

Capelton and by a comparison of the enormous size of the lode in the lower levels, with the comparatively limited extent at the surface. Among others, not noticed in the list of 1866, may be mentioned the Suffield mine, on lot two, range eleven; the Hepburn mine, on lot seven, range nine, at which a large amount of exploratory work appears to have been done; and the Cillis mine, on lot five, range eleven, which has, within the last year, been reopened to a greater depth, and the ore has been found to increase in quantity and quality so greatly that it is now considered an exceedingly valuable property. It has been purchased by an American syndicate and will be worked.

The Cillis mine.

The Hepburn mine.

From notes obtained by Mr. Willimott in 1882 * the Hepburn mine was then being worked quite extensively. Like the Ascot and Suffield mines, it was the property of the Sherbrooke Mining and Smelting Co. A shaft was sunk to a depth of 156 feet, and at sixty feet a level had been driven for thirty feet, from which a north and south cross cut was made. The latter was carried 110 feet, at which distance a bed of yellow sulphide twenty-four feet thick was cut, averaging about seven per cent. metallic copper. The north cross cut was carried ten feet, where another bed of yellow ore was cut, said to be twenty-seven feet thick. No ore has been raised, the object of the company being to develop a large reserve.

The Suffield mine.

About twenty men were employed at the mine. Work at this mine was shortly after abandoned. The quality of the ore in the dump, seen in 1885, looked well. Of the Suffield mine, Mr. Willimott says: "A shaft has been sunk 200 feet; at the depths of eighty-five feet, and at two hundred feet, levels have been driven to the east, the former 300 feet and the latter 100 feet, connected by a ventilating winze."

The amount of exposed ore is reported at about 40,000 tons, of which 3,500 to 4,000 tons have been taken out with the intention of concentrating and smelting at the mine.

At this mine the drilling was done by compressed air driven by an engine of sixty horse power.

Silver in the Capelton ores.

The ore resembled that from the Capelton and Hartford mine, an assay of which was made by Dr. Harrington in 1877, yielding 75.03 ounces of silver to the ton. Assays of the Suffield ore, by John Massey & Co., London, England, gave percentages of silver, varying from eight ounces to 235 ounces per ton and from four to twenty-nine per cent. of metallic copper.

The Moulton Hill mine.

In the area north of the St. Francis deposits of ore occur precisely similar to that of Capelton, and in similar rocks. What has proved to be a very valuable deposit was found about three years ago by Mr. Burke, the owner of the land, on lots twenty-three and twenty-

* See Geo. Sur. Rep. 1882-3-4.

four of the third range of Ascot, which has since been somewhat extensively developed, and purchased by the same syndicate which acquired the Cillis mine. The bed of ore which dips with the slate south-easterly at an angle of 45°-50° was found to rapidly increase from four to six feet at the surface to a reported thickness of not far from fifty feet, at a depth of seventy feet, revealing an enormous body of ore. This location was revealed by the uprooting of a tree, and is in the direct course of the Capelton deposit, which it so much resembles.

Ore beds probably repeated by folding of the strata.

In view of the fact that these several ore beds, which are found over a breadth of some three to four miles, resemble each other very closely, and from the crumpled and overturned character of much of the strata in which these are contained, it seems most reasonable to suppose that the greater part of these mines are located upon different portions of the same lode, repeated by folding from place to place, and that as large and valuable deposits of the ore have been found at widely separated portions of the same vein, both in the southern and northern portions of the township, and almost equally valuable deposits are known in the more western portion of the belt, as at the Cillis mine, it may be very safely predicted that the real value of many of the mines which were opened twenty-five years ago and speedily closed, has never been ascertained, and that other masses of ore, of equal importance to those so long worked, will, at some not distant date, by careful prospecting, be found. Much of the failure of twenty-five years ago was, doubtless, due to the speculative character of the work done. Mines were bought and sold on the flimsiest sort of evidence as to their value or worthlessness; often on samples which were obtained from an entirely different location from that represented. The growing importance of these ores as a source of supply for sulphuric acid is being very fully realized by the men interested in this industry in the United States; their superiority over most of the ore there found, for this purpose, being acknowledged. There are yet, in this eastern belt, many places thickly covered by forest growth, the prospecting of which is a difficult matter, but of the many mines already opened and abandoned it is highly probable, as in the case of those now worked, that deeper and more scientific testing would change the aspect of things greatly for the better.

Importance of the ores for sulphuric acid.

Garthby.

Further to the north, in Garthby, a considerable deposit of pyrites is found on lot twenty-two of range one. This deposit is described in the Geol. of Can. 1863, p. 733, as "a large mass of iron and copper pyrites, subordinate to the stratification of the enclosing rock which is a calcareous serpentine, dipping to the south-east at an angle of 50°. The extent of the deposit has not been determined, but there appears to be a breadth of about twenty feet, in which the two ores are more or less mingled with rock. Large masses of the mineral consist of a fine-grained iron pyrites, without any copper, while in other portions the ore is such an admixture of copper pyrites as to afford eight per cent. of the metal."

The ore at this place occurs in rocks differing in age from those of the area just described, being more closely allied to the deposits of Bolton and Potton. The first opening was made by Mr. J. B. Coulombe, in 1860, and was nine feet long, five feet wide, and said to be sixty feet deep. No work was done on the property after 1861. An analysis of the iron pyrites apparently free from copper gave iron 42, sulphur 48, copper 1·1, silica 8·9.

This property is about four miles from the Quebec Central railway, and recent explorations, during the past year, in the southern part of the area, are said to have developed a large body of ore, the measures being traced into South Ham for a distance of three miles, but no definite information can be obtained on this point.

South Ham. Nicolet branch mine.

In the townships of Ham and South Ham, several mines were also at one time started, but these, apparently from an insufficiency of ore, have long since been closed. Among these may be mentioned the Nicolet Branch mines on lot twenty-eight, range four, where the variegated and vitreous ores were found scattered through a band of dolomite and chloritic schists, overlaid by glossy black slates. The ore is found in small veins only, disseminated through the rock, and by exploration over several hundred feet, several tons of rich ore were obtained. On range B, lots thirty-three to thirty-six, explorations were made; on the right bank of the Nicolet River on similar ores in green rocks, like the last, but without success, only small quantities apparently being found. In South Ham, in the serpentine and diorite rock of the south and east side of Nicolet Lake, small deposits, mostly of the yellow sulphuret, occur on lot twenty-two, range one, old numbering, or lot forty-four, range one, new numbering. This was styled the Nicolet Copper mine. A small amount of exploratory work was also done on lot fifty-two, range two, new numbering, but no returns are to hand.

Nicolet Copper mine.

Thetford.

Further north, in the township of Thetford, copper ore has lately been reported by Dr. Jas. Reed, as occurring on lots three, four, five and six of the first range, and on lot fifteen of the second range of Leeds, as well as lot nineteen of the second range of Thetford, but the quantity and character of the ore is unknown, as not yet explored.

GOLD.

Location.

The gold fields of Quebec, although now known for more than fifty years, have not, from various causes, attracted as much attention or come so prominently before the public, and the mining public in particular, as their actual importance would appear to warrant. They are, in so far as yet known, confined for the most part to that portion of the province lying east of the St. Lawrence, and more especially to that part contiguous to the boundary of New Hampshire and Maine or along those streams which take their rise in that region. The areas producing gold in Ontario, such as those of Madoc and Marmora, do not appear to have their counterpart east of the Ottawa, though possibly this may, to some extent, be due to the fact that much of the country in this direction, occupied by the Archæan rocks, is largely unexplored, but within the last few years, assays of some of the quartz veins from the Ottawa county district have shown traces of gold, though no vein has yet been located carrying, as indicated by the assays, sufficient gold to be economically important. The rocks in the auriferious area of eastern Quebec were, for many years, regarded as of upper Silurian age. They were thus described in the Geological Survey Report on this district in 1847, when the presence of the gold of the Chaudière was first officially noticed, and at the same time the presence of gold in small quantity in a quartz vein carrying copper and galena near Sherbrooke was pointed out. Visible free gold has also been reported as occurring in certain quartz veins carrying copper, blende, etc., in the seigniory of St. Sylvester, and in the concession of the Handkerchief, as well as at several other points, but no attempt on a large scale has ever been made to test these veins for gold.

Gold of Ottawa county.

Visible or free gold.

While the rocks of the Chaudière district, where the gold of Quebec was first found, were supposed to be of upper Silurian age, the question of the source of the gold which occurred in the overlying gravels was long a mystery. By some it was held to be derived from the decomposition of quartz veins in the crystalline rocks of the Notre Dame range of hills, while by others it was thought to have been transported from long distances in the glacial drift from some unknown source. The great resemblance of the underlying slates and sandstones of this district to those of the gold-bearing rocks of Nova Scotia was pointed out by various observers more than twenty years ago, but it was not till the year 1886 that their probably Cambrian age was declared and their parallelism to the Nova Scotia rocks cloudy asserted, both as regards not only their character but their geological horizon.

Age of the gold-bearing rocks of Eastern Quebec.

The early history of the gold fields of Quebec has been given with more or less detail by several writers on the subject. The discovery was first announced to the scientific public by General Baddeley, R.E., then stationed in Quebec, who in 1835 called attention * to the finding of gold in the Chaudiere. This was followed by numerous other papers, among which the following may be mentioned: "On the Gold Fields of Canada," by the Rev. James Douglas, read before the Literary and Historical Society of Quebec, 1863; Report to the Quebec Government, 1863, by T. F. Judah, Clerk of Crown Lands, "On the Gold Mines of the Chaudière;" "Report of the Select Committee appointed by the Quebec Government to ascertain the value of the Chaudière gold areas," 1865; and a paper by Mr. W. Chapman, "On the Gold Mines of Beauce," 1881. From these and other sources the writer has endeavored to prepare as complete a history as possible of this important mining field from the date of its first discovery to the present time, not only because of the large amount of work which has already been done in it, but in the hope that some wise provision may be made to encourage the further development of what should become one of the most important factors in the financial welfare of the province.

Early history of the Chaudière gold mines.

Sources of information.

According to Mr. Douglas "gold was first discovered some forty years ago by a woman near the mouth of the Touffe des Pins, now the Gilbert River, a tributary of the Chaudière; but it attracted no attention." As this statement was presented to the Society in 1863, it would place the first discovery of gold in the district about the year 1823-24. "In 1834 another woman, taking a horse to water near the same spot, perceived, as she supposed, a stone glittering in the bed of the river, and thinking it curious enough to preserve, took it home with her." This was the discovery announced by Gen. Baddeley in Silliman's Journal, 1835. The piece he described was said to weigh 10.63 grains; but he was unaware that this piece had been chopped off a larger nugget, the weight of which was 1056 grains. Owing to the smallness of the piece described by Gen. Baddeley but little attention was paid to the discovery, the only person apparently who manifested any interest being Mr. C. DeLery, the owner of the seigniory in which the discovery was made. Pieces of gold, several of which were of considerable size, of a value of over fifty dollars, were picked up from time to time, but no systematic attempt to work the gravel was made for some years, so that the total value of the gold obtained up to the end of October, 1846, was estimated at about three hundred dollars. From the assay of a specimen of gold from this river it was found to contain 13.27 per cent. of silver, the fineness being 20 $\frac{19}{24}$ carats.

First discovery of gold. Mr. Douglas quoted.

* Silliman's Journal, 1835.

Mr. Chapman quoted.

According to Mr. Chapman,* gold was found for the first time in the Gilbert River by a young girl named Clothilde Gilbert, daughter of Leger Gilbert, and now married to Mr. Oliver Morin, of St. George, Beauce. She was crossing a ford of the stream when she found in the sand a nugget about the size of a pigeon's egg. Her own account as given by Mr. Chapman is as follows:—"My father sent me on Sunday morning for a horse in the field to go to mass; when crossing the stream I saw something shining alongside of the water, and took it up to show my father. I never thought that such a pebble would make so much noise afterwards."

The DeLery patent.

In 1846 Mr. DeLery obtained a patent from the Crown giving him the exclusive right *forever* to work for gold within the limits of his seigniory, that of Rigaud Vaudreuil. Explorations were carried on by Mr. DeLery, and an examination and report on the value of the property was made by Mr. J. P. Cunningham. The letters patent to Mr. DeLery comprised an extent of nine miles along the River Chaudière in the seigniory of Rigaud Vaudreuil and of six miles in depth on either side, the privilege of working the ores being granted upon the condition of a payment of ten per cent. royalty upon all the metal obtained from smelting in furnaces. No royalty was paid to the Government, however, since no gold was obtained in this way. In consequence of the uncertainty experienced in working the mines himself, Mr. DeLery very shortly leased all his rights to the Chaudière Mining Co., in consideration of receiving an improved royalty, amounting for the first portion of the leasehold term to twenty-five per cent., and for the latter portion to thirty-three and a half per cent, but this arrangement not being found satisfactory, the improved royalty was bought up for a fixed sum. The company also obtained the right of working in the fief La Barbe, through which the Famine River flows.

Leased to the Chaudière Mining Co.

The Chaudière Mining Co.

The Chaudière Mining Co. began operations on the Touffe des Pins, or Gilbert, at a point about one mile from its mouth, where they worked for several years, but in such a reckless and unscientific way, that expenses were not met. They also operated on the Des Plantes River in 1847, and several rich deposits were struck. At one of these, just above the first fall, three to ten ounces of gold were obtained daily for several weeks. Dry digging from the gravel hills was also tried, but though gold was found in considerable quantity, the appliances for washing and collecting were so poor that the attempt was abandoned.

Mr. Cunningham reports.

Of the two reports written by Mr. Cunningham, the first, in 1847, was addressed to the proprietors of the seigniory Rigaud Vaudreuil, Messrs. Charles and Alexander DeLery, and related rather to the character of the rocks as compared with those of the mining areas of

* "The Gold Mines of Beauce, 1881."

Carolina and Virginia. He, however, refers to the finding of nuggets of gold weighing from thirty to fifty pennyweights, which had their angles rounded, and which he concluded had their source in close proximity to the spot in which they were found.

The second report was addressed to the Chaudière Mining Company in 1850, in which the results are given of two experiments in working the gravels of the Gilbert. The first of these extended from the 24th of June to the 6th of August. The work consisted in digging several pits or trenches, the largest of which was 150 feet in length, with an average width of twelve feet. In these the gravel directly overlying the slates was found to be auriferous, while an overlying stratum, directly beneath the soil, was also found to carry gold in places. Much difficulty was experienced from the water, and the work was at last abandoned for another portion of the deposit. The amount of gold obtained from the first trial is said to have been one hundred pennyweights. Mr. Cunningham's second report.

The second trial lasted from the 8th August to the 20th September. The course of the stream was changed for a short distance, and the gold was collected from the old bed, amounting in all to 940 pennyweights, which is stated to have been the result of about two men's labour for that time. Further explorations of a similar character were made subsequently and good results obtained, the examination of a quartz vein at this place, which was stripped for 150 feet, showing several fine pieces, one of which weighed twenty-five pennyweights. In the construction of a canal and dam for the purpose of working a second portion of the river channel, one man is reported, in the six weeks in which the work continued, to have taken out, by panning, 380 dwts. of gold. Fine pieces of gold are reported to have been found at this place along the course of a fissure, caused by the decomposition of a vein of quartz, while the loose gravel lying upon the slates yielded upon several trials, more than three grains of gold per bushel of 100 lbs. Early work on the Gilbert stream.

In the summer of 1851-52, the Canada Mining Company obtained the right to wash for gold on the flats, near the forks of the DuLoup and Chaudière, and somewhat extensive operations were carried on there during both summers, under the supervision of Capt. Richard Oatey, a Cornish miner. The results of his work are given in Mr. Oatey's report to Mr. James Logan, and incorporated in the report of the Geological Survey for 1851-52, and in the Geology of Canada, 1863. By this work the auriferous character of the gravel was well established, although the difficulties of mining were great, and the best results were probably not by any means attained. In these experiments, that of the trial made in 1851, on three-eighths of an acre of The Canada Mining Co. Operations at the Forks of the DuLoup and Chaudière.

gravel two feet thick, yielded 2,107 pennyweights of gold, of which 160 were in the form of fine dust mingled in about a ton of fine black iron sand. Several pieces of gold were obtained of over an ounce in weight. The value of the gold was $1,826, and the expenses, including $500 lost by the bursting of a dam, were $1,643, leaving $182.00 as net profit, to which, under ordinary conditions, the $500 should be added. In the second season, 1852, about five-eighths of an acre of gravel was washed and yielded 2,880 pennyweights, worth $2,496.00, and of this 307 pennyweights were in the form of fine dust mixed with the iron sand. A number of nuggets were found, one of which weighed 127 pennyweights and the smallest eleven pennyweights. The washing lasted from the 24th of May to the 30th of October, and the expenses aggregated $1,888.00, including a certain amount expended on permanent construction, equivalent for the season to seventy-two dollars, so that the actual profit should be placed at $800.00. The total yield of gold, therefore, from an acre of gravel, two feet thick, at this place, was $4,323.00, and the proper expenses $2,957.00, so that the actual profits for that year were $1,480.00. The result of a week's work, under the inspection of the Geological Survey, yielded 143 pennyweights of gold worth $124.00, the expenses for the time being $60.00, leaving a profit of $64.00. From the assays made in recent years of black sand from this district, it seems very probable that a large amount of gold therein contained was not extracted, so that the profit might be largely increased. A list of nuggets with their weights, obtained from this second experiment, is given in Mr. Oatey's report as follows:—

Results and profits.

Nuggets obtained.

	dwts.	grs.
June 7	126	19
July 30	83	21
August 25	10	20
August 25	38	21
September 7	98	21
September 24	55	2
September 30	23	20
October 2	16	22
October 9	13	2

The Napanee Company.

Owing to some disagreement with the proprietor of the adjoining lands, this company, the Canada Mining Co., had to abandon its working. Later the Napanee Company endeavoured to sink a shaft at the same place through the slate, in the hope of finding a layer of auriferous gravel and sand beneath, but after two years' unsuccessful work they abandoned their attempt.

From 1855 to 1863, the gold mining was almost entirely abandoned and work was carried on for the most part by the habitants of the district in a very desultory sort of way. Among these the Poulin brothers, five in number, were the most persistent workers, and they took out apparently a large amount of gold in a very quiet way. The discovery of the rich gravels on the North Branch of the Gilbert was made by these men in the summer of 1863. This stream was thereupon set apart as a mining district for a distance of a mile above the forks, and a rush set in for that locality. Two spots were selected for work—the upper, on land owned by a man named Veilleux, the other, about half a mile lower down on the same stream, on a lot owned by a man named Rodrigue. Upon these claims, but more particularly upon the upper, a large number of people worked during the season of 1863, and a large quantity of gold was obtained. The largest piece reported, which was sold for $22.00, was said to have been found by a woman named Parie. Among other instances quoted by Mr. Douglas was that of a party of six, including two of the Poulins, who acknowledged to finding fifteen ounces in three days, and another party of the same number found six ounces and a half in two days. These miners were all working without license, and upon the facts being reported to Mr. DeLery, bailiffs were sent and the crowd of workers driven off. On the lower, or Rodrigue property, according to sworn affidavit, given in Mr. Chapman's pamphlet, by the Poulin brothers before Mr. Belanger, N.P. of St. Francis, in 1880, three of the Poulins, with Rodrigue, washed, in tin pans, from the auriferous alluvium in one day, seventy-two ounces of gold. This party is said to have admitted finding ten pounds of gold in eleven days' work, with tin pans only. The largest piece found at this place during the season was sold for $200.00. After exhausting the bed of the stream they washed the gravel from the banks in a sluice, and are reported to have found a pound of gold one day, and ten ounces another. Rodrigue, working with one man only, is said to have panned out in one day two ounces, two pennyweights and eight grains, valued at thirty-eight dollars. The earnings of this party, for twenty days in each month for four months during the summer, averaged sixteen dollars per day per man. But this success was not general, and many only cleared their expenses. The bed of the stream, at this place, is composed of a dark, highly cleaved slate, and the banks are made up of alternations of sand and gravel. The richest workings were where the gravel directly overlies the bed rock.

Mining from 1855 to 1863.

Discovery of the rich gravels on North Branch of the Gilbert.

The Poulin brothers.

Large finds of gold.

Rocks of the Gilbert.

Although there appears to be a widespread notion that no visible gold has ever been found in the quartz veins of this district, Mr. Douglas says that, in a number of cases, specks of visible gold have

Visible gold.

been discovered in the quartz veins that cut the slates, and that handsome specimens have occasionally been found, and others, who are most familiar with the district, have made a similar statement. Considering the large quantity of alluvial gold that has been obtained, and mostly in close proximity to quartz veins, and from the assays that have been made of the quartz from different areas, it would be very strange if visible gold were not found at many points. In so far as I have been able to learn, however, but very few attempts have been made by anyone to examine the veins, and the workings have been entirely confined to the gravels.

Work practically confined as yet to the gravel.

Parker, Hagans & Co.

The lease from the DeLery Company to Mr. Douglas was transferred in 1863 to Parker, Hagans & Company of Quebec, who, however, did not meet with very great success, owing apparently to bad management and the loss incurred in removing débris, as well as to the fact of the local or patchy character of the rich deposits of gold.

The DeLery Gold Mining Co.

The thirty years lease.

Crusher at the Devil's Rapid.

The Reciprocity Co.'s work.

In consequence of the great success attained by the Poulins on the Gilbert River a rush set in, and the lots sixteen to twenty-one of the concession of DeLery were explored in all directions, generally by small parties, with very varying success. In 1864 the DeLery Gold Mining Company was formed to work the quartz veins as well as the alluvions in Rigaud Vaudreuil, under a lease for thirty years from the DeLery family, which granted the new company all the rights originally possessed by the owners of the seigniory. This company erected extensive works, comprising a crusher, at the place known as the Devil's Rapid on the Chaudière River, a short distance below the mouth of the Gilbert; and the claims and operations of the company prevented the explorations of private individuals for some years, over that portion of the seigniory covered by their letters patent. This crusher, however, proved to be an entire failure. In 1865 an American company styled "The Reciprocity," organized by Col. Rankin, leased from the DeLery Gold Mining Company the mining rights over several lots along the Gilbert. They constructed a wooden flume 1,800 feet long, with a dam at its head, in order to supply water for washing the gravels on the North Branch. This, although supposed to be well and strongly built, was not able to withstand the heavy freshets which occur on these streams, and was, for the greater part, swept away before any good results from its erection could be obtained, and consequently proved an almost total loss. This company, after the destruction of their flume, washed upon a trench dug along the river bed, from which the water had been diverted, and took out some $2,500 in gold, the whole expenses, including the dam and flume, being from twelve to fifteen thousand dollars. The DeLery Gold Mining Company then granted permits to a few miners to work on the lots on the North

Branch already so celebrated, and in the summer of 1866 Mr. Henry Powers, with several miners, drove a tunnel across lots fifteen, sixteen and seventeen of the concession DeLery. A large amount of gold is reported to have been obtained along this tunnel, for the use of which, each company paid to Mr. Powers two dollars per day. In the official documents of the time it is stated that a value of $142,581 was realized, and that two nuggets were found, one of which, found by Mr. Kilgour, weighed 52 ounces 11 pennyweights and 6 grains, and the other, found by Mr. Arch. McDonald, was worth $821.56. In the following summer Mr. John McRae, on a claim of seventy-five square feet on lot fifteen, is said to have realized the sum of $17,000.

Work by Mr. H. Powers.

Large nuggets from the North Branch of the Gilbert.

Among those who obtained leases from the DeLery Gold Mining Company was Mr. W. P. Lockwood, who acquired the mining right over three sections of the seigniory of Rigaud Vaudreuil, and attempted to prevent any other mining company or private individual from carrying on mining operations in the concessions DeLery and St. Charles, where considerable mining was still being done, in large part, by the owners of the lots themselves. Mr. Lockwood opened a number of exploratory pits in the gravels of the Gilbert, and showed that the gold was abundant, not so much in the river itself, as in the ancient filled-in channels, which were proved to extend to a depth of over thirty feet below the present bed of the stream; the gravel being covered by a bed of clay, with a thickness of twenty-four feet or more, following the elevation of the gravel beds.

Mr. W. P. Lockwood.

Discovery of the old river channel.

In the year 1876, the St. Onge Bros., with several others, made arrangements with Mr. Lockwood to work on the Gilbert. They experienced great difficulty in reaching the bed of gravel directly overlying the rock, owing to water and quicksands. The first shaft sunk was on lot eleven of the concession St. Charles. The difficulty of keeping out the water was such, that a ditch 1,800 feet in length was dug by which a water wheel connected with pumps was driven, and by this means they were enabled to carry on their mining operations. These works were prosecuted for several years, and from the statement in their books during the period in which they worked, though under great disadvantages, $70,000 worth of gold was obtained; individual nuggets being found valued at from $125 to $740 each. Owing to various difficulties with which they had to contend, the company at last sold out to the Messrs. McArthur, of Toronto, for the sum of $16,000.

The St. Onge Brothers.

Large returns by the St. Onge Brothers.

The success of the St. Onges induced others to enter the field, among whom were the following companies:—Payne & Chapman, Forgie, North Star, Victoria, Gendreau and others, who bought mining rights from the habitants, although these were supposed to be covered by Mr.

Trouble about mining rights.

Lockwood's leases, and that gentleman was led to request protection on the part of the Quebec Government in his rights, by force of arms if necessary. This, however, was refused by the Government, but he was advised to bring his case to the Civil Courts, in order that the validity of his leases might be established, a proceeding, however, which Mr. Lockwood would not consent to, and shortly after ceded his rights to the Canada Gold Company, England, represented by Mr. J. N. Gordon. Mr. Gordon, upon assuming control of the district, at once impeached several of those found mining on the property, covered by the lease, before the Inspector of the District, Mr. Duchesnay, the result of which was to so exasperate the men that serious trouble was with difficulty averted. The objectionable clause of the law, which declared that "whoever should be found searching for gold without the consent of the proprietor should be liable to a fine of $5.00 for every such day of work," was repealed, and a special Act passed for the guidance of exploration in the district.

The Canada Gold Co., Eng.

New regulations.

New companies and locations.

Owing to the favorable impression produced by this new law the interest in gold mining again revived. New companies were formed, among which were the Ainsworth Company of New York, to mine on lot thirteen, concession DeLery; and the Beauce Mining and Milling Company, on lot fourteen of the same concession, under the management of Mr. W. J. Smart, of New York. A short distance below these the Canada Gold Company, Limited, under Mr. Gordon, carried on operations under the direct supervision of Mr. W. Moodie, while the old St. Onge property under Messrs. McArthur was still worked. On the East Branch of the Gilbert, the East Branch Company was working on lot sixteen with very fair returns, and on the lot adjoining, Mr. Morey of New York was established; while on the North Branch Mr. Ascher of Montreal carried on some preliminary explorations by shafting. On lots twenty-nine and thirty of concession Chaussegros, Mr. Wilder of Boston succeeded in finding an ancient channel and obtained some good gold. The amount of gold obtained in October, 1880, by the three companies, the Ainsworth, the Canada and the Beauce, according to the returns of the Inspector of Mines, was 581 ounces.

Returns.

New companies in 1880.

Among other companies who began operations or secured leases in this district about the year 1880, according to the statement of Mr. Chapman, were Messrs. Coupal on the North Branch of the Gilbert; Messrs. Poulin and Fortier on Slate Creek at St. George; Messrs. Home and Lionais at Bolduc Creek; Mr. P. A. Dupuy on lots sixteen and seventeen, concession DeLery; Messrs. Côté, Doris and Clouthier, concession St. Charles; Messrs. Cadot, Bernard and Company; The Eureka Company, comprising Messrs. Powers, Tomlinson and McDonald, in the same concession; Messrs. Nicol and Osgood in the first range north-east of the Chaudière; Messrs. Poulin and Bernard at the Devil's Rapids; and Mr. Spaulding from Maine on the Gilbert River.

In 1879-80 the explorations along the Des Plantes and DuLoup were resumed, and the ancient beds of these streams are reported to have been found. On the former river Messrs. Mathieu, Bérubé and Gendreau found promising indications, and Mr. A. McKenzie of Montreal also commenced to work by hydraulic process on the bank of the same stream, about one mile above the road to St. Joseph. These workings were abandoned some years ago, owing to various reasons, but more lately Messrs. Bacon and H. Sewell commenced shafting at a point about half a mile above the St. Joseph road on the east bank of the river, and, at twenty-five feet from the surface, reached what appeared to be an old river channel, in which there was about four feet of well-washed river gravel, cemented with clay and sand. Owing to lack of proper appliances for mining and sluicing, or to other causes not known, this enterprise has in turn been abandoned.

Work on the Des Plantes and DuLoup.

A. McKenzie.

Bacon and Sewell.

About 1880 Mr. A. A. Humphrey began explorations on the DuLoup River, with an apparently ultimate intention of employing the hydraulic process in washing the gravel banks along its lower part. In 1881 a company of English and French capitalists was formed under his management, by whom a canal eleven miles in length, for a supply of water, was constructed along the bank of the stream. This was completed in 1882 and gave a head of not far from 150 feet. The washing of the gravel was continued for some months, but the work was closed down in the fall of 1883; the undertaking, apparently owing to poor management and lack of facilities for saving the gold, having been unsuccessful. Mr. Humphrey thereupon went into partnership with the St. Onge Brothers, who, after leaving the Gilbert, had established themselves on Slate Creek, a branch of the Chaudière at the village of St. George. The St. Onges had been prospecting this creek for several years prior to the advent of Mr. Humphrey, and several shafts were sunk at a point nearly one mile back from or to the north of the village. Great difficulties were encountered in sinking, owing to large quantities of quicksand, and four attempts were made before the bed rock was reached. The last shaft was 165 feet deep and consumed nearly a year in the sinking; the bottom being many feet beneath the bed of the present stream near by. A layer of auriferous gravel was found at the bottom lying upon the bed rock. Mr. Humphrey left the mine in 1886, it not having been found remunerative, and, after attempting to carry on the work by themselves, the St. Onges, at last, apparently from lack of funds to prosecute the work,

A. A. Humphrey on the DuLoup river. Hydraulic process.

Slate Creek, St. George.

Old channel.

Famine river. also abandoned the property, which has since been sold for debt. The St. Onges thereupon began operations upon the Famine, a short distance above the road, near the mouth, and are reported as having been successful in finding an old channel, which is said to promise well.

Dr. James Reed. In 1864 leases were granted on the Famine, in the township of Watford, to Dr. James Reed, on lot four, concessions three and four, and to Geo. Desbarats, on lot five in the same concession, the river traversing these areas. In the evidence presented before the Select Committee in 1865, mention was made of the presence of gold in considerable quantity on this river, as well as in most of the streams leading into the Chaudière and the DuLoup between this place and the boundary of the state of Maine. Quartz veins. Quartz veins traverse the slates at many places; and from the fact that gold, some of which is of a coarse character, can be obtained from the gravels of most of these streams, there is no doubt that many of these are auriferous in paying quantity.

Cumberland stream. Capt. Richards. On the Cumberland stream, which is a branch of the Famine from the west, explorations have been carried on by Capt. Richards for some years. Several shafts have been sunk to the bed rock, but no returns as to the amount of gold obtained are to hand.

Pozer stream. On the south side of the Chaudière work has been done at several places. Some exploratory work on the Pozer stream led to the finding of an old channel there by Mr. Humphrey, but no attempt has yet been made to ascertain its value. Gosselin stream. On the Gosselin stream in St. Victor de Tring, a shaft sunk by Mr. Kennedy is also said to have reached an ancient channel. Gold has also been found on the Mill stream in rear of the village of St. Francis, Beauce, St. Francis, Beauce. and on the Noire and Meul Brooks, on the latter of which, at its forks with the Mill stream, Messrs. McArthur, Coupal & Company are at present engaged in mining on an old channel of that stream. Old channel of the Gilbert. As regards the old channel of the Gilbert, the width has been found at some places, where worked, to amount to 700 or 800 feet as compared with a width for the present stream of forty to fifty feet, and to have a depth below the present bed of nearly or quite 100 feet. Quartz veins. Gold-bearing quartz veins are reported at the Devil's Rapid on the Chaudière, on Home and McDonald's property, concession St. Charles and St. Francis; on Humphrey's area, St. George; and on the Kennebec Road range, belonging to Messrs. Gibb, Ross and Campbell; also on the concession DeLery, lot eighteen, as well as at other points.

Explorations of Mr. Michel. The examinations of the Chaudière district in 1865, by Mr. Michel, on the part of the Geological Survey, the results of which appeared in the report for 1866, furnished very much important information in regard to the value of this area. While the report deals largely with the alluvial workings, the question of the value of the quartz leads was also taken up, and, Dr. T. Sterry Hunt had a series of assays made of the quartz from different veins, which clearly showed that, in many cases, these contained gold in sufficient quantity to amply repay proper working. This opinion is supported by the fact that in the great majority of cases when profitable washings have been found, as on the Des Plantes and the Gilbert, the most satisfactory results have been obtained in close proximity to veins of quartz which traverse the measures. During the past season, owing to the low state of the water in the Chaudière, the vein at the Devil's Rapid, below which some years ago a very large quantity of coarse gold was obtained, was laid bare to such an extent, that very excellent results were achieved by working in its immediate vicinity. The assays of this vein also give a large yield of gold and silver.

Assays by Dr. T. S. Hunt.

Gold in the Devil's Rapid vein.

The character of the rocks in the Chaudière gold district have been very fully given in the earlier reports of the Geological Survey, and need but be briefly alluded to here. They consist for the most part of slates and hard sandstones, the former black, bluish gray and grayish in color. These are associated with dioritic and serpentinous rocks, and in places, as on the Bras du Sud-Ouest, are associated with bosses of granitic and whitish felspathic or garnetiferous rock. A great part of these strata were, for many years, regarded as the equivalents of the Gaspé limestone series, though their lithological resemblance to the Nova Scotia gold series was also recognized.

Character of the Chaudière gold series.

The rocks of the Ditton gold field are precisely similar in character to those between St. Francis and St. George, Beauce. In fact, the whole belt of rocks which flank, on the west, the crystalline masses of the chain of hills along the boundary of New Hampshire and Maine evidently belong to the same great series, till they become overlaid to the north-east by the Cambro-Silurian and Silurian rocks of the Upper St. John River series. In Ditton they are cut by numerous quartz veins, most of which are along the bedding planes, but others cut transversely across the stratification. The gold mining operations have, in this section, been confined to the Little Ditton stream, a branch of the Ditton River, which in turn falls into the Salmon River, the principal upper tributary of the St. Francis; and although such mining as has been here carried on appears to be of the rudest description, a large quantity of gold has been obtained, most of it very coarse, since no provision has apparently ever been made by which the finer gold could be saved. The richest washings here have been found in close proximity to the quartz veins which cross the stream; and from what is already known of this locality, as good results doubtless will be here obtained as ever were known in the Chaudière district. As this area

The Ditton gold field.

Unskilful mining.

Difficulty in obtaining returns from this district.

is entirely in private hands no returns are available, though desultory mining has been going on for a number of years, and the samples of gold obtained are very good, much of it being coarse and heavy.

Extent of explorations in the Chaudière district.

While in the early days of gold mining on the Chaudière district—for our remarks must, for the most part, apply to this district, owing to the fact that the Ditton area is inaccessible to the general miner and explorer—explorations were carried on very generally on the several branches as far east as the Quebec boundary, the principal work was done in three localities only, viz., the Gilbert, the Chaudière itself and the Des Plantes, though of late years much work has been done on the Mill stream and its branches near St. Francis, and on the DuLoup already referred to. The character of the gold obtained is very much the same at all of these places, much coarse gold being found, but without doubt the coarsest has been obtained on the Gilbert, owing doubtless to the fact that much more work has been done there, since the same run of beds and veins extends from the Mill stream on the south side of the river across toward the former stream. The richest gold-producing areas are without doubt found in the old river channels which have been excavated long prior to the glacial period, to a depth of a hundred feet or more below the level of the present beds of the several streams, since the boulder clay is found resting upon the top of these ancient deposits of sand, gravel and clay, which make up the material now found in these old pre-glacial channels. The gold in these channels is confined almost entirely, or at least in paying quantities, to the belt of gravel at the bottom, lying directly upon the bed rock, though, in some of the reports of the early workings on the Gilbert, it is reported as also occurring in the clay where that rests upon the slates. The lowest gravel consists of well-washed pebbles cemented with sand and clay, and in the working of these beds it was found that some portions were enormously productive of gold, while others, on either side, were comparatively poor and did not more than pay expenses, though this latter fact may, to a large extent be due to the crude methods employed in its extraction. Lack of water seems to have been largely instrumental in causing the failure of mining operations in many cases; no proper provision having been made by which a constant and regular supply would be afforded in periods of dry weather, and in certain cases, quite recently, the same cause has led to a great loss of gold. Making due allowance for exaggerated statements as to the amount of gold obtained, there is no doubt that many areas yet exist, not only in the Chaudière district, but also in Ditton, which with proper appliances and right methods of working will yield very large returns to capital rightly invested, and it may be safely presumed that much of the old gravel so rudely washed contains yet a very large amount of fine gold.

The old channel gravel chief source of supply of gold.

Character of the gravel.

Lack of proper appliances for successful mining.

From the trials made by Mr. Michel of certain lots on the Gilbert, it would appear that certain localities did not possess sufficient gold to pay for the working by the methods then practised. It is probable, that in these cases, the areas in question were above or were too far removed from the quartz veins from which the gold is in large part undoubtedly derived, the character and courses of which should be carefully considered in carrying on explorations by the ordinary process of hand-washing. Another point noted by Mr. Michel was that when the gravel rested upon the clay it was poor, but when resting upon the slates under the clay became appreciably richer; while in the case of two layers of gravel, separated by a parting of clay, that on the bed rock contained more or less gold, while the upper stratum was generally without or contained but little.

Poverty of certain areas.

With regard to the valley of the DuLoup and its tributaries on either side, as well as of the Upper Chaudière below Lake Megantic, judging from the experience already obtained from the Gilbert and other streams, and from the character of the rocks along the upper portions of these rivers, it may be safely said that areas of rich gold-bearing alluvion will be found at different points, and possibly of equal value to those in the streams mentioned. Many quartz veins are found there, some of which have yielded gold in good paying quantity upon assay, while from the evidence presented to the Commission of 1865 good indications were obtained. The experiment at the mouth of the DuLoup by Mr. Oatey in 1851-52, already referred to, was attended with sufficiently good results to warrant the prosecution of further work with proper and modern appliances, while with the exception of the hydraulic experiment by Mr. Humphrey, which cannot by any means be accepted as testing the value of the gravels along this portion of the stream, no attempt has been made in this direction for nearly forty years. The occurrence of gold in the quartz veins of Risborough and Marlow, as shown by the assays of Prof. Donald of Montreal and by others, as well as that of Mr. Hoffmann, of a sample from a vein cutting the slates near Lake Megantic in which traces of gold were observed, is strong corroborative proof that in other portions of this area, along the eastern border of the province, gold-bearing veins will also be found; but perhaps the greatest confirmation of this view is in the fact that south-west of the Chaudière River, from the foot of Lake Megantic to the forks of the DuLoup, gold can be found in nearly every pan of gravel washed where trials have been made, as was ascertained by Mr. Arthur Webster of the Geological Survey during his exploration in 1880-81.

Distribution of the gold.

Risborough and Marlow.

Explorations by Mr. A. Webster.

While, then, it can be very conclusively shown that the true source of most of the gold, if not all, is in the quartz veins of the Cambrian

Probable true source of gold in the lower Cambrian rocks.

rocks, it is also a well-known fact that in the great basin, which extends between the Cambrian and pre-Cambrian rocks of the Stoke Mountain and Sherbrooke anticlinal, and the similar rocks found along the border of Quebec and Maine, fine gold can also be obtained in small quantity from the gravels of nearly every brook or river. In but few places, however, throughout this area has coarse gold been met with, and this may to a large extent be due to the fact that a considerable portion of the surface is occupied by slates, limestones and sandstones of the Cambro-Silurian system. While it would be presumptuous to state that gold-bearing veins do not occur in these newer rocks, the experience so far has been that the richest workings and presumably the most productive leads will be found in the rocks of the lower portion of the lower system.

Mapping of the district.

On the old geological determination by which much of this area was colored as belonging to the Upper Silurian, much confusion unavoidably arose, since what we now regard as the Cambrian, the Cambro-Silurian, the Silurian and even the Devonian were to a large extent included under one head. On the map of this district accompanying the reports for 1886-88 the rocks of these several systems have been separated as carefully and accurately as was possible in dealing with a series of rocks, most of which are devoid of fossil remains by which to identify them; and the prospective gold bearing belt of the Cambrian portion can be distinguished from the newer or Cambro-Silurian rocks; the Upper Silurian and Devonian occupying areas of very limited extent.

Gold fields south-west of Sherbrooke.

In addition to the areas of the Chaudière and in Ditton, reference may also be made to the section lying to the south-west of Sherbrooke along the valley of the Magog River, as well as in the valley of the St. Francis for some distance north of Lennoxville. Along the west flank of the Sherbrooke anticlinal at the Magog River, and about the shore of Little Magog Lake, certain black slaty beds occur, very similar in aspect to those of Ditton, and like these have recently been regarded as of Cambrian age. Trials by Mr. Michel showed that, in certain places, the gravels resting upon the upturned edges of the slate contained gold, while in the clays above the gravels, or where these clays rested upon the bed-rock, no trace of gold could be obtained. These results are also very similar to those obtained in the Chaudière gold district. Certain areas also on the east flank of the Stoke Mountain range in West Bury are reported as yielding gold in a similar manner, while on the east slope of the Massawippi Mountain, on the west side of the lake of that name, nuggets of fair size are reported to have been found. It is probable in all these localities that the gold, if found, will be in workable quantities only, in proximity to

Magog River and Little Magog Lake.

West Bury.

Massiwippi mountain.

quartz veins traversing the slates as in Ditton, and that in places remote from these veins, as, for instance, over a great extent of the country lying east of the Sherbrooke anticlinal, the gold is so fine and so widely scattered that its mining will not, in the present condition of things, be attended with profit. Fine gold of the upper St. Francis basin.

According to the reports of the Golconda Mining Company and the Ascot Gold Mining Company, good workings were found on lot eleven, range eleven, Ascot, and on lots two and three, range thirteen. Mr. Michel examined the ground and found the same sequence of stratified gravel and clay as on the Gilbert, but apparently did not strike any old channel of the Magog River. The succession of beds at this place was, at the surface, a yellowish clayey gravel containing grains of pyrites and a little fine gold; second, a stratum of large pebbles and masses of quartz and slate cemented by a blackish clay, without gold, and beneath, resting upon the slates, a layer of iron-stained gravel richer in gold than the above. The average thickness of the deposits was about six feet. Galconda and Ascot Mining Cos. Quartz of the Magog River.

As regards the Lambton area, which Mr. Michel also refers to in his report, 1866, the quantity of gold obtained was, in most cases, very small. This might be due to the general principle already stated, that the richest deposits will be found in what are regarded as the Cambrian rocks; those in which the Lambton explorations were made being on the belt of limestones and slates, which are classed as Cambro-Silurian and similar to those of Eaton and vicinity. A belt of Cambrian slates, however, cut by granite, crosses Lake St. Francis about midway, where the conditions for gold should be more favorable. This area has, however, never been tested, and certain portions of the Cambrian slates, along with the serpentines and diorites of Thetford, Broughton and Adstock, and extending thence northward to the Chaudière at the Bras and the Colway, present many features in common with the rocks of the gold-bearing districts on these streams. Lambton. Lake St. Francis.

Although reference has been already made in former reports to the presence and probable value of the quartz veins at various points, this report would be scarcely complete if it omitted all mention of the results of assays obtained by the officers of the Geological Survey and by other competent assayers. For, while the mere assay of a sample of supposed gold-bearing quartz may be but a very indifferent test of the value of the vein itself, the true worth of which can only be ascertained by trial of a large average sample, the presence of gold by assays of well certified samples, in which the result obtained by one assay is largely confirmed by that obtained by another conducted in a different way, at least proves that gold is present in the vein matter; and this is an important fact to have definitely settled, since the remark Value of assays of gold quartz.

has frequently been made that the quartz veins of Eastern Quebec are not auriferous. Further, the gold is found by assay not to be confined entirely to the quartz veins of the Cambrian or gold-bearing series just described, but is known to occur also in connection with silver; the latter often showing a comparatively large percentage in many of the copper lodes or other mineral veins which traverse the crystalline schists, as in Ascot, Leeds, St. Sylvester, &c.

St. Sylvester, St. Giles.

In the concession of St. Sylvester, seigniory of St. Giles, several specimens of visible native gold are reported to have been obtained from quartz veins in the Handkerchief location. Dr. James Reed informs me that he has broken these specimens himself from the vein.

Devil's Rapid vein.

From the gangue of the quartz vein at the Devil's Rapid on the Chaudière, native gold has also been obtained. This vein is now broken down nearly level with the containing slates, and is without doubt the source of supply from which the largest quantity of the gold obtained from the bed of the stream in its immediate vicinity, was derived. A shaft in this vein for a few feet would be of great interest.

Haskell Hill.

The presence of native gold in the quartz and copper lode at Haskell Hill has already been referred to, and is of interest principally as confirming the fact of its occurrence in the copper-bearing veins.

While of course we cannot in many cases vouch for the accuracy of the assays that are reported, yet the accuracy of the statements that have been made as to the highly auriferous character of many of the veins can scarcely be questioned when published by reliable authorities.

Assays of gold quartz for the Chaudiere district. Con. St. Charles.

Thus in a quartz vein running north-easterly through lot twenty-one, concession St. Charles, in Rigaud Vaudreuil, certain portions assayed in Toronto are said to have yielded $136 per ton. An assay by Mr. Calvin gave $34; another by Dr. A. A. Hayes of Boston, a good authority, gave for the quartz from this vein $77.56 of gold and a little silver; and from specimens collected by Mr. Michel himself for the Geological Survey in October, 1865, the average of five assays was $26.66, the highest being $101.29 a result due to the presence of a scale of visible gold in the sample assayed. There can, therefore, be little doubt as to the actual value of this vein.

N.E. Chaudiere range.

On lot eighty-three, range one, N.E. Chaudière, while samples of a quartz vein assayed in Boston gave $37, and another sample assayed by Mr. Calvin gave $106, a specimen tried by Dr. Hunt from the same vein gave no trace, although a mechanical assay by Mr. Michel gave five small particles of gold. Several assays of samples from a quartz vein on lot sixty-two, range one, N.E. Chaudière, having a breadth of four to five feet, made in New York and other places, gave from $15 to $106 per ton, but in a sample sent to the Survey laboratory no trace of gold was found.

A specimen from a vein of quartz, twenty-four inches thick on the outcrop, yielded on assay, by Dr. Hayes of Boston, $70.95 of gold, while the mean of six assays by Dr. Hunt, of specimens from the same vein, gave $24.71; the mean of four samples being $5.03 and of two others $64,07, a good confirmatory test of the auriferous nature of the vein, and which, if uniform throughout, should, from its large size, be an exceedingly valuable one. Quartz veins also occur on lot thirty-nine, range one, N.E.; on lot twenty-six, concession DeLery; also on lot fourteen, same concession. A mechanical assay of twenty pounds from lot twenty-six gave Mr. Michel no traces of gold.

On lot twenty, concession DeLery, a large vein from seven to eight feet thick, enclosed between slates having a south-east dip, was observed to cross the Gilbert River. Mr. Michel states that twenty pounds of the quartz from this vein were crushed and washed, from which twenty-two particles of gold visible to the naked eye were obtained. From an assay by Dr. Hayes of a sample from this vein $16 to $18 are reported, and the mean of two assays by Dr. Hunt gave $15.15 of gold per ton. It is very possible, from the position of this quartz vein, that much of the very rich gravel found in the Gilbert River was derived from its decomposition and distribution. On lot twenty-one, same concession, quartz veins are also reported, though not tested, by Mr. Michel, owing in part to the fact that the excavation made on it had become filled up. A sample, however, tested by another assayer is said to have yielded $40 to the ton of quartz. Con. De Lery.

From lot fifty-one to fifty-three, range one, N.E. Chaudière, near the Devil's Rapid, several veins of quartz occur. From a mechanical assay of fifty pounds, from lot fifty-five, particles of gold were obtained, but that taken from lot fifty-three yielded nothing. Devil's Rapid.

A vein on lot two, concession St. Charles, with a breadth of five feet, was also slightly explored, but gave no results to a mechanical assay of twenty pounds of the quartz; but on lot sixteen, concession Chaussegros, a mechanical assay of twenty pounds gave five small particles of gold. No further assay was made of this vein, nor was any trial made of a vein of lot forty-nine A., range one, north-east. Con. St. Charles Con. Chaussegros.

On lot fifty-nine A, range one, north-east, near Bolduc Creek, a vein of quartz, mixed with slate, can be traced for some distance. A mechanical assay of twenty pounds gave six small scales of gold, while an assay of a sample of quartz by Dr. Hunt gave no trace. Bolduc Creek.

Among other localities where quartz veins have been observed may be mentioned lot nine, range one, Aubert Delisle; lot thirty, range one, and lot seventy-six, Aubert Gallion; but an assay of specimens by Dr. Hunt showed no gold in the portions tested, though of the last an assay by private parties in New York gave $54 per ton; but on the Aubert Delisle Aubert Gallion.

Lineare. second lot of range one, Lineare, a sample from one of several veins there found gave $6.76 per ton. Other veins occur in this vicinity, and it is to be regretted that the examinations of Mr. Michel were at so late a date in the season that much of the country was covered with snow. Risborough. An assay of a vein from the silver mine in range fifteen, Risborough, gave to Prof. Donald $10 in gold per ton. An assay by Mr. Hoffmann in the Survey laboratory, of a sample from a vein in the same locality, gave traces of gold and forty-three ounces of silver. Further assays Whitton. of a sample of quartz from Whitton, lot six, range eleven, gave also Ditton. traces of gold. An assay of a quartz specimen from Ditton, mentioned in the last report of Mr. J. Obalski, according to the assay of Mr. Nahant, of Quebec, showed an appreciable quantity of gold.

Magog River. The quartz veins found in the slates of the Magog area south-west of Sherbrooke have received little attention. An assay of a sample by Dr. Hayes, of Boston, gave no satisfactory result, but according to Mr. Michel, the character of the quartz veins examined by him was such as to lead him to suppose they ought to be auriferious. A quartz vein Lambton. from Lambton on lot eight, range A, gave by mechanical assay of a twenty-pound sample a small quantity of visible gold. Late assays of a small piece of quartz from the Bras du Sud Ouest, near the Falls, gave Bras du Sud Ouest. to Mr. Hoffmann 0.117 of an ounce of gold to the ton. This result, owing to the presence of diorites, serpentines and granite among the slates of this stream, is important and sufficient to warrant further exploration in this direction, while a mass of white garnetiferous rock near this place is also reported to contain visible grains of gold.

Ottawa and Pontiac counties. The Laurentian rocks on the Upper Ottawa, in the province of Quebec, have not as yet yielded gold in paying quantities, in so far as the assays made in the Survey laboratory are a test of the value, with one or two possible exceptions. In the report for 1887-88 the results of the assay of eighteen samples of quartz veins are given, mostly from locations in the counties of Pontiac and Ottawa, in none of which was more than a trace of gold visible, though in some an appreciable quantity of silver was present. Several assays from the same locality are given in the reports 1882-83 and 1886, but these show the same almost barren character of the veins tested. In the report 1878-79, however, an assay of a small sample of a quartz vein from the township Wakefield. of Wakefield, received through Mr. Vennor from Mr. A. Cotes of Peche village, gave to Dr. Harrington 11.725 ounces of gold to the ton of 2,000 lbs., and 52.323 ounces of silver.

Whitefish Lake The highest yield of gold obtained from the other assays by Mr. Hoffmann is from a sample said to be from near Whitefish Lake, which gave .058 of an ounce to the ton.

SILVER OR ARGENTIFEROUS GALENA.

The first reference to the occurrence of silver in Canada is found in a paper by General Baddeley, R.E., read to the Literary and Historical Society, Quebec, 1830, where the deposit of galena at Bay St. Paul is alluded to. The proportion of silver in the ore is not stated, but the quantity of galena was thought to be insufficient for successful working. Its presence was also reported in the galena near the Owl's Head Mountain, on Lake Memphremagog, in the township of Potton and near the Vermont boundary. Later, in the report of the Geological Survey, 1847, reference is made to the presence of silver with a small quantity of gold in the ores of copper in Ascot and Upham, while in an assay of a quartz vein from the Chaudière the presence of silver was also alluded to. In the report for 1849, the galena of Bay St. Paul is described and the quantity said to be small; but in 1854 the examination of a large quartz vein at the Devil's Rapid on the Chaudière showed the presence of silver in quantity sufficient to render the vein of importance; the other minerals present being quartz, blende, galena, arsenical sulphuret of iron, cubic and magnetic pyrites and native gold; the amount of silver from one assay equalling thirty-seven ounces per ton, and from a second portion of the same vein, 256 ounces, while the presence of gold was detected in a number of assays from this place. Attention was also early directed to the presence of silver in the galena of Gaspé Bay at Indian Cove and Little Gaspé, which were mined to some extent some thirty years ago, but the percentage of silver was small, and the extent of the veins of galena not sufficient to render profitable returns, and after attempts had been made for several years by different parties the property was apparently abandoned. An assay of galena from Indian Cove, where the mine was worked, gave only .146 of an ounce of silver to the ton.

First reference Bay St. Paul.

Lake Memphremagog.

Ascot and Upham.

Devil's Rapid vein.

Gaspé Bay.

Indian Cove.

Among the most important deposits at present known in Quebec is that in the townships of Risborough and Marlow on the DuLoup River, a branch of the Chaudière, and near the eastern boundary of the province. The country rocks of the district are the ordinary black and gray slates with hard sandstones of the lower Cambrian or gold-bearing series, which at this place are traversed by several dykes of diorite and intersected by a number of quartz veins, some of which follow the stratification of the measures, while others cut across the bedding. Some of these contain a large amount of galena, in much of which the percentage of silver is high. Several of these veins, more particularly on lots one, two and three, ranges fourteen, fifteen and sixteen, Risborough, and lot one, range seven, Marlow, were partly opened up by trial shafts in 1883-84. From a visit to the place in

Risborough and Marlow.

Risborough mine.

1885 it was seen that the main vein had a width of ten to twelve inches, carrying galena, blende and some pyrites, of which probably about half the vein carried ore in fair quantity. In this a shaft thirty feet deep was sunk, the vein being uniform in width for this distance. A second vein twenty feet further west, with a thickness of eight to ten inches, carried ore on the north side, of a peculiar character and very rich in silver, but this had not been sufficiently developed to determine its full value, only three or four shots having been fired. This is called the North vein. In the immediate vicinity yet another vein, similar in character to the main vein, had been opened by a shaft for a few feet and good ore found, while nearly a mile to the south-west two other veins were disclosed, styled the Senator and the Armstrong; the latter with a width of eighteen to twenty inches, the other much smaller; gangue and mineral contents resembling those first met. Similar veins from ten to twelve inches wide, carrying blende, galena and pyrite, are found on lot one, range seven, Marlow, while smaller veins intersect the enclosing slates.

From all these outcrops of vein matter we have an area of considerable prospective value; at present accessible with difficulty, but which will be easily reached by the proposed extension of the Quebec Central railway to join the Canadian Pacific railway in Maine. Assays have been made by several parties to prove the value of the several lodes, in all of which good results were obtained. One specimen from the North vein, assayed by the Rev. E. Pagé of Laval University, gave at the rate of 430 ounces of silver to the ton of 2,000 pounds; one from the Main vein, by Prof. Richards, School of Technology, Boston, gave twenty-nine ounces from a large sample of several barrels. Assays from the Senator vein gave 260 ounces per ton, and one by Mr. Hoffmann of an ordinary sample from the Main vein taken from the dump gave 43.63 ounces with traces of gold. An assay of a piece from the Armstrong vein gave, in addition to the silver, half an ounce of gold to Prof. Donald, of Montreal.

Assays for the several veins.

Spaulding.

What is probably the extension of the same mineral belt to the south-west, in the direction of Ditton, is reported by Mr. Gordon, contractor, of Sherbrooke, in the township of Spaulding. From three to four miles north of the Canadian Pacific railway, though no particulars are to hand as to the exact location, the presence of the galena in quartz veins only being reported. Indications of galena were also observed in the quartz veins at several points in Emberton and Ditton, but no attention has yet been paid to the occurrence of silver in this quarter, partly because the amount observed was apparently not great, and because the property is entirely in private hands.

Emberton and Ditton.

Among other localities where silver or argentiferous galena has been observed and worked to some extent is the hill in rear of the city of Sherbrooke. This vein was opened in 1888 by Mr. John Blue of Capelton, and a shaft sunk to a short distance. The surface indications were promising, but the percentage of silver upon testing was found to be insufficient to warrant the carrying on of operations, and the mine was abandoned. From an assay of a sample from this place by Mr. Hoffmann in the Survey laboratory, the amount of silver per ton of 2,000 lbs. was only 9.479 ounces, and of gold a trace. **Sherbrooke.** **Assay.**

From specimens of galena obtained in the county of Pontiac, assays, by Mr. Hoffmann, showed amounts of silver ranging from two to twelve ounces per ton. These amounts, if representing average samples of the ore, would scarcely repay the cost of extraction. Farther up the Ottawa, however, on the east side of Lake Temiscamingue, a very large deposit of argentiferous galena has been known for several years. This location is on lots sixty-one, sixty-two and sixty-three of range one, township of Duhamel, in what is known as blocks A and B, and owned by Mr. E. V. Wright, of Ottawa. Assays of the ore are given in the Geological Survey Report for 1879, by Dr. Harrington, of three specimens which contained of silver 18.958, 11.66 and 18.229 ounces to the ton of 2,000 pounds. **Pontiac county** **Lake Temiscamingue Wright's mine.** **Assays.**

This property has been reported on by Prof. Marsan, late of the University of Ottawa, from whose statements it would appear that the deposit is very considerable. Prof. Marsan states that the breadth of the lode is eighty-five feet, the gangue mixed with the galena in almost equal portions. The vein occurs in rocks of supposed Huronian age. From the statements of the mining captain, Mr. John Wearne, the lode is said to have a breadth of sixty feet, with a vein or portion six feet wide carrying richer ore than the general mass. Two shafts have been sunk, one twelve feet deep, the other sixty-three feet on the lode, with a bore-hole to a further depth of sixty feet, which was still in the ore. **Description.**

The mean of two assays by Mr. Hoffmann gave of silver 13.58 ounces with a trace of gold; by Prof. Donald, of Montreal, silver $21.17; by Dr. Baptie, Ottawa, silver 23 ounces; by School of Mines, London, 13 oz., 14 dwt. and 10 grs. per ton of 2,240 lbs., and lead 52 per cent. The percentage of silver in the galena itself was 26 oz. 7 dwts. and 21 grs. **Assays.**

In describing the silver ores of Quebec it would be unfair to make no mention of the percentage contained in many of the copper ores of the Ascot belt. Presumably silver enters into the composition of all or most of the copper ores of this district, in proportions varying from a very small amount up to ten to twelve ounces per ton, and even in places carrying a much higher percentage. The average, however, **Silver in the copper ores of the Sherbrooke belt.**

obtained from the mines at Capelton is from three to four ounces per ton, or nearly one ounce to each unit of copper in the ore. Of the percentage of gold in this ore no returns have been made, though that it is present in small quantities is clear from the assays made. The silver, however, forms a very important factor in the profitable working of these deposits, and from the several assays of pyrites from different mines large percentages have been obtained. Thus, in the ore from the Suffield mine, assays, by John Massey & Company, of London, England, gave from 8 to 235 ounces per ton. From the Hartford mine, Capelton, an assay by Dr. Harrington gave 75.03 ounces of silver to the ton, and from a sample of ore from a locality near Sherbrooke, composed of copper and iron pyrites and quartz, 19.687 ounces of silver to the ton. From the specimen submitted by Mr. Vennor from the township of Wakefield, already referred to under gold, the yield of silver was at the rate of 52.323 ounces per ton.

Suffield and Hartford mines

Wakefield.

ANTIMONY.

First reference Bay St. Paul.

Although antimony was reported as occurring at Bay St. Paul and so recorded in General Baddeley's paper to the Lit. and Hist. Soc., Quebec, 1830, no importance ever appears to have been attached to the discovery, and presumably the quantity was found to be too insignificant for economic purposes. The only deposit at present known in the province of Quebec is on lot fifty-six, new numbering, range one, South Ham, which was discovered in 1863. Attempts were made to work it for several years, principally by the late Mr. Willis Russell, of Quebec, and machinery was erected for crushing, separating and concentrating the ore, and a shaft sunk to a depth of 100 feet. The ore occurs here in different forms, viz., sulphide or stibnite, kermesite or red antimony, and as valentinite, while beautiful specimens of native antimony are also obtained. This deposit is of commercial importance from the fact that good ores of antimony are comparatively rare, only two others deposits being at present known to occur in Canada, viz., that of Prince William, twenty-four miles west of Fredericton, in New Brunswick, and that of Rawdon, Hants county, in Nova Scotia. At both these places the ore is principally a sulphide of great purity. At the former several veins occur, one of which has been mined at irregular intervals for over twenty years. The vein at Rawdon is said to have a thickness of four to eighteen inches, and has yielded a large quantity of fine material, chiefly for the English market. At the South Ham mine in Quebec the width of the principal vein at the surface was from six to sixteen inches; the gangue consisting of quartz and dolomite, which intersects the magnesian slates and schists, presumably of pre-

South Ham mine.

Size of lode.

Cambrian age. This mine was examined by Mr. C. W. Willimott in 1882, from whose notes we learn that the deepest shaft was 100 feet, and that several levels had been driven along the course of the vein for short distances only. From the examination of the vein and of the ore taken out Mr. Willimott estimated that the ore would assay about five per cent. of the whole, exclusive of some very rich pockets said to have been extracted. No returns as to the amount of antimony obtained from this mine, while worked, are available, but from the crude nature of the appliances for saving the metal it was evident a very large proportion of good ore was lost in the working. The vein matter was crushed in a set of stamps, then by a stream of water carried on to a broad revolving belt by which heavier portions were deposited in a receiving trough, while the lighter portions were carried along by the water. This property was acquired in 1886 by Dr. James Reed, by whom an adit has been driven in from the base of the hill in order to tap the bottom of the 100-foot shaft. This adit is 304 feet long, and by it all the old workings can be easily drained, while the ore can be removed much more easily than by hoisting. A small amount of work has also been done of late years in driving drifts, but no returns of output are to hand. The country rock of the mine consists of black slates with talcose and micaceous schists. The property is about eight miles distant from the line of the Quebec Central railway at Garthby.

Explorations by Dr. Reed.

NICKEL.

The occurrence of nickel in small quantities, with cobalt, was pointed out in the Geol. Can., 1863, in association with iron pyrites in a vein of quartz, cutting Laurentian gneiss in the eleventh concession of the seigniory Daillebout, on the River Assumption; the amount of oxide of nickel contained being 0.55 per cent. Similar small quantities are found in veins traversing the magnesian rocks of the serpentine belt of the townships of Orford, Sutton, Bolton and Ham, but the amount of nickel in most cases is unimportant. The only place where any attempt to work this ore in the townships was made was on the sixth lot of the twelfth range of Orford, about three-fourths of a mile east of Brompton Lake, where a vein of calcite, holding chrome garnet, contains grains and crystals of the sulphuret of nickel (millerite) disseminated. The ore, which is soft and somewhat resembles copper pyrites, yields about sixty per cent. of nickel, but the quantity of millerite found was so small, not averaging more than one per cent. of the mass, that mining operations were suspended at this place some years ago. Two shafts were sunk to a considerable depth on the vein, which

Daillebout.

Brompton Lake mine.

was of large size, and smelting works were erected, but the extraction could not be profitably made. For the cabinet, magnificent specimens of chrome garnet, pyroxene and calcite are here obtained, of which large quantities have been removed by collectors both from Canada and the United States. It seems scarcely probable in view of the large quantities derivable from the Sudbury ores, that the extraction of such small percentages as occur in the rocks of eastern Quebec can now be successfully accomplished.

CLASS II.

MATERIALS USED FOR THE PRODUCTION OF LIGHT AND HEAT.

Coal seam at Point St. Peter.

Of the materials embraced in this class the number is very few. Coal occurs in but one place, viz., the south shore of Gaspe Bay, near Point St. Peter, where in the Devonian rocks of that locality a thin seam of only three inches is seen. Bituminous shales are found in the Utica formation at several places along the St. Lawrence, but are not sufficiently rich to warrant any attempt at distillation. Petroleum is known to occur, in small quantity at least, about the shores of Gaspé Basin, and peat exists in immense quantities at various places throughout eastern Quebec.

COAL.

Former belief in its occurrence in Quebec

Of the coal it may be said that, while it is generally acknowledged by the best authorities on the subject that no deposits of value can ever be found in the Province of Quebec, there are yet certain persons who do not hesitate to affirm, not only the possibility of its occurrence, but who make strong assertions to the effect that coal does really exist at several points. Possibly in most cases this belief is due to the fact that in some of the rocks about Levis, and on the Island of Orleans, as well as at various points along the south side of the River St Lawrence, a coaly, or rather a pitchy, material is found filling cracks or seams, of which, from time to time, limited quantities have been obtained. In the earliest reports on the formations about Quebec by Dr. Bigsby these rocks were regarded as the possible equivalents of the Carboniferous of England—a conclusion, doubtless, to some extent founded upon the presence of this coaly matter. In the sandstone of the Sillery quarries also, a short distance above Quebec, thin seams or partings of what at first sight appears to be anthracite coal are seen and

Bituminous matter in rocks along the St. Lawrence River.

can be traced for several yards. These have at one place a thickness of from one to two inches.

The age of these rocks along the St. Lawrence has, however, for some years been known to be much older than that of the coal measures, and whatever carbonaceous matter may be found does not partake in any way of the nature of the coals of that formation anywhere at present known.

The coal of Bay St. Paul.

In one of General Baddeley's papers, 1831, an account of the finding of coal at Bay St. Paul or St. Urbain is given. This deposit was reported in Quebec on April 1st, 1829; and though the examination of the locality by General Baddeley proved conclusively that the coal there found was no other than Newcastle coal which had been deposited on the banks and in the bed of the stream in rear of St. Paul's Bay, the excitement over the reported discovery ran so high, and so many persons professed belief in the existence of coal in that vicinity, that Sir William Logan in his report for 1849-50 found it necessary to discuss the whole subject at length, and to point out clearly the utter uselessness of anyone attempting to mine coal at such a place. In Gaspé also, where an extensive coal field was at one time supposed to exist, he also clearly pointed out the impossibility of any such deposit ever being found there, since the highest rocks in the geological scale were proved to belong to the lower Carboniferous formation, which underlies the true coal measures everywhere. By some also the black bituminous shales of the Utica have been supposed to indicate the presence of coaly matter in large quantity—a supposition, however, in face of the known facts concerning the occurrence of coal all over the world, which need not here be refuted.

Entire absence of coal measures in the province.

PETROLEUM.

Petroleum of Gaspé Basin.

The only place in the province in which petroleum is known to occur, in any quantity, is near the extremity of the Gaspé Peninsula around the upper portion of Gaspé Basin. In the first description of this coast by Sir William Logan in 1844 the presence of several petroleum springs is noted, one of which was on the beach on the south side of the River St. John, about a mile and a half above Douglastown; the other in a small branch of Silver Brook, itself a branch of the South-West arm, and about seven miles from its entrance into Gaspé Basin. The presence also of a peculiar dyke of trap which holds petroleum in drusy cavities, and which is seen on the beach on the north side of Point St. Peter, near Seal Cove, was at the same time pointed out. The strata in which these springs occur belong to the

Devonian system, in the rocks of which, at this place, a series of anticlinals occur, along the line of some of which, these springs are supposed to issue. In the Geology of Canada, 1863, reference is again made to these two springs, and the possibility pointed out that the source of the oil may be in the underlying rocks, as in the case of the oil regions of Western Canada. The great interest arising from the discovery of native oil in wonderful quantity in that section directed attention to the Gaspé district which resulted in the finding of several other springs similar to those already noted.

History of the Gaspé boring operations. A company was thereupon formed to test the locality by boring, and a large tract of land contiguous to Gaspé Basin was surveyed and set apart as a oil district. A company styled the Petroleum Oil Company secured land in the townships of Galt, Blanchet, La Roque and Baillargeon comprising about 40,000 acres, as well as mining rights at Sandy Beach, in York, Gaspé South and Douglastown, with a further area of about 30,000 acres, all of which belonged to W. B. Fowler & Company. These put down several holes at Sandy Beach and at Silver Brook, and spent a large sum of money; but as none of the borings penetrated deeper than 1200 feet, as far as can be learned, no definite results were obtained, and the company finally suspended operations.

Bore-holes. From notes furnished by Mr. J. B. Simpson of the Audit office, Ottawa, the following additional particulars as to the operations of this Company may be given.—Three bore-holes were put down as follows; Douglastown, 1860, 200 feet, Sandy Beach, 1862, 400 feet, Silver Brook, 1861-62, 1200 feet. At Silver Brook, a pocket of oil was struck at 900 feet, which overflowed the stream, took fire, and burned the derricks and the surrounding forest over several thousand acres. This hole was continued downward 300 feet further, when a strong flow of salt-water occurred, and the work was abandoned. The logs of these were preserved with the samples taken out, for some years, but no record can now be found of them. The Company which carried on the principal boring operations was composed of the following **Company.** gentlemen: Messrs. W. E. Mercer, Norfolk; D. Roblin, Belleville; James McLeod, Essex; John Simpson, Niagara; and Malcolm Cameron, Quebec. The amount spent by this Company during their three years' work was about $40,000.

Recent explorations in Gaspé. Very lately interest in the oil of this area has been revived, and two companies have commenced operations with the apparent determination of proving the lower measures. In these the old company's rights as regards lands, etc., are now represented by Mr. James Foley, of Boston, and boring operations have been resumed at Sandy Beach, near the site of the former bore-hole. Derricks have been built and a hole put down to the depth of 800 feet, in which several small shews of oil are reported between the depths of 500 and 800 feet. At this depth salt water was struck, which necessitated piping. A little gas was also met with in the boring. It is the intention, after piping off the water, to continue the hole, if possible, to a depth of 2,500 feet as a test hole. Throughout the depth bored only a succession of sandstones and shales appears to have been encountered.

The second company engaged in boring is the "International of St. Paul, Minnesota." They have acquired lands in block forty-one, Galt, on a branch of the first fork (Martin's Fork), of the River York about eighteen miles from Gaspé Basin. The indications on the property are reported to consist of a gum bed and several shews of oil, one of which is stated to be an oil spring from which several gallons of oil can be collected in a day.

The boring on this property is reported to be down 240 feet through dark sandstone, in which depth no oil was found.*

Several other areas have been secured by different parties in the immediate vicinity of those already being operated on. The question of the occurrence of oil in the Gaspé limestone series of this place cannot therefore be said to be satisfactorily settled yet, but if the original company carries out its present scheme, something definite will be ascertained concerning the prospects from this area, more directly along the coast.

PEAT.

Early references.

While deposits of peat are found at many points throughout the province of Quebec, but more particularly in the great stretch of comparatively level land lying to the east of the St. Lawrence, and have been referred to in the several reports of the Geological Survey since 1849, but few attempts to work these on a large scale have been made. In the Geological Survey report for 1855 Dr. Hunt gave much information of the highest value in reference to the economical working of these deposits, basing his observations upon the methods in use in France, where peat fuel is very extensively used and where the indusgives employment to a large number of persons.

Dr. Hunt on the importance of the peat deposits.

The methods of manufacture there employed in the preparation of compressed peat and charcoal, and of the by-products which are derived in the several stages of the process, such as paraffine, ammoniacal salts, illuminating gas, oil, etc., are also stated, as well as the cost of the production of a very useful fuel, which appears to equal in value much of the coal or wood there consumed and with which it

* For much of this information I am indebted to the late Mr. Joseph Eden, of Gaspé Basin.

enters into close competition. The importance of the peat bogs as a source of supply for fuel was still further insisted on in the Geology of Canada for 1863, where much additional information was given, and in view of the scarcity and present high prices of coal, both bituminous and anthracite, in the provinces of Ontario and Quebec, and the great and rapidly increasing demand for imported fuel, owing to the yearly decrease in the supply of wood, the facility with which an excellent fuel can now be manufactured from peat is such as to warrant some little attention being devoted to this branch of our mineral wealth; more especially, if by improved methods of preparation, a fuel sufficiently hard and dense can be produced which may be used in the blast furnace for smelting purposes or can be readily converted into a firm and durable coke.

The prime difficulty in the utilization of peat as a fuel for the various processes of manufacture, or for domestic purposes, is apparently the large quantity of contained moisture and the great difficulty experienced in its removal. This difficulty arises in large part from the porosity or springiness of the material, and many trials and experiments have been made by which this tendency to absorb moisture could be checked when once it had been eliminated. As a result of these, the plan of pulverizing the peat as it comes from the bog, drying it as rapidly as possible, and then soldifying it under great pressure, has, in so far as yet tried, been found to yield the most satisfactory results.

Peat machines of Mr. Hodge.

Applying in part these principles, Mr. Hodges, an English engineer, some years ago invented a machine, which by means of huge revolving disks, attached to the front of a large scow, cut the material of the peat bog, the surface of which had been previously prepared by clearing away the roots, and at the same time pulped the peat to a very fine and uniform mass. The pulp was then distributed by means of a long spout over the side of the scow upon the prepared surface of the adjoining bog and left to dry in the sun for some days. As soon as a skin formed on the surface of the drying peat the mass was divided into blocks of convenient size by cuts along the length of the bed, generally at intervals of about six inches apart, and subsequently upon further drying by a series of cuts at right angles to these at intervals of eighteen inches, so that in a comparatively short time, if the weather was favorable, the bed of prepared peat was resolved into a series of blocks, eighteen inches by six, which, as soon as sufficiently hard for handling, were carefully taken up and stacked for further drying, the final result being a very excellent quality of fuel at a very low cost. The peat by this process was not compressed.

Preparation of dried peat by this process.

Work on the Arthabasca branch of the G. T. railway.

A practical application of the invention was made by Mr. Hodges in 1864-65 in a peat bog along the line of the Arthabaska branch of the

Grand Trunk railway. The machine, which has, however, subsequently been very greatly improved, required for its management six men, and was capable of digging, pulping and spreading over 14,000 cubic feet per day of ten hours. This was estimated to yield fifty tons of air-dried peat fuel, costing in the barges on the canal ninety-two cents per ton, and containing about twenty-five per cent. of water, which was lessened by further drying. Experiments with this fuel were made for some time in the locomotives of the Grand Trunk railway, both on the Arthabaska branch and on the main line to Montreal, with such satisfactory results, that a contract was made by the Company for a daily supply of 300 tons after the first year, and extending over a period of five years. The produce of such a bog per square mile, cutting the peat to a depth of five feet, was very nearly half a million tons. The cause of the failure of the enterprise has not been made public, but that the quality of the fuel was satisfactory may be inferred from subsequent operations in the samedirection. From the description of this industry given in the "Catalogue of Economic Minerals," prepared by the Geological Survey for the Paris Exhibition of 1878, we learn that the Canada Peat Fuel Company subsequently engaged in the manufacture of the fuel prior to 1877, near St. Hubert, in Chambly county, ten miles from Montreal, and at Ste. Brigide ten miles east of St. Johns on the Richelieu; the machines employed being those of Mr. Hodge, two of which were at work at St. Hubert and one at Ste. Brigide. These in 1874 produced 20,000 tons of prepared peat, and in 1875 13,000 tons, of which the greater part was sold to the Grand Trunk for their locomotives. Upon the suspension of operations by this Company, Mr. Aikman, who for nine years had been their manager, undertook the business of peat-making on his own account near the same locality, but he substituted for the Hodge machine an improvement of his own invention, less costly, more simple, and giving better results. By the Aikman process the peat, after being pulped and freed from roots and other impurities, was artificially compressed and then dried in the air, the drying requiring only about six days. These machines were made in Montreal and cost about fifteen hundred dollars each, and had a capacity of twelve tons of compressed peat per day, the price of which in Montreal ranged from three to four dollars. The time of working extended from the first of May to the first of October. The operations of Mr. Aikman were, however, largely experimental, and no great output was obtained. In 1875 about 400 tons were taken from the bogs near Port Lewis, in Huntingdon county, by the Huntingdon Peat Company using a system know as the Griffin process.

Its use by the G. T. railway.

Operations at St. Hubert and St. Brigide.

Huntingdon county.

Anticosti.

A long list of localities at which peat bogs occur is given in the Geology of Canada, 1863, both for the north and south side of the St. Lawrence. In the island of Anticosti also very extensive bogs of apparently excellent peat occur, one of which is said to be twenty-four miles in length by two in breadth.

The following table, taken from the Catalogue of Economic Minerals above cited may be added as showing the analysis of four samples of peat prepared by the Aikman and Hodge process. Nos. I and II are by the former, III and IV by the latter :—

Analysis.

	I	II	III	IV
Water	14.83	16.52	17.06	14.96
Combustible and volatile matter	50.15	53.29	50.73	59.60
Fixed Carbon	28.18	22.48	25.95	22.20
Ashes	6.84	7.71	6.27	3.24
	100.00	100.00	100.00	100.00

Value of peat as fuel.

There appears, with proper treatment, to be no difficulty in manufacturing an excellent quality of charcoal from peat, either from the air-dried or the compressed. From the figures quoted by Dr. Hunt as obtained from the Paris manufacturers, air-dried peat yields from thirty to forty per cent. of its bulk and twenty-five to thirty of its weight in charcoal, while from the compressed peat higher results were obtained. The price in Paris of peat charcoal and wood charcoal was about the same. Experiments were made with peat in Montreal some years ago in puddling iron, with very satisfactory results; and from the experience obtained from various places in Europe as well as in Montreal, it would appear that in a country like Quebec, where coal commands a high price, these peat deposits should be found very well adapted, not only for the manufacture of iron, but for many other purposes for which coal is at present used.

CLASS III.

MINERALS APPLICABLE TO CERTAIN CHEMICAL MANUFACTURES.

Of the minerals which naturally come under this head several have already been described in preceding pages, more particularly under the heads of ores of copper and ores of iron. The greater part of the copper and iron sulphides which are now mined in the province of Quebec is utilized for the manufacture of sulphuric acid, the residue being subsequently treated for the extraction of the copper and silver Within the last three years extensive works have been erected for this purpose near the mines at Capelton, and the acid is largely used at the same works for the manufacture of superphosphate from the apatite of the Ottawa valley. No further reference is considered necessary here as regards the deposits of pyrites, as their distribution and their geological relations have been already stated.

Apatite or Phosphate of Lime.

First reference, 1847.

The occurrence of apatite in Canada was pointed out by Dr. T. Sterry Hunt, in 1847, in the report of the Geological Survey for that year, and attention was at the same time directed to its great value as a fertilizing agent. The deposits described were found principally in the township of Burgess, Ontario, but in the Catalogue of Minerals and their Localities, published in the report for 1849-50, reference is also made, under the head of "Manures," to the occurrence of phosphate of lime in Hull, the lot and range not specified, but near Blasdell's mills, as also at Bay St. Paul and Murray Bay. But little importance appears to have been attached to the Quebec deposits, since in the list of economic minerals in the Exhibition Catalogue, London, 1862, the only sample mentioned is from Burgess, where fine crystals had been obtained. The occurrence of phosphatic nodules near the base of the Chazy limestones in Lochiel and West Hawksbury, opposite Grenville, on the River Ottawa, as well as in sandstone with green shale at the latter place, was pointed out in the report for 1851-52, and the opinion expressed that, if the sandstone in which the nodules were thickly distributed was burnt and ground, a very fine manure for stiff clay soil would be produced. Similar nodules were found to occur in a limestone conglomerate at Kamouraska and at River Ouelle Point, but these were apparently confined to limited areas of the rock, and are not likely to be of any economic importance.

Phosphatic nodules on the Ottawa.

Kamouraska.

In the Geology of Canada, 1863, pp. 757-61, much valuable information is given relating to the uses of ground or superphosphate; but even at that date, although the presence of the mineral was known in the Laurentian rocks of the Gatineau, the importance of the deposits had not begun to be realized; the principal examinations and work having been confined to the townships of Burgess, Elmsley and Ross, in the province of Ontario, and it was not till ten years later, or in 1873-74, that the examination of these areas in Quebec was taken up on the part of the Geological Survey.

Report of Mr. H. G. Vennor, 1873-79. In the first report by Mr. H. G. Vennor, the apatite openings in Burgess are very fully described, and the probabilities of the occurrence of the mineral in other portions of the Laurentian rocks considered, in so far as the information available at that date permitted. The rocks of Quebec in which the apatite was known to occur were held to belong to the same horizons as those of Ontario, and these consisted for the most part of gneiss, crystalline limestone, quartzite and pyroxenite, with mica schist and occasional masses of red syenite, which were regarded as of Laurentian age.

In the early history of the industry, many mistakes were made as to the nature of the mineral, the green granular pyroxenite rock being frequently regarded as phosphate and mined for the purpose of shipment. The interest now taken in this mineral had then scarcely begun to manifest itself, and but little further information can be obtained from the report quoted, except that veins or masses of apatite are found at several points along the Lievre River, in the townships of Buckingham and Portland, and that workings had been commenced at the Little Rapids in what was known as the Garrett mine.

H. G. Vennor, 1876-77. In the report for the succeeding year, while Mr. Vennor goes quite fully into the history of the apatite industry in Ontario, no further mention is made of the deposits found in Quebec, but in that for 1876-77 the results of his examination of the apatite and plumbago deposits of Ottawa county appeared, and furnished the first authentic account of the progress of phosphate mining in Quebec. Mr. Vennor, in this report, divides the rocks which constituted the Laurentian of the apatite district into four parts, as follows :—

Rocks of the apatite district. 1st. Red granitic gneiss and hornblende gneiss, with small bands of crystalline limestone, containing apatite only in small quantity, and that near the summit. This constitutes the lowest division.

2nd. Red orthoclase gneiss, quartzite and pyroxenic strata, with irregular deposits of apatite, largely in the form of crystals, with mica.

3rd. Rust-colored gneiss and pyroxene, and felspar rocks with small bands of crystalline limestone. This contains rich and numerous deposits of apatite associated with mica.

4th. Rust-colored garnitiferous gneiss, rust-colored quartz and orthoclase rocks, crystalline limestone with serpentine and pyrallolite, containing irregular deposits of apatite and mica.

Mr. Vennor expressed the opinion that the rocks which contained the apatite in quantity constituted a distinct horizon, and belonged to a higher portion of the series than those in which the iron ores of Hull, South Sherbrooke and Bristol are situated, as well as those which contain the plumbago of the same district. In Buckingham and Templeton the apatite was stated to be "confined to a belt of rocks averaging about one mile and three-quarters in width, which runs in a general north-easterly direction from Perkin's mill on the Blanche River, near the centre of Templeton, through the extreme north-western corner of Buckingham, and thence across the Aux-Lievres River, through the south-eastern corner of Portland, into about the central portion of Derry township. This belt is very productive, and yields a finer quality of apatite than I have met with in any other section of the country. On it are situated all the apatite mines of any importance which have so far been opened, and it will be on the repetition of it, on the opposite sides of anticlinal and synclinal folds of the strata, that other similar deposits will probably be discovered." These were the views held by Mr. Vennor in 1876.

H. G. Vennor, quoted.

The deposits of apatite in the townships of Hull and Wakefield, which were at that date discovered, were held by him to occur in a repetition of the same belt of rocks as those just described. A very important paper, bearing upon the mode of occurrence of apatite in the Ottawa district, is found in the Geol. Rep., 1877-78, by Dr. B. J. Harrington. In this the resemblance between the apatite-bearing rocks of Norway and those of Canada is pointed out, as well as the points of difference. According to Dr. Hunt (see Geol. Canada, 1863), the workable deposits were, with few exceptions, at least in the Burgess district, confined to the veinstones, although the mineral did occur at times in beds. From the evidence observed by Dr. Harrington, the conclusion was reached that many of the apatite deposits were not beds, since they cut across the strike of the containing rocks, while in other places deposits that presented the aspect of interstratified beds in places were seen to give off lateral branches, which also cut across the strike of the rocks.

Dr. Harrington, 1877-78.

Apatite both as veins and bedded deposits

The rock containing the apatite veins is very frequently pyroxenite, though they occur also in gneiss. They are said by Harrington to be frequently characterized by a want of regularity in the arrangement of their constituents rather than by any degree of symmetry. Sometimes a true fissure vein occurs, and in some cases a regular alternate deposition of minerals from side to side. Sharply defined walls are rarely seen, the sides of the vein frequently merging into the contain-

Segregation origin of the veins.

ing wall. As to the mode of their formation, Dr. Harrington's conclusions were the same as those of Dr. Hunt, viz., that they were the result of the filling in of fissures or cavities by the deposition of material derived from the adjacent strata. While in this case the presence of the apatite is held to be due to the segregation of this and other minerals which accompany it from the surrounding rocks into lenticular or irregular shaped masses, without the existence of any true cavity or crevice, Dr. Harrington also holds that the views of the Norwegian geologists, as to the eruptive origin of apatite in that country, cannot apply to the Canadian deposits, since the composition and character of the mineral is found to vary as it passes from one kind of rock to another; those cutting limestone, or in proximity to that rock, being calcareous in a much greater degree, while, in those cutting pyroxenite, grains of apatite are found imbedded in the mass of the containing rock, and tend to show that the apatite was derived from these strata, probably by segregation.

Sir William Dawson.

Sir William Dawson, in a paper, read before the Nat. Hist. Soc., Montreal, 1878. "On the Phosphates of the Laurentian and Cambrian of Canada" discusses the probability of the animal origin of the Laurentian apatite, and holds that there are certain considerations which point in this direction, although there is no direct testimony on the subject. Among these are the presence of the iron-ores, the graphite, and of Eozoon Canadense, which he, with others, holds to represent the earliest known forms of life. Sir William further, says, that the possibility of the animal origin of this phosphate is strengthened by the presence of phosphatic matter in the crusts and skeletons of fossils of primordial age, "giving a presumption that in the still earlier Laurentian a similar preference for phosphatic matter may have existed and perhaps may have extended to still lower forms of life." In this connection, Dr. Harrington remarks that, "if the apatite of these ancient strata, represents material, accumulated by organic agencies, then the connection of the pyroxene and the apatite may be, that the material of the former constituted an ocean bottom, particularly suitable for the life of the creatures which secreted the phosphatic matter."

Possible organic origin of apatite.

Extent of deposits downwards.

The formerly received opinion, that the deposits of apatite were comparatively shallow or extended downward to a very limited depth, has, by the work of late years, been completely disproved. Shafts to a depth of over 600 feet still continue in good phosphate, and the vein matter, though irregular, is continuous. The occurrence of the apatite is somewhat peculiar in this respect, resembling strongly the ores of manganese and of iron, as found in the Carboniferous and Devonian rocks of Nova Scotia and New Brunswick. In places pockets of large size are found, which extend irregularly for some distance, and gradually, or sometimes abruptly, diminish to mere threads, with a subsequent enlargement; and it is this great element of uncertainty as regards the permanence of the veins or beds which has acted so unfavorably in many cases, as regards the successful development of apatite locations. This irregularity in structure and mode of occurrence may be due to the great crumpling or pressure to which these rocks have been subjected, and which may, in some cases, have occurred subsequent to the formation of the vein itself. Some of the veins appear as if they had been disrupted by the effect of pressure, the mineral occurring in very irregularly shaped and disconnected masses.

Resemblance to the manganese ores of new Brunswick.

The apatite of Norway, where considerable quantities are found, presents some points of resemblance to that of the Ottawa district. The veins occur in granitic or gneissic rocks, and are frequently surrounded or enclosed by layers of black mica or hornblende. These veins are very irregular in their character, frequently thinning out, or at other times thickening into large pocket masses. They are sometimes suddenly broken and interrupted by masses of rock, after the nature of faults apparently, on the other side of which, by careful search, the vein can be again located, and is frequently of large size. The veins are often from one to two feet thick at the surface, but, in following them downward to a depth of fifty feet or so, they are often found to increase to five or six feet, below which they descend to an unknown depth.

The apatite of Norway.

The quality of the Norway phosphate is generally high, averaging 85 to 95 per cent. of tribasic phosphate of lime, and, though not quite uniform, its richness does not vary greatly, and it is said never to yield less than 85 per cent. The apatite of Norway varies in color, being rose-red, yellowish, green and sometimes whitish. A vein near Drammen is said to have attained a thickness of thirty feet at a depth of one hundred feet from the surface.

The geologists, Messrs. Brœgger and Reusch, in a paper on the occurrence of apatite in Norway, presented to the Geological Society of Germany, hold to the eruptive origin of these apatite veins, in which conclusion they differ from the opinion expressed by Hunt, Harrington and others, of the Canadian Geological Survey, * as applied to the Canadian mineral. The association of other minerals with the apatite is, however, very much the same in both countries, although

Messrs. Brœgger and Reusch.

Eruptive origin of apatite.

* My own examinations of the Canadian apatite deposits (veins, etc.) have led me to a conclusion respecting their origin corresponding with that of the Norwegian geologists. I hold that there is absolutely no evidence whatever of the organic origin of the apatite, or that the deposits have resulted from ordinary mechanical sedimentation processes. They are clearly connected, for the most part, with the basic eruptions of Archæan date.—A. R. C. SELWYN.

limestone is said to occur very rarely in the districts of Norway, where the apatite deposits are principally found. The gabbro, in which the veins are said to occur in Norway, is very similar to that which in the Canadian reports is described as blotched diorite, consisting of dark-green to black hornblende, with labradorite or oligoclase, and sometimes a little mica. According to Dr. Harrington, while veins of apatite have been found in this dioritic rock, they were apparently of but little value.

Resemblance of Canadian rocks to the Norwegian.

Present sources of supply.

Among the present sources of supply for phosphate of lime, one of the greatest is in the Southern States of America, more particularly in South and North Carolina, though similar deposits are found in Florida, Georgia and several other places. This mineral is of a different character and origin presumably to the Canadian and Norwegian apatite, being without doubt entirely organic in its nature. It occurs in nodules of phosphate of lime, often of very large size, distributed through marly clays, through which the streams of that section are excavated, and which belong geologically to the Tertiary or Cretaceous period. These are particularly well seen in the vicinity of Charleston, South Carolina, where they are extensively mined for shipment both to England and to other points in the United States. The average per centage of tribasic phosphate from the mineral shipped is from 53 to 60 per cent., among other ingredients present being sulphuric and fluoric acid, ammonia and sesquioxide of iron.

Mr. Hoffmann's assays.

The percentage of tribasic phosphate of lime in the Canadian mineral is tolerably uniform, as shown by a series of analyses by Mr. Hoffmann, and given in the Geological Report, 1877-78. The result of seven samples tested in the laboratory, including the townships of Storrington, Buckingham, North Burgess, Portland, Loughborough and Templeton, give percentages of tribasic phosphate ranging from 85.241 to 89.810, which compare very favorably with the analyses of specimens from Norway, Spain, Germany and Russia.

Report by Mr. Torrance.

The latest report on the apatite deposits of Ottawa county, on the part of the Geological Survey, is by Mr. J. Fraser Torrance, M.E., 1882-83. Mr. Torrance, after a careful examination of the several deposits, came to the conclusion that those in Portland and Buckingham were "irregular segregations from the country rock, and were confined to one or more zones of rock, that approximately followed the course of the Rivière du Lièvre in a general north-north-west direction, and are more or less heavily impregnated with apatite." In regard to the bedded character of some of the deposits, he says: "During the past season I often noticed in the same pit, patches of apatite, that might easily be taken for the contents of a fissure vein, if there were any casing rock on either side of it to separate it from the country rock, and patches of flat-lying apatite, that might easily be called bedded, if they were of any great extent or approximately uniform thickness, and if the country rock showed any planes of bedding parallel to the longest axes of such patches; or else it might easily be assumed that the country rock had been more or less tilted and overturned since the deposit of the apatite, and that the vertical patches were interbedded and the more horizontal ones were veins, if their relations to the country rock were such as veins and beds respectively are wont to maintain, but unfortunately I failed to perceive these conditions." Mr. Torrance did not find the presence of the band of rusty-colored gneiss to be a guide to the richest deposits of phosphate, as supposed by Mr. Vennor, but found that these rocks were commonly associated with the graphite. From the description of the many pits and workings, as given in the report of Mr. Torrance, it would appear that, in "by far the greatest number of cases, the containing rock of apatite is pyroxenite, and that the veins are very irregular, consisting of large bunches or pockets of ore, yielding hundreds of tons, which suddenly pinch out, but soon reappear when followed on their course. The great depth to which several of these mines have been proved already shows that the mining of the apatite, when carried on in a scientific and systematic manner, can be profitably conducted. The loose and unscientific methods formerly pursued, while giving rapid returns for the time, since these were for the most part entirely confined to surface shews which rapidly became exhausted, will of necessity require to be changed, and the entire industry placed on a proper basis for future successful work, and the exploitation of the veins will have to be carried on in a proper manner. In this connection it will doubtless be found an advantage to have several pits in operation at the same time, so that in case of encountering dead ground, owing to the pinching out of the vein in any one, a supply of ore will still be at command in some one or more of the other workings, and prove sufficient to carry the mining in the poor ground into productive work again."

Progress of the industry.

The increase in the production from the Quebec mines since 1877, when an output of only 2,823 tons was returned, has been for the most part constant, reaching in 1886 no less than 28,535 tons. * The estimated figures of the output for 1889, according to the Ottawa Mining Review, are 33,000 tons, including that from the Ontario mines, but a new feature has of late been introduced into the industry, viz., the increased demand in the United States market; the export to that quarter for last year having aggregated over 4,000 tons,

* See report, E. Coste, Geological Survey, 1887.

Output.

most of it of a quality not sufficiently rich for the English trade. The introduction also of sulphuric acid works in Capelton and the manufacture of superphosphate, which is now being commenced in connection therewith, will also tend to provide a market for the lower grades, which in the past have been regarded simply as waste rock.

Crude phosphate.

The question of the utilization of the crude phosphate as a fertilizer is also receiving much attention. While it is recognized that the apatite itself is unacted upon in its raw state by the atmosphere, if finely pulverized it can be taken up by the little rootlets of the plant when brought into contact with these by admixture with the soil, though not so readily as in the shape of superphosphate. The report of the experiments conducted on the Central Experimental farm, on this subject, will be awaited with interest.

Further information on the subject of phosphate.

In addition to the reports of the Geological Survey, already referred to, several others of great importance, bearing on the question of the Canadian apatites, have quite recently appeared. As most of these are of later date than the latest views on the subject by the officers of Canadian Survey, a brief *résumé* of the principal ones is here summarized, more especially as they all have a practical bearing on the discussion of the mode of occurrence of apatite, together with its economic and commercial value, in order that the subject may be treated as fully and completely as possible.

Views of Mr. G. C. Brown, 1884.

In a paper on the apatite deposits of Ontario and Quebec, by Mr. G. C. Brown, read at the Montreal meeting of the Bri sh Association, 1884, it is stated that apatite occurs in different ways—first, as a constituent of the rock, much in the same sense that quartz is a constituent of granite, with the proviso that apatite-bearing rocks are in much smaller masses than granite. In such rocks apatite may vary from five or ten to fifteen per cent., in grains and particles from the size of peas to hazel nuts, enclosed in pyroxenite. Mica is not always present. In these cases the pyroxenite rock is said to sometimes occupy an area of several acres having the general strike of the country rock; the length of the areas being from four to five times the breadth. Mr. Brown holds that there are seldom clear walls of separation between the apatite and the enclosing rock, such as occur with crystals, and, in detaching a piece, some of the apatite may be left with the pyroxenite, or some of the latter come away with the apatite.

A further development of this type shows fewer but larger masses of apatite, sometimes of more than 1,000 tons in weight, having the same indistinct walls of separation and containing masses of pyroxenite, Massive iron pyrites occur in the larger deposits, but not in the disseminated grains. Where the wall is other than pyroxenite the apatite separates cleanly from it. The presence of the massive apatite was held to indicate the presence of pyroxenite, but the latter frequently occurs without the former. In quantity the apatite deposits vary from a few hundreds of pounds up to several thousands of tons.

Deposits of apatite, on the surface soil being removed, have sometimes been found to have a length of ten times the breadth. Thus, one of four feet wide might be forty feet long; in which case, the deposit thins out at either end, and continues sometimes as a mere thread. The strike of these masses is generally that of the country rock, and the appearance, according to Mr. Brown, is as if the mass had been squeezed up and enfolded in a bed-like form.

Mr. F. D. Adams.

In a paper by Mr. F. D. Adams, at the same meeting, the presence of rocks near Arnprior, on the Ottawa, is pointed out, which resemble very closely the Norwegian rock called "*apatit bringer*," in or near which the apatite of Norway is found. Slices of these rocks, under the microscope, showed the presence of scapolite, sometimes in large amount.

Dr. T. S. Hunt, 1884.

Dr. T. S. Hunt, in his paper in the "Transactions of the American Institute of Mining Engineers," 1884, on "The Apatite Deposits of Canada," makes a distinction between the character of the bedded and vein deposits. He says: "The gneissic rocks, with their interstratified quartzose and pyroxenic layers and an included band of crystalline limestone, have a general north-east and south-west strike, and are much folded, exhibiting pretty symmetrical anticlinals and synclinals, in which the strata are seen to dip at various angles, sometimes as low as 25° to 30°, but more often approaching the vertical. The bedded deposits of apatite which are found running and dipping with these, I am disposed to look upon as true beds, deposited at the same time with the enclosing rocks. The veins, on the contrary, cut across all these strata, and, in some noticeable instances, include broken angular masses of the enclosing rock. They are, for the most part, nearly at right angles to the strike of the strata, and generally vertical, though to both these conditions there are exceptions. One vein, which had yielded many hundred tons of apatite I found to intersect, in a nearly horizontal attitude, vertical strata of gneiss, and in rare cases, which appear from their structure and composition to be veins, are found coinciding in dip and in strike with the inclosing strata."

"The distinction between the beds and the veins of apatite is one of considerable practical importance—first, as related to the quality of the mineral contained, and second, as to the continuity of the deposit. The apatite of the interbedded deposits is generally compactly crystalline, and free from admixtures, though, in some cases, including pyrites, and more rarely magnetite iron-ore, with which it may form fine interstratified layers. . . . . . The veins present more complex conditions. While they are often filled throughout their width by apatite as pure and massive as that found in the beds, it happens not unfrequently that portions of such veins consist of coarsely crystalline, sparry calcite, generally reddish in tint, holding more or less apatite in large or small crystals, generally with rounded angles, and often accompanied by crystals of mica, and sometimes of pyroxene and other minerals. Occasionally these mixtures, in which the carbonate of lime generally predominates, will occupy the whole breadth of the vein. . . . . . . These calcareous veins often carry so much carbonate of lime as to be worthless for commercial purposes, unless some cheap means of separating the apatite can be devised." While the thickness of the deposit in both veins and beds is very irregular, Dr. Hunt expresses the opinion that those in the bedded form are the most continuous and persistent throughout, and, as a whole, more likely to give more profitable returns, other things being equal.

Dr. Hunt, 1885. In a subsequent paper read by Dr. Hunt at the Halifax meeting of the same institute, in 1885, he states that "the crystalline apatite of the DuLievres district belongs to lodes of great size, which traverse the ancient gneiss of the region. These lodes include a granitoid felspathic rock, and a pyroxene rock with large masses of quartz, of carbonate of lime, of pyrites and of apatite. All of these show a banded structure not unlike that of gneiss, to which they are evidently posterior, and of which they often contain fragments."

Improved machinery for mining and systematic methods of work have greatly increased the output from these mines, so that Dr. Hunt says some of these have put out from 600 to 1,000 tons per month, yielding on an average 80 per cent. of phosphate of lime, and worth in Montreal $18 per ton. This is for the summer of 1885. He also says: "The growing demand for high fertilizers on this continent, and the fact that the apatite of Canada may be shipped to the valleys of the Ohio and Mississippi much more cheaply than the phosphate rock of South Carolina, give a great importance to these Canadian mines."

Professor W. Dawkins, 1884. Professor W. Boyd Dawkins, in a paper presented to the Manchester Geological Society, 1884, on "Some Deposits of Apatite near Ottawa, Canada," after an examination of the Little Rapids and the Emerald mines, as well as of several others, held that these deposits occur in veins, formed either in the massive state or as large independent crystals, shooting from the side of the fissure, or sometimes perfect at both ends, and completely surrounded by calcite, but that these veins have no uniform direction. They occur in bright crystalline, massive schists, composed of pyroxene (augite) more or less altered, mica, orthoclase, triclinic felspar and apatite, which, if not bedded, would pass for an eruptive rock; but from this fact, and in addition that it is associated with crystalline limestone and quartzite, he is of the opinion that the containing rock of the apatite at these places is an altered rock of the Laurentian series, and to be classed with the hornblende gneiss of that system.

The reasons for the vein structure of the apatite are summed up under five heads, which may be summarized thus:—

1st. The veins are in some cases sharply defined, and deposited in a series of fissures, striking across the rock in various directions. The vein stuff sometimes shades off into the pyroxenite, as might be expected on the hypothesis that these deposits took place under conditions of enormous heat and pressure in the presence of water.

2nd. The character of the vein stuff is such as is usually found in fissure veins, sometimes presenting a banded structure formed by layers of apatite and pyroxene.

3rd. That both rocks and veins most probably received their charge from some common deep-seated source by hydrothermal action, while both were sunk deep beneath the surface, and the heat and pressure were sufficient to allow of apatite and the other minerals in the veins being deposited by water.

4th. The surfaces of some of the crystals present traces of hydrothermal action in their rounded angles and honeycombed surface.

5th. That the vein was in a state of movement while in a pasty state, shown in the crumpling and distortion of crystals of mica there found.

From the opinion expressed by Prof. Dawkins, dissent was taken by Mr. G. A. Kinahan, who, after an examination of the Emerald and other mines, came to the conclusion that the structure did not resemble that of a true fissure vein or lode. He says: "There is an absence of continuity in any particular direction, and in cross sections there is no correspondence between deposits on opposite sides. Calcite occurs on the foot and apatite on the hanging wall." Views of Mr. G. A. Kinahan.

The views held by Mr. Kinahan as to the origin of the deposit were that "it had resulted from the action of a solution, bearing fluorine and phosphorus (in what combination it was impossible to say) upon a bed of limestone." He held that this solution had traversed the main mass and been distributed by means of side fissures, the result of which upon the limestone of the bed was to convert a portion into fluor-apatite.

Mr. G. Henry Kinahan, in a paper before the same society, on "The Possible Genesis of Canadian Apatite," also expressed the view that "it is possible the present Canadian apatites were originally limestone or Mr. G. H. Kinahan.

allied rocks, the change to apatite being due to paramorphosis which at present cannot be satisfactorily explained." No attempt to explain the source of the phosphoric acid was, however, made. Mr. Kinahan in his paper compares the Canadian apatite-bearing rocks with certain rocks of Ireland, and says, in relation to the change of the limestone to apatite, that "if in the Irish assembly of submetamorphic rocks there are found phosphoritic eruptive rocks and limestone associated, while in the Canadian metamorphic rocks, apatite and nonphosphoritic eruptive rocks are similarly related, it may be supposed that the additional action to which the latter were subjected was such as to allow the phosphoric acid to replace the carbonic acid."

Dr. R. Bell, 1885.

In a paper to the Engineering and Mining Journal, 1885, "On the Mode of Occurrence of Apatite in Canada," Dr. R. Bell states that the apatite is derived principally from the pyroxenite, and that there is no evidence whatever of the organic nature of the mineral. The pyroxenite is held to be probably derived from igneous sources, either as submarine injections, while the Laurentian rocks were being formed, or as subsequent intrusions, even though at present they exhibit much of the aspect of bedded rocks. While not as a rule regarded as occurring in true fissure veins, certain large deposits, as at the Little Rapids appear to have that structure. Dr. Bell holds, in this paper, that the lines of deposit mark approximately the original jointing of the rock, which occurred in three sets, two of which were nearly vertical, intersecting each other, and the third was nearly horizontal; the apatite being deposited in these joint planes by the usual processes of segregation. The apatite is held to be accumulated in the largest masses along the intersection of the planes of the joints, more especially where all three come together at one point. He further remarks that "the apatite sometimes follows only one set of natural joints, when it appears on the surface as parallel veins; at others it is mostly confined to the horizontal ones, when it forms a succession of 'flaws,' and again it may follow both of the vertical sets or even all three, in which cases it appears in a reticulated form which is of very common occurrence."

Dr. Bell also says that on this view "we should naturally expect to find the mineral most freely exposed when upward movements of the apatite-bearing rocks had occurred, and that the deposits of the mineral between the blocks of the country-rock would be widest above, and further, that in going downward they would become pinched toward the next horizontal joint below, where they would open out again; also that the successive bunches of the mineral would become smaller and smaller in descending. These conditions appear to correspond with the experience of mining so far."

Mr. F. J. Falding, M.E., in a paper to the Engineering and Mining Journal, vol. xlii, 1885, on "Notes on Canadian Fluor-Apatite or Fluor-Phosphate of Lime," in which much valuable information is contained, states his belief in the organic nature of the mineral; arguing from the standpoint of the organic origin of all other phosphates yet known, except possibly those of Norway and other similarly situated deposits, and from the fact that many of the remains of fossils from the primordial rocks are largely phosphatic in their character, and also that the presence of the Eozoon limestones, the magnetic iron ores and the graphite also indicate the presence in those rocks of living organisms. As to the mode of occurrence of apatite he claims that:— Mr. F. J. Falding, 1885.

"1st. The apatite, pyroxenite and calcite were deposited in bed form.

2nd. That the phosphate of lime separated and concentrated, filling up fissures and breaks, the result of violent motion of the strata.

3rd. That although much contorted and disturbed, the formation of the principal deposits where the mineral may be said to be in place is still bedded."

Mr. Falding says: "If we consider these deposits to form part of an immense bed two hundred miles long and cropping up over a tract at least twenty-four miles in width, this bed consisting of banded gneisses, limestones, pyroxenites and apatites, crushed, contorted, broken up into synclinals, crystalline in all its constituents, it is easy to understand its practical occurrence, its varying thickness, its sudden cutting off, and yet its general persistency when followed. . . . If the deposits are the remains of original beds they are likely to be subject to the same laws that govern such deposits elsewhere; in short subject to demineralization and to faulting. The extreme action to which they have been subject will naturally make the occurrence of mineral more varied and even precarious than in beds of similar but less altered formations. Experience has shown that, while subject to all these vicissitudes, well defined surface croppings continue to produce an average quantity of mineral." According to Mr. Falding the supply is limited only by the demand.

In a paper by Dr. G. M. Dawson, read before the Ottawa Field Naturalists' Club, 1884, on "The Occurrence of Phosphates in Nature," the view is expressed that the stratified rocks of the Laurentian series, in which the apatite largely occurs, are of sedimentary origin, which have become changed from the original mud and sands into the crystalline rocks as we now find them, in which category is also included the contemporaneous volcanic materials. Dr. Dawson asserts his belief in the two modes of occurrence, viz., that the mineral occurs both in beds and as distinct veins and fissures, the former of which have apparently derived their apatite from the original presence of phosphatic Dr. G. M. Dawson, 1884. Apatite both as veins and bedded deposits nodules or coprolitic matter which has become changed by the processes of metamorphism into true phosphate of lime or apatite, while the veins have been filled by "processes of segregation in which the mineral is found, either nearly pure or more frequently mingled with crystals of other substances."

Dr. Penrose, 1888.

Among the most recent publications on the subject of Phosphate may be mentioned a very valuable and comprehensive paper by Dr. Penrose, published by the U. S. Geological Survey, Bulletin No. 46, 1888, in which the author not only discusses the question of the mode of occurrence of Laurentian or Canadian apatite, but presents a very comprehensive outline of the phosphate industry in general. For convenience of reference the classification of the phosphates as expressed by Dr. Penrose may be given. They are divided into two general classes thus :—

Mineral phosphates. { Apatites. { Fluor-apatites. Chlor-apatites. } ; Phosphates. }

Rock phosphates. {
- Amorphous nodular phosphates. { Loose nodules; cemented or conglomerates. }
- Phosphatic limestone beds.
- Guanos. { Soluble guanos. Leached guanos. }
- Bone beds.

This classification is stated to be intended simply as a matter of convenience in describing the various deposits, and as a consequence is, in some respects, somewhat arbitrary.

In this paper, which presents very clearly the greater part of the observations made by the officers of the Canadian Geological Survey, and includes many others, as well as the result of direct examination of the deposits by the writer, Dr. Penrose has included a number of very interesting sections of apatite deposits which show very clearly the different forms in which this mineral occurs, and illustrates the very great irregularity of its deposition. No new features as to its occurrence, other than those already stated, are presented. The pyroxenite is said to be "never found distinctly bedded, though occasionally a series of parallel lines can be traced through it, which, while possibly the remains of stratification, are probably often joint planes. Sometimes when the pyroxenite is weathered, apparent signs of bedding are brought out, which are often parallel to the bedding of the country rock." The presence of numerous trap dykes which occur in the Quebec district is pointed out, and their later age as compared with

Occurs both in veins and beds.

the apatite is shown by the fact that these in places traverse the apatite veins. An instance of the bedded character of some of the deposits is mentioned as occurring in an old pit in Buckingham township, where the apparent lines of stratification in the pyroxene are marked by bands of apatite. The distinctly banded character of some of the veins is also pointed out. Good sections are presented of the Emerald and the North Star mines, in which the vein structure of the former is well shewn, and the often pockety character of the mineral at the latter.

Deposits of Canada, Norway and Spain.

According to Dr. Penrose the deposits of apatite proper as at present known, are confined to three countries, viz., Canada, Norway and Spain. Of these the two former furnish a mineral very similar in character and mode of occurrence, though the views held by the geologists of the two countries as to its origin and mode of occurrence differ very considerably. From the series of assays presented by Mr. Hoffmann in the Geological Survey Report 1877-78, it would appear that the apatite of Norway and Spain contains a slightly higher percentage of tribasic phosphate of lime than the Canadian. The deposit in Norway was somewhat extensively mined a few years ago, the output being sent to the English market; but the difficulties presented in its extraction and shipment, together with the competition from the Canadian mines and from other sources, is said to have nearly driven it out of the market at present. The mode of its occurrence in Norway and its supposed eruptive origin have already been noted. The Spanish deposits, also a very high grade phosphate, occur principally in granite, but have never been mined to any very great extent, the shipment being limited to but a few thousand tons yearly.

Other sources of supply.

Among the other sources of supply of phosphates mentioned by Dr. Penrose, and which may here be briefly stated for the sake of reference and as having a marked bearing on the commercial aspect of the question, although furnishing mineral of a somewhat different character, are the following:—For the variety of apatite known as phosphorite, those of Nassau in Germany; the Bordeaux phosphate from the south-west of France; and those of certain provinces of Spain. The mineral at the last locality occurs principally in well defined veins or as pockets. In the former case the veins are in the country slate near the junction of granite; in the latter the mineral occurs in large pockety veins largely composed of limestone and quartz, the masses of phosphorite being often of very large size. The French and German deposits differ in their mode of occurrence, in that they are frequently found to occupy hollows or fissures in the limestone rock underlying the clay covering, and not as regularly defined veins. The origin of these deposits is by most regarded as purely organic, although the presence of organic remains is of exceedingly rare occurrence. They are supposed by

Phosphate of Germany, France and Spain.

Their supposed organic origin.

many authorities to be caused by the action of a phosphatic solution upon the limestone of the vicinity, and by others to have their origin in the action of phosphatic vapors arising from below and thus acting upon the limestone. They are, however, of comparatively recent date, and are generally referred to the Eocene period.

Rock phosphate of North and South Carolina of organic origin.

Among the phosphates of the second division, viz., that called rock phosphate, probably the most important at the present day are the nodular deposits of the States of North and South Carolina and Florida. These have already been referred to and their origin given as purely organic, the phosphatic matter having been derived from the carcasses, bones and other parts of animals, both terrestrial and marine, with which certain portions of the clay beds, in which they are now found, were impregnated. The enormous demand at present existing for this form of the mineral no doubt arises from the fact that it can be very cheaply mined and shipped; and even though the percentage of phosphoric acid is much less than is the case of the higher grade phosphate of Canada or Norway, this cheapness of production is such as to give it a very great present advantage over other and superior deposits not so advantageously situated. This is seen in the fact that from the South Carolina beds alone several hundreds of thousands of tons are shipped annually. In age these deposits belong to some portion of the Tertiary series, and probably are later than the Eocene.

Nodular phosphate of England and Wales.

The phosphate deposits of England and Wales belong to two entirely different periods. Those of Wales are found in beds of the Cambro-Silurian formation or system, in the form of phosphatic nodules clearly associated with the Bala limestones. The nodules, which are very numerous are said to be cemented into a solid mass by a black matrix; the whole mass giving a yield of 46 per cent. of phosphate of lime, while the percentage in the nodules themselves is very much higher, or about 65 per cent. tribasic phosphate. In the mode of occurrence the phosphatic nodules resemble somewhat the deposits found in the shales and limestones of the fossiliferous Quebec group, along the south side of the St. Lawrence, already alluded to, although the quantity in the Welsh beds appears to be much greater than from any known deposit of the kind in Canada. The thickness of the bed is about ten to fifteen inches; the underlying limestone, however, for a thickness of six inches or so, contains from fifteen to twenty per cent. of phosphate of lime. The second series of deposits, or those found more particularly in England proper, is of the nodular variety belonging to the Cretaceous and Tertiary formations. In their mode of occurrence they much resemble those of South Carolina. The nodules are of organic origin, and are of various sizes from mere grains up to several pounds in weight. In phosphate of lime they range from forty to sixty per cent., in this respect, also agreeing very closely with the best Carolina phosphate. The greater cheapness, of the latter combined with the fact that many of the beds in the English district are nearly exhausted, has seriously affected the output from these diggings; the figures given by Dr. Penrose for the three counties of Cambridge, Bedford and Suffolk, showing a falling off in 1875 from 250,000 tons to only 31,500 tons in 1881.

The deposits of Belgium, of France and of Russia in great part are very similar to those already described both for England and the Southern States of America. They appear to belong to the Cretaceous period, and to consist largely of phosphatic nodules, sometimes cemented to form a conglomerate, at others disseminated through the clays and marls of the Cretaceous formation. They may for the most part be classed as low grade phosphates, yielding from forty to seventy-five per cent., though much of the Russian phosphate is of very much lower grade. *Nodular phosphates of Belgium, France and Russia.*

From the paper of Mr. Hermann Voss, read before the Chemical Manure Manufacturers Association, London, 1888, we are able quote some figures bearing on the commercial aspect of the question, which are of importance as affecting the possible future of the industry in Canada, and as showing the enormous demand on the part of the English market for phosphatic material of all kinds, much of which, under proper management and improved methods of mining and transport, Canada should be able to supply. The imports of bone and bone ash into the United Kingdom for the year 1887 were 52,519 tons, and for the nine years from 1879 the average was 73,000 tons. *Mr. Hermann Voss, 1888.* *Statistics of output and consumption.*

Of guanos, owing to the general exhaustion of the most important deposits, the importation has nearly ceased as compared with the large quantities of twenty years ago. *Guanos.*

The production of coprolitic or phosphatic nodular matter from the deposits of Bedford, Cambridge and Suffolk have continued to decrease from 34,000 tons in 1879 to only about 20,000 tons in 1886. *English deposits.*

The importation of crust guano, by which is meant a phosphate derived from the contact of the coral rock limestone with the extensive bird deposits of certain places in which, through the long continued action of the guano on the rock itself, the upper portion of the mass has been converted into phosphate of lime, from various sources has for the last nine years ending 1887, averaged over 52,000 tons yearly. *Crust guano.*

Of Spanish phosphate the average of the nine years to 1887 has been 28,300 tons, while of Carolina phosphate the figures quoted by Mr. Voss show a total importation in that time of no less than 1,032,842 tons. the amount for 1887 being given as 165,275 tons. *Spanish phosphates.*

Canada phosphate.

From Canada the imports from 1882 to 1887, both inclusive, are stated to have aggregated almost 100,000 tons, the figures for 1887 being given as 19,194 tons.

English imports

The total import of phosphate of all kinds into the United Kingdom for the three years, 1885-1887, are stated to be no less than 745,048 tons, or a yearly average of 248,366 tons.

Basic slag.

In addition to the various kinds of phosphate already described, mention may be made of the variety known as basic slag, a product of comparatively recent date, but which has rapidly risen to prominence, and to some extent is said to affect the market of the Canadian mineral. Of this it is stated that Germany in 1887 used no less than 300,000 tons alone, yet without materially affecting the established superphosphate industry of that country. This material is generally of low grade; good slag containing from seventeen to twenty per cent. of phosphoric acid, though some grades range several per cent. higher. The total production of the basic slag, or, as it is sometimes called, "Thomas slag," for the year ending October, 1887, is estimated at 494,300 tons, obtained from the manufacture of 1,702,252 tons of basic steel, of which Germany alone produced 262,000 tons. In the year ending 31st of December, 1886, 1,375,000 tons of basic steel were produced, representing more than 400,000 tons of basic slag, which contained on an average seventeen to twenty per cent. phosphoric acid, fifty per cent. lime, four per cent. magnesia, five per cent. of manganese, two per cent. of aluminum, fourteen per cent. of oxide of iron, and eight per cent. of silica. The cheapness of the material has made it exceedingly popular for fertilizing purposes; more especially in view of the fact that recent experiments in Germany, where this material is largely employed, have shown that the untreated slag as it comes from the converter, simply ground to a fine state of division, has been found, when applied to certain soils, to give very satisfactory results, and no injurious effects seem to have occurred from the presence of the contained iron. The soils to which this material appears best suited are those which are peaty, sandy, loamy and poor in calcareous matter. In such poor soils it is said, from the German experiments, to equal in productiveness the better grades of superphosphate.

Production of basic slag.

Its advantage as a fertilizer.

Messrs. Stead and Ridsdale. 1887.

The material is derived as a by-product in the manufacture of steel from phosphoric pig, and is described in a paper by Messrs. Stead and Ridsdale in the Iron and Steel Institute, 1887. The quantity of basic slag produced is said to vary from one-third to one-half the pig iron used, and the process is thus stated :—"The basic or Thomas Gilchrist process is conducted in converters or furnaces lined with a base, generally lime and magnesia in varying proportions, with the

Basic or Thomas Gilchrist process.

addition of some more basic material, almost invariably lime, to the charge of molten iron, as contradistinct to the 'acid' process, in which the converter or furnace has an acid lining, such as silica fire-brick, and in which the slag is never basic.

"It is the lime, together with the solid oxidation products of the impurities, and of part of the iron, and together with the material worn from the furnace linings, which forms the 'basic' slag.

"It consists mainly of phosphate of lime, silicate of lime, free magnesia and the oxides of iron and manganese."

In a paper by Mr. Percy C. Gilchrist, in the same Institute, 1887, it is stated that the total amount of phosphatic manures used in 1886 in England, the United States, Germany, Austria and France was, by estimate, no less than 2,443,000 tons. The market therefore, from the foregoing statements, is practically unlimited. Mr. Percy C. Gilchrist, 1887.

In his presidential address in Section III, Royal Society of Canada, 1887, Mr. Thomas Macfarlane has given an excellent description of the process for the manufacture of basic slag, and has pointed out its great value and importance as a fertilizing medium, as well as its relation to the production of apatite from the Canadian mines. Mr. Thomas Macfarlane, 1887.

In regard to the increased output of the Canadian phosphate, it is gratifying to notice the gradually increasing demand, more especially for the lower grades—that is, those containing less than seventy to seventy-five per cent. tribasic phosphate; since, in the present state of the foreign market, these low grades will scarcely warrant the expense of transportation. These can, however, it is found, be placed on the markets of the Northern and Western States at a cost which permits them to enter into active competition with the ordinarily low grade Carolina mineral, while the establishment of extensive works for the manufacture of superphosphate, either at the apatite mines or at the sulphuric acid works in the eastern townships, bids fair to still further utilize and to make valuable much of the product which, up to the present, has largely been regarded as waste. In addition to the increased demand on the part of the American market, which, according to the figures published in the Ottawa Mining Review for December, 1889, amounted for that year to 4,176 tons, the lower grades of phosphate are now being shipped to the English market as well, and a considerable quantity of sixty per cent. apatite has already been sold there. Increasing demand. Utilization of lower grades. Ottawa Mining Review, Dec., 1889.

The output of Canadian apatite for the year 1889 is given by the Mining Review as 33,000 tons; the shipment from the Quebec mines to the English market aggregated 23,981 tons, and to the United States from the Quebec mines 2,810, while the balance of several thousand tons remained on hand awaiting shipment.

List of phosphate properties, now companies, and mining phosphate.

The companies engaged in mining in the Templeton and Buckingham, Portland and Wakefield districts at present number about twelve, and may be enumerated from a list kindly furnished by Mr. Bell, of the Mining Review, the positions of the different areas being supplied by Mr. James White, who is engaged in the topographical survey of the district, as follows:—

NAME OF MINE.		LOCATION.
North Star	Dominion Phosphate Co. (Limited)	Lot 18, R. VII, Portland East.
High Rock	Phosphate of Lime Co. (Limited)	Lot 5, 6, 7 and 8, R. VII, and 1 and 2 R. VII, Portland West.
Union Mines	Canadian Phosphate Co	Lots 3 and 4, R. VII, 3, 4, 7, 8, 9, R. VIII, 5, 6, 7, 8, R. IX, 1 R. X, Portland West.
McMillan Mines	Dominion Phosphate Co. (Limited), London, Eng	East ½ Lot 7, R. II, East ½ Lot 8, R. I, Portland East.
Little Rapids Mine	W. A. Allan	Lots 6, 7, R. I, Portland East.
Ætna Hill, Lansdowne	Anglo-Continental Guano Co., of London, Eng	Lot 18, R. XII, Buckingham.
Emerald	Ottawa Phosphate Co	Lot 19, R. XII, Buckingham.
Blackburn	East Templeton District Phosphate Mining Syndicate	N. ½ Lots 7, 8, 9, 10, 11, R. XI, Gore of Templeton.
McLaurin	McLaurin Phosphate Mining Syndicate	S. ½ Lot 7, R. XI, Gore of Templeton.
Jackson Rae	Jackson Rae Co	W. ½ lot 9, R, X, Gore of Templeton
Thompson		Let 27, R. X. Templeton.
Moore Mine	Seybold & Gibson	Lot 18, R. II, Wakefield.

Among other prospectors are the

Central Lake Mining Co	Lots 7, 8, 9, 10, R. X, Portland West.
The Chapleau Lot	Lot 18, R. VI, Portland East.
The Grier Lot (East Templeton)	Lot 7, R. X, Templeton.
Charles Lionais & Co	E. ½ Lot 9, R. X, Templeton.

The DuLievre Basin Mining and Milling Company are at present engaged in the manufacture of ground phosphate only, and have no mining location.

Among other properties formerly worked under different names, but now apparently idle from some cause, may be mentioned, in order to make the list of mining locations as complete as possible, the following, taken from the reports of Mr. C. W. Willimott, 1882, and Mr. J. F. Torrance, 1883:— Properties formerly worked, now partly closed.

NAME.	LOCATION.
The Moore Mine	Lot 17, R. I, Wakefield.
Haldane's Mine	Lot 12, R. I, Wakefield.
Wilson's Mine	Lot 17, R. II, Wakefield.
Moore's Mine	Lot 12, R. XVI, Hull.
Apatite Mine	Lot 7, R. VII, Templeton.
Post's Mine	Lot 9, R. X, Templeton.
Jackson Rae Mine	W. ½ Lot 9, R. X, already noted.
Murphy's Mine	S. ½ Lot 10, R. X, Templeton.
Mr. A. McLaurin's Mine	S. ½ Lot 8, R. XII, Templeton.
Breckin's Mine	Lot 23, R. XIII, Templeton.

From Mr. Torrance's report, 1883, the following list is extracted. Several of these properties have since that date changed hands, and some have been abandoned. The list will be useful for future reference. The principal mines at that date were the High Rock, the Star Hill and the Emerald, the output of apatite for that year, 1883, being 19,666 tons. Of these the first two are apparently included under the present name of High Rock, already described; of the others may be mentioned :—

NAME OF MINE.	LOCATION.
The Fowler and Bacon Properties	Lot 3, R. 1, Portland.
La Companie Francaise des Phosphates du Canada	Lots 1, 2, R. III, Lot I, R. IV, Lot 16, 17, R. VII, Portland East.
Tamo Lake Mines	Lot 14, R. V, Portland East.
Major Chapleau's Co	Lot 16, 17, 18, R. VI, Portland East.
The Haycock Mine (now North Star)	Lot 18, R. VII, Portland East.
The Watt Mine	Lot 6, R. I, Portland East.
Cameron Property (Philadelphia and Canada Phosphate Mining Company).	Lot 27, R. VIII, Portland East.
McLaren's Mine	Lot 27, R. VIII, Portland East.
Croft's Mine	Lot 24, R. VII, Portland East.
The Ross Property	Lot 2, R. VII, Portland West.
Kendall's Mine	Lot 26, R. XI, Buckingham.
Vennor's Lot	Lot 26, R. XII, Buckingham.

Very full descriptions of these different mining areas, with the amount of work done on each up to the date of the report, are given by Mr. Torrance, which it is unnecessary to introduce here.

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Mr. Percy C. Gilchrist... { Journal Iron and Steel Institute, The Utilization of Basic Slag for Agricultural Purposes.

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Magnesite or Carbonate of Magnesia.

The occurrence of magnesite was noted at several points in the eastern townships in connection with the serpentinous rocks, in the early reports of the Geological Survey. A deposit on the seventeenth lot of the ninth range of Bolton, and referred to in 1847, is stated to

Bolton.

have a breadth of twenty yards, a large portion being marked by light green stains of oxide of chromium. The analysis of a portion free from these stains gave carb. of magnesia 83.35, carb. of iron, 9.02, and silica 8.03. This mineral can be economically employed for the manufacture of Epsom salts. Other localities in which magnesite occurs are lot twelve, range seven, Sutton, in a bed one foot thick, in gray mica schist; and on lot twenty-four, range nine, Bolton, in a bed of unknown thickness, in argillites. This rock is also said to be well fitted for ths manufacture of cement, and when sufficiently free from foreign matter or too large a percentage of insoluble silica is employed for the lining of crucibles for steel castings. Much of that in Sutton and Bolton contains a large proportion of insoluble matter, reaching in some places as much as 46 per cent.; this is from the Sutton bed. Two other analyses of the great Bolton bed gave: insoluble, 29.90, 32.20; carb. of magnesia, 59.72 and 59.13; carb of iron, 10.31 and 8.32. The material is often difficult to distinguish from the crystalline dolomites of this section.

Sutton.

Analysis.

Chromic Iron.

This valuable mineral is found at many points throughout the serpentine belt of the eastern townships from the boundary of Vermont to the Shickshock Mountains in Gaspé. In Vermont state adjoining, its presence in the serpentine of Troy and vicinity is also recorded. It was first described in the Geological Report, 1847-48, as occurring in the township of Bolton, on the twenty-sixth lot of the seventh range, in a vein said to be one foot thick, a sample of which gave Dr. Hunt on assay 45.90 oxide of chromium. A large block of 600 lbs. weight, picked up near the lower end of Memphremagog Lake, and indicating a vein of at least eighteen inches, gave also on assay 49.75 per cent.

Distribution.

From the mineral resources of the United States, 1883-84, we learn that the principal works for the manufacture of chromium, the successful extraction of which appears to be to some extent in practice a secret, are owned by the Tyson Bros. of Baltimore, who have almost entire control of the American output, though large amounts of the bichromate are also annually imported, principally from Scotland. The supply of ore for the chromium works is obtained from very widely separated points, probably the largest quantity now being derived from the Pacific coast, from certain deposits in California. In the eastern States the large deposits which have been worked for some years in Maryland and Pennsylvania appear to have become, to a large extent, exhausted.

Manufacture of chromium.

Value of the chromic iron.

The value of the ore depends upon the amount of oxide contained, and an ore of less than fifty per cent. is not considered sufficiently rich to warrant shipment to the English or Scotch market. The price of the ore has also greatly decreased within the last twenty years. The mineral occurs very irregularly, and frequently in a series of pockets in the serpentine rock, some of which may yield hundreds of tons, while others are speedily exhausted, and the miner has no assurance that this source of supply may not terminate at any time. In the eastern townships, while chromic iron is found at a number of places, the attempts to mine it have not been attended with much success. In the township of South Ham, on lot forty, range two, a lenticular mass, having a thickness of fourteen inches, was worked about thirty years since, and some ten tons of forty-four per cent. ore extracted by Mr. Leckie, when the supply apparently gave out and the locality was abandoned. In Wolfestown, on lot twenty-three, ranges two and three, several pockets occurred in the serpentine, and were mined by Mr. Wm. Grey, manager for Bell's asbestus mine, at that place in 1886, about twenty-five tons in all being obtained, but the ore still remains unsold, presumably owing to the fact that it did not contain the requisite per centage of chromic oxide. In Leeds, on lot ten, range ten, a deposit of excellent ore was mined, several years ago, by Dr. Reed of Inverness, and about fifty tons taken out, for which a ready sale was found, and in the township of Thetford, on lot seventeen, range four, there is apparently a very extensive deposit which has been slightly opened up. A sample of this assayed in the laboratory of of this survey gave chromic oxide 35.46. This location is also owned by Dr. Reed.

South Ham mine.

Wolfestown.

Leeds.

Thetford.

Shickshock Mountains.

In the exploration of the Shickshock Mountains, the serpentines of Mount Albert were found to contain certain small veins of this ore, and a considerable quantity of pieces, some of which were twenty pounds in weight, was picked up. It is possible that further exploration in this direction would result in finding workable deposits. As a rule, however, the ores found in the serpentine of the townships are not remarkable for their richness, though an assay of a sample from a loose piece in Bolton gave sixty-five per cent. of chromic oxide, and the greater portion will not repay the expense of mining and shipment, that is, in so far as the present discoveries are concerned. There are yet, however, large areas of these peculiar rocks so concealed by forest and soil that their examination cannot yet be accomplished. The opinion was expressed by Dr. Hunt in the Geol. Can., 1863, that the manufacture of bichromate of potash ought to be a profitable undertaking in this country; since while the quality of the ore might not, from its lacking a few per cent. of the required standard, be adapted for transport to Scotland, large quantities might be utilized on the spot, which otherwise would be of no commercial value, and thus a fresh impetus be imparted to the search for this valuable mineral. The price quoted for the Leeds ore at the station on the Quebec Central railway was $18.00 per ton.

MANGANESE.

The deposits of manganese in the province of Quebec are, in so far as yet observed, confined to the variety known as wad or bog manganese, which is a hydrated peroxide. The most important ores of manganese occurring in Canada are pyrolusite or psilomelane, of which large quantities are found in the provinces of Nova Scotia and New Brunswick. The wad of Quebec, though found at a number of places, is generally regarded as poor in quality and of but small commercial value. Bog manganese

This mineral was referred to by Sir Wm. Logan in the Report for 1847 as occurring in the township of Bolton, lot twenty, range twelve, in a bed from three to six inches thick, resting on slates and with a superficial extent of several hundred square yards; the amount of pure peroxide in the ore being, according to assay by Dr. Hunt, 26 per cent. Bolton.

In Stanstead also, on lot nine, range ten, a considerable deposit, estimated to cover about twenty acres, and with a thickness in places of ten to twelve inches is found; the yield of the ore, after being washed from the sand, was 37 per cent. of peroxide. Stanstead.

Other localities in which this ore has been observed at different times may be mentioned. A deposit on the road from Lambton to St. Francis, Beauce,near the eastern boundary of the township of Tring, yielded 25 per cent., and one on the west side of the Chaudière, opposite the mouth of the Famine River, yielded 20 per cent. Similar deposits occur in the seigniory of Ste. Mary, but presumably unimportant in extent, as also in the seigniory of Ste. Anne de la Pocatière in rear of the church. In the village of La Plaine, Cacouna, and on the St. Louis road about four miles from Quebec city, small deposits also have been observed. Other localities noted in the Report for 1866 by Mr. Jas. Richardson are in Cleveland, lot sixteen, range thirteen; St. Sylvestre, lot nine, range St. Charles; half a mile west of St. Apollinaire church, Gaspé seigniory, and near the line between St. Antoine and Lauzon, about two miles south of the St. Lawrence. Localities.

In the Report of the Geological survey, 1877-78, Dr. Bell notes the occurrence of spathic iron ores in the chain of islands along the east coast of Hudson Bay, called the Nastapoka group, which are found to Hudson Bay.

contain upwards of twenty-four per cent. of carbonate of manganese and 25.449 metallic iron, constituting a very extensive band of not less than twenty feet thick. The high per centage of manganese in these ores will render them valuable for the manufacture of speigeleisen, and owing to their abundance and accessibility, they will probably some day be found to be profitably workable. This locality is, however, not within the limits of the province of Quebec.

CLASS IV.

Mineral Manures.

Shell marl.

With the exception of the apatite, which when applied in its raw state may come under this heading, the only mineral of value yet known is shell marl. This is found at many places from the Ottawa River to the extremity of Gaspé, occupying the beds of lakes and marshes, and is so named from its containing, generally in considerable abundance, the shells of certain species of fresh water molluscs. It is generally white and earthy, and, unless containing foreign matter, is nearly a pure carbonate of lime, of great value as a fertilizer for certain classes of soils which are lacking in calcareous matter. It produces also, when burned, a white and very pure lime, well suited for building purposes, and is, in some places, largely used in this way.

Argenteuil.

In Quebec, among other localities, marl is found on lot three, range one of Argenteüil, underlying a bed of peat nine feet thick. The marl is from five to thirteen feet thick, and is reported to cover an area of over twenty acres. On the twenty-second lot of the eighth range of Wentworth, and on the fifth lot of the fourth range of Harrington, deposits of considerable extent also occur. In Vaudreuil, at Point à Cavagnol, a bed of marl from twelve to eighteen inches thick extends over twenty acres, and has been largely used as a manure with very beneficial results.

Wentworth.

Vaudreuil.

Montreal.

Near Montreal, marl is found underlying the peat along the St. Pierre River between the city and Lachine; also at Thornberry on the west side of Mount Royal, but this deposit is not regarded as very extensive. In the seigniory of St. Hyacinth, near the foot of Yamaska Mountain, and near the road to Granby and St. Pie, a bed of marl one foot thick extends over seven acres and is covered by a thin layer of peat, also on lots one hundred and fifty seven and one hundred and fifty eight of St. Armand there is an apparently extensive deposit,

Yamaska Mountain.

St. Armand.

covering from thirty to forty acres, which is in places seven feet thick, while on lots four and five, ranges ten and eleven, Stanstead, it appears at the margin of a pond, and is reported to be thirty to forty feet thick over an area of twenty acres. Stanstead.

In eastern Quebec marl is found in the basins of a number of lakes along the north side of the Bay of Chaleur, in the counties of Bonaventure and Gaspé. On the west side of the Cascapedia River, from three to five miles back from the shore of the Bay, there are several lakes, called from their peculiar tint the "Blue Lakes," the color being apparently due to a considerable deposit of marl over their bottoms. In rear of New Richmond also and of Paspebiac and New Carlisle other large deposits occur. On the north side of the peninsula, about five miles below the Matane River near the St. Lawrence, a deposit underlies a marsh with an area of sixty to seventy acres and about fifteen inches thick. Bay of Chaleurs. Matane.

On the island of Anticosti, Mr. Richardson, in the Report of Progress for 1857, in speaking of the marl says that "the bottoms of all the lakes and ponds examined, with the exception of those surrounded by peat, were more or less covered with it. Marl Lake is one of these; its area is about ninety acres, and though the thickness of the marl was not ascertained, it appeared to be considerable. The brook which empties the lake into Indian Cove at the west end, carries down a large quantity of the marl to the sea, where it becomes spread out for a considerable distance over the rocks in the vicinity." An assay of a marl from Anticosti, by Mr. F. D. Adams, shewed the presence of 0 0137 per cent. tribasic phosphate of lime.* But little attention is, however, apparently paid to these deposits at the present time. Anticosti.

CLASS V.

Mineral Pigments.

These, in the province of Quebec, are practically confined to iron and manganese ochres. Veins of sulphate of baryta occur, however, in the rocks of the south side of the Gaspé peninsula, and at Port Daniel a vein nine inches thick is reported in the Niagara limestone. Other smaller veins occur on the beach along the streams flowing into Gaspé Basin, and on lot twelve, range twelve, of Templeton, a vein of impure baryta is found; but these do not appear to have any economic importance. The deposits of iron ochre in the province are, however, large and valuable, and some of them have been worked for many years. Sulphate of baryta.

*See Report Geological Survey, 1886, p. 41 T.

This material is a hydrated oxide of iron, very similar in composition to bog iron ore or limonite. The ochre, however, lacks generally the coherence of the bog ores, being, for the most part, soft and easily powdered, and contains frequently a considerable amount of organic matter and earthy impurities. In color, the ochres are generally reddish, brownish or yellowish, though purple or dark brown tints are sometimes found. By burning, the contained water and organic matter are eliminated, the ochres change color and become frequently a dark red. They can be used, however, either raw or burned, mixed with oil or water as paints or as stains of various colors for furniture; for which purpose some of them are well adapted and quite extensively used. The value of an ochre depends very much upon its facility of mixing with oil when ground, so as to form an easy flowing and durable paint; a great difference being found in this respect.

Iron ochre.

North side of the St. Lawrence.

Many of the deposits of this province exist in the vicinity, or near the foot, of the Laurentian hills along the north side of the St. Lawrence River, where also the largest beds of bog iron ore are found. In places these ochres contain a certain amount of manganese, which, when burnt, tends to impart a brown or umber tint instead of a red color, as is generally the case in ochres free from this mineral. Among other numerous deposits of ochre may be more especially mentioned one of three feet in thickness, extending over several acres, on lot fifteen, range ten, Hull. Among the deposits described in the Geology of Canada, 1863, two of special importance may be noted as having been quite extensively worked for some years. Of these, that found in the seigniory of Pointe du Lac, range St. Nicholas is said to cover about four hundred acres, and to have a thickness of from six inches to four feet, averaging about eighteen inches. The prevailing shades are red and yellow, but in some parts the ochre has a dark purple tint; when burned, it assumes a dark red color. A blackish brown variety is also found, which, when burned, becomes a lighter brown.

Hull.

Pointe du Lac.

Manufactures.

An attempt was made in 1851 by a New York company to work these ochres on a large scale, and furnaces were erected for their calcination. They are said to have produced as much as twelve barrels per day for some time, worth in New York about five dollars per barrel. Eight different tints were made from the ochre, a rare blackish brown variety being the most valuable, which was sold under the name of raw sienna, in the raw state, or calcined as burnt sienna. The manufacture has long since been abandoned.

Cap de la Madelaine.

Another large deposit, said to extend over six hundred acres, occurs in St. Malo range in the seigniory of Cap de la Madelaine, about two miles below the parish church and the same distance back from the

St. Lawrence. It is here interstratified with peat in an old lake basin, the bottom of which is occupied with shell marl. The presence of the peat here might prove advantageous in calcining the ochre which has a thickness, in different portions of the deposit, of from six inches to two feet, and is capable of yielding a very large quantity if required. In the vicinity of Three Rivers also ochre is found in considerable quantity.

The most extensive deposit probably as regards thickness is that near the Ste. Anne de Montmorency River, which has a depth in places of from four to seventeen feet, and extends over an area of four square acres. This deposit is very fully described in the Geology of Canada, 1863, pp. 511-12. The color is said to vary in different parts; being yellowish brown at the surface, reddish or purplish brown where most exposed to the light and air, and at a little distance beneath the surface a greenish or greenish white. The mineral has been carefully assayed by Dr. Hunt and contains peroxide of iron 59.10, organic acids 15.01, water by difference 21.14, soluble silica 1.15, sand 3.60. The deposit is very favorably situated for working, being on the top of a bank overlooking the road, so that by beginning on the lower side the working could be so carried on as to obviate the necessity of further drainage. This deposit was referred to in the Geological Survey Report, 1851-52.

Ste. Anne de Montmorency.

Analysis.

Other deposits of greater or less extent are found at Ste. Rose, on the fourth lot of the fourth range, Durham, having a thickness of four feet and an area of some 1500 square yards; on the sixteenth lot, range nine, Ascot; lot twenty-four, range three, Stanstead; and in the seigniory of Lotbiniere, near the mouth of the Grande Riviere du Chene.

Durham. Stanstead. Ascot.

A similar deposit of very good ochre occurs on lot twelve, range fourteen, Stoke, on property of Mr. Gansby. The ochre is of two shades, a yellow and a brown, burning to a chocolate tint; the ochre contains a few roots of plants, but appears to be otherwise remarkably pure. The brown deposit has been dug to a depth of three feet, though the whole thickness is unknown, and the superficial extent is very considerable; being traceable into the woods on the adjoining lot. The burned and raw ochre has been tested with very satisfactory results; showing it to constitute a valuable pigment when properly prepared.

Stoke.

In addition to the ochres, other sources of supply for the mineral paints are found in many of the highly colored slates of the Sillery formation, where red, green, and gray shades are obtained. Serpentines also are very common, and in one of the islands in Brompton Lake the variety diallage forms large masses which could be easily ground for paint. Large deposits of steatite or soapstone occur at many places in

Serpentine and soapstone.

Bolton, Hatley, Ham, Wolfstown, Broughton and Leeds, which are easily and cheaply ground, and which, when mixed with the prepared ochres and with white lead, are said by actual trial to give a paint of great durability.

Stanstead. In Stanstead, lot thirteen, range nine, a soft talcose slate, which shows different bands of yellow and greyish white, the former being due to the hydrated peroxide of iron, has been locally used, when mixed with oil, for painting houses and outbuildings, and a similar rock occurs in Leeds on the seventeenth lot of the thirteenth range. Certain low grades of asbestus also are used for the manufacture of a fire proof paint, and deposits of actinolite on the fourth lot of the fourth range of Bolton, and in St. Francis, Beauce, described by Dr. Hunt in the early reports of the Survey, might also be found useful for this purpose.

Asbestus.

CLASS VI.

Salt, Brines and Mineral Waters.

Importance of mineral springs While in the province of Quebec we have, in so far as known, no considerable deposits of salts or brines, mineral waters occur at a number of places, and although these may not be classed as minerals in the true sense of the term, they present many points of interest and have a very considerable economic value, more particularly from the medicinal standpoint; since the presence of a mineral spring of recognized therapeutic properties tends to draw to the vicinity a large amount of wealth, not only by the erection of sanitariums, but by the influx of a very considerable transient population; so that in this way such a spring may be regarded as a source of very considerable revenue to an entire neighborhood. Further, certain springs obtain such a reputation for the cure of disease that they are greatly sought after from abroad, and the waters when bottled are shipped to remote portions of the country, and may even acquire a much wider celebrity than a merely local one.

Dr. Hunt's analysis. In the Survey Report for 1847-48, Dr. T. Sterry Hunt published the first results of a very careful and extensive series of examinations of the waters from many localities both in Ontario and Quebec. These were regarded as of such importance that in the subsequent report of 1853, additional analyses were presented, so that the greater part of the mineral springs in the two provinces were very thoroughly examined. In consequence of these analyses, practical results followed in the establishment of large sanitariums at the Caledonia Springs, at

Plantagenet, at St. Leon, and at other points, and in later years at Bolton. Dr. Hunt arranged the waters from the different springs into six classes, according to their chemical composition; the details of which are presented in the Geology of Canada, 1863. Those which relate to the province of Quebec may be briefly summarized.

In the first three classes chlorides predominate, in the fourth carbonates, and in the fifth and sixth, sulphuric acid and sulphates. The waters of the first, second and sixth are neutral; of the third and fourth, alkaline; and of the fifth, acid. Classification of mineral waters.

The springs of the province of Quebec belong for the most part to the second, third and fourth classes, of which the second class comprises saline waters, which include considerable portions of bicarbonate of lime and magnesia, in addition to the chlorides of sodium, calcium and magnesia.

The waters of the third class include those saline waters which contain also in addition to the chloride of sodium a portion of carbonate of soda with bicarbonate of lime and magnesia. Small amounts of baryte, strontia and of boracic and phosphoric acid are also present, as well as of bromides and iodides. The fourth class contain but a small amount of chloride of sodium, with a large relative quantity of carbonate of soda, and have no marked taste, unless evaporated, when they are strongly alkaline.

These springs have been so well described in the Geology of Canada, 1863, that it will serve here simply to enumerate the principal ones and indicate their class.

Assumption.—Saline spring of the second class; the "Aurora Spring," containing 7·86 parts of solid matter in the 1,000, gives off large volumes of carburetted hydrogen gas, contains small quantity of strontia. Localities.

Baie du Febvre.—Four springs examined, two of the second class containing strontia; one of which, near the line of Nicolet in the Grand Range, on land of Antoine Loizeau, contains 5·44 parts of solid matter and 4.54 of alkaline chlorides in 1,000, two of which latter are chloride of potassium; the other, in the same range on land of Mr. Lafort, about one mile above St. Antoine church, contains 15·94 parts solid matter, with a little boracic acid. The two other springs belong to the third class, and also contain small portions of strontia and give off carburetted hydrogen gas. One of these, on land of David Houle, adjoining Loizeau's, contains 4·96 parts solid matter; the other, on Ignace Courchese, half a league east of the church, contains carbonate of soda and magnesia, in addition to the chlorid of sodium; the chlorid of potassium equalling 0.92 per cent of the chlorid.

Bay St. Paul.—A bitter saline spring of the first class, containing 20.68 parts solid matter to 1,000.

Belœil.—Saline water, third class, contains notable proportion of strontia; the iodides and bromides not determined.

Berthier en haut.—Saline spring, second class, on land of Chas. Boucher, on the Bayonne River, contains 8 parts solid matter to 1,000, including carbonate of magnesia 0.8354.

Bolton.—Sulphur spring, analysis not yet made.

Caxton.—A saline spring of second class, containing 13·65 parts of solid matter to 1,000, of which carbonate of magnesia is 1·059.

Chambly.—One league north of the village, in the Rang des Quarantes, on land of Mr. Chevrier; two saline springs of the third class, solid matter 5·74 per 1,000, with baryta and strontia present in considerable quantity.

Champlain.—Two springs, which have a local reputation, belong to the second class.

Jacques Cartier River.—Strongly sulphurous spring, Marcotte's Mill, of the fourth class. The amount of solid matter is small, carbonate of soda making up the largest part. Holds a considerable quantity of borates.

Joly.—A sulphurous spring of the fourth class, on the banks of the Magnenat Brook, five miles from Methot's Mills; feebly saline, contains a portion of boracic acid, with sulphuretted hydrogen gas equal to 7·5 cubic inches per litre.

Lanoraie.—Saline spring, second class, midway between the villages of Industry and Lanoraie, gives off large volumes of carburetted hydrogen gas, and contains a considerable quantity of salts of strontia and baryta.

Nicolet.—Concession of Quarante Arpents, near the line of St. Gregoire; two springs, one on farm of widow Honore Hebert, and one on land of Olivier Roy, in Nicolet. Both of the fourth class; alkaline when evaporated.

Quebec.—A sulphurous spring of the fourth class, in St. John, situated on the property of Mr. Joseph Hamel, contains, in addition to common salt and carbonate of soda, a portion of sulphates.

River Ouelle.—Third concession, on the south side of the river; water strongly saline and bitter, belonging to the fourth class, yielding 13·36 parts solid matter to 1,000.

Sabrevois.—Near the village of Pike River, several mineral springs of the second class, two of which are known as the Saline and the Sulphur Spring. The first containing salts of baryta and strontia; the second, soluble sulphates.

Ste. Anne de la Pocatiere.—Two springs. One in the second concession, on land of Nicholas Rouleau, sightly sulphurous, containing 0·36 of a part solid matter to 1,000, belonging to the fourth class; the other, one mile south of the college, small spring of bitter saline water, containing, besides chloride, an abundance of sulphates of lime and magnesia and a small portion of carbonates, and yielding 5·06 parts solid to 1,000.

St. Benoit, Two Mountains.—A spring of the first class, with 6·0 parts of solid matter to 1,000; traces of carbonates, and a large amount of calcareous and magnesian salts.

St. Eustache, Two Mountains.—A spring of the second class, feebly saline, yielding 1·85 parts of solid to 1,000.

St. Genevieve.—In the Batiscan River, contains several strongly saline springs of the second class, two of which were analysed, and were remarkable for their large proportion of iodide.

St. Hyacinthe.—The Providence spring, a saline water of the third class, strongly alkaline, and containing a portion of strontia; solid matter 5· to 1,000.

St. Leon.—Strongly saline, second class, gives off large quantities of carburetted hydrogen gas, and contains small portions of strontia, with sufficient carbonate of iron to give it a chalybeate taste.

Ste. Martine, Beauharnois.—Feebly saline, belongs to the third class, with 1·98 solid matter to 1,000, contains small portions of sulphates.

St. Ours, Richelieu River.—Spring of the fourth class, contains only 0·53 solid to 1,000, with large percentage of potash salts.

Varennes.—Two saline springs, one mile and a half below the church, and near the St. Lawrence. One, styled the "Gas Spring," from the quantity of carburetted hydrogen gas given off; the other, called the Saline Spring. They contain carbonates of soda, lime and magnesia, and belong to the third class; the Saline Spring is also slightly chalybeate.

The analysis of several of these waters, as determined by Dr. T. S. Hunt, will be found in the Geology of Canada, 1863, pp. 547-550.

CLASS VII.

Materials Applicable to Common or Decorative Construction.

Wide distribution.

While there is no lack of valuable material for building purposes at many points throughout the province, the absence of suitable means of transport at present existing prevents many of these deposits from being utilized. Large and valuable quarries of granite, limestone, sandstone and quartzite exist, while unlimited quantities of gneiss, marble, serpentine and other rocks could be easily reached at no very great expense. At the present time the material most commonly employed in ordinary building construction is limestone, more particularly that of the Trenton or Chazy formations. This occurs at so many points throughout the province, more particularly along the west side of the St. Lawrence River, that it is scarcely necessary to enumerate them; while of limestone, for other purposes, such as burning for ordinary lime and for the manufacture of hydraulic cements, great deposits are found in the palæozoic rocks to the extremity of the Gaspé peninsula.

Trenton and Chazy limestone.

While there is a great variety in the texture and quality of the stone employed for the different purposes, certain beds are specially worthy of notice from their purity and fitness for the use intended. Among building materials, probably that most extensively employed is from the Trenton division of the Cambro-Silurian, as seen in the buildings of the cities of Hull, Ottawa, Montreal, Quebec and Levis. This may, to a large extent, be due to the fact that the beds of this formation lie in a generally horizontal position, and are of convenient thickness for the purpose required, the stone is easily obtained and readily dressed, and most of the cities named lie either in close proximity to the rocks, or in some cases being built directly upon the spot where it is quarried. As a source of lime, also, the Trenton formation is very extensively used at many points, and yields a very excellent material, though in some cases the rock contains a considerable proportion of argillaceous matter. A limestone, which is really a marble, occurs in connection with the crystalline series in the eastern townships, and has been used to some extent in construction. Examples are seen in the beautiful marble church of North Stukely; the rock being derived from a very good quarry near South Stukely, where quite extensive beds of this stone are found, which have been quarried both for building purposes and for lime burning.

South Stukely.

A good limestone from the Chazy formation, obtained from the St. Dominique quarries not far from St. Hyacinthe, is somewhat extensively used, and certain beds of the lower Chazy and Calciferous, near Philipsburg and at St. Armand, of a dove grey color and partly crystalline, are capable of furnishing large quantities of excellent building material.

St. Dominique.

St. Armand.

In the eastern portion of the province the massive limestone of Port Daniel, on the south side of Gaspé Peninsula, is quite extensively quarried for shipment to P. E. Island and the adjacent shores of New Brunswick, where it is burnt for lime. In Dudswell, and at various points on the St. Francis River north of Lennoxville, the Silurian limestone, nearly the same age as that of Port Daniel in Gaspe, produces, when burned, a lime of great purity and value, and specially adapted for use in factories for the manufacture of chemical pulp, and for paper mills, where large quantities are employed. So excellent a reputation has this lime of Dudswell now acquired, that the product from the kilns of this place, which have at present a possible capacity of about 3000 bushels a day, is shipped over the greater part of eastern and southern Quebec and the adjacent States, as well as over a large portion of eastern Ontario.

Port Daniel.

Dudswell.

The Devonian limestones on the Chaudière are burned locally for lime, and the semi-crystalline limestones of Thetford, Broughton and Ste. Marie also furnish a small quantity for local consumption, but the competition of the Dudswell works has had the effect of nearly closing these smaller industries.

In the manufacture of hydraulic cement, a limestone is required which contains a certain amount of argillaceous matter. The qualities of a good cement include that of rapidly setting or becoming solid under water. Experiments have been made at a number of places in Quebec to produce a first class article, but as this necessitates a series of tedious and somewhat costly experiments, the works at present in operation are apparently confined to only two localities, viz., Hull and Quebec. The rock at Quebec is taken from a dark or black argillaceous limestone found in the Trenton-Utica formation of the city, and of the north side of the Island of Orleans. The same material also occurs at various points along the north side of the Gaspé Peninsula, where a similar series of beds occurs. The black matter of the Quebec rock, being carbonaceous, disappears in the calcining; the rock becoming yellowish, and the cement is said to be of excellent quality. The cement made in Hull, by Mr. C. B. Wright, is from rock brought from the township of Nepean, Ontario; though precisely similar bands occur on the Quebec side of the Ottawa. The limestone contains about twelve per cent. of carbonate of magnesia, and belongs to the Chazy

Hydraulic cement.

Quebec.

Hull.

formation and can be traced for a considerable distance. The cement manufactured from this stone does not harden so rapidly as the "Portland," but is otherwise a very excellent article.

Granite of the eastern townships.

Building Stones.—These have been partly referred to under the head of limestone. Of the other materials employed in construction, granite is found in inexhaustible quantities in the south eastern portion of Quebec, more especially in connection with the area of Cambro-Silurian rocks lying to the east of Sherbrooke anticlinal. Great mountain masses occur in the Little and Big Megantic Mountains, and along the boundary from Memphremagog Lake, nearly to the Hereford and Connecticut Valley railway, while extensive areas are seen to the east and along the shores of the upper end of Lake Megantic. At Barnston also and in Stanstead, as well as on the shores of Lake Memphremagog, quarries have been opened from which a very fine quality of stone has been obtained. The rock is of the variety known as white granite, composed of quartz, whitish felspar and black mica. This granite is comparatively free from pyrites, and is but little affected by the action of the atmosphere. It splits readily into blocks of almost any desired size, and has been used in the public buildings in the city of Sherbrooke and in the Eastern Township Bank of that place, as well as in the magnificent wall which now surrounds the grounds of the Parliament buildings at Quebec.

Syenites of Grenville.

The syenites are for the most part confined to the rocks of the Laurentian system. They differ in color from the granites just described, having for the most part a reddish tinge due to the color of the felspar; the rock, like the granite, splits readily, and dresses with comparative ease. It has been worked for some years extensively near Gananoque on the St. Lawrence, by Mr. R. Forsyth of Montreal, but excellent stone can be obtained from Grenville, and at many points throughout the Laurentian belt of the north side of that river.

Gneiss.

Gneiss, which is very often scarcely distinguishable from syenite or granite, occurs as a very important factor of the Laurentian rocks, and can be well seen in the township of Grenville, Chatham and Wentworth, while among other locations mentioned in the Geology of Canada, 1863, as affording fine material for building purposes, and easily accessible, are Jeune Lorette, on the St. Charles, near Quebec city; on the Batiscan, near the old blast furnace; and at Bay St. Paul. Of sandstones, several varieties are found well adapted for construction. Probably the most durable of these occur in the Potsdam formation at Beauharnois, Vaudreuil, Grenville, and along the lower Ottawa. The rock is generally white or yellowish-white in color, and frequently free from stains. It is hard and very durable, not only readily resisting the weather, but the fire as well; but this feature of hardness

Potsdam sandstone.

and toughness renders it more difficult to work than the softer calcareous beds of the Trenton and Chazy. The strata, however, are readily separable and easily quarried. Good beds for quarry purposes are obtained at St. Scholastique and at Hemmingford, as also at various places between Lachute and St. Jerome, where this formation rests directly upon the Laurentian gneiss. The stone has also been used for the lining of blast furnaces, and found to be well adapted for that purpose. It enters somewhat largely into the construction of the magnificent Parliament and Departmental buildings at Ottawa; a large part of it being obtained from the township of Nepean. It has also been used to some extent for building purposes in Montreal.

Sillery sandstone.

The Sillery sandstone, found largely developed near the city of Quebec and to the south and east of Lévis on the upper side of the River St. Lawrence, is extensively used in construction at both cities. Much of the city wall is built of this stone, as well as the Citadel, while it enters largely into the structure of both private and public buildings. It is for the most part a green or greyish-green rock, which in some places becomes highly quartzose, passing into a whitish weathering, yellowish-brown quartzite. The rock frequently contains small pebbles of quartz and pieces of shale of various colors; the quartz pebbles sometimes becoming sufficiently numerous to constitute a fine conglomerate. Certain portions of the rock quarry readily, but it is said not to weather uniformly, and does not resist atmospheric influences so well as the Potsdam sandstone. Used by itself in large buildings, its dark-green shade tends to give the structure a heavy, and not pleasing, aspect, but the dark color blends well with lighter materials. This rock is very widely distributed along the south side of the St. Lawrence, below the mouth of the Chaudière, and is found at many places inland. Quite extensive quarries exist at Sillery, about four miles south-west of Quebec, and also from one to two miles south-east of Lévis, where large quantities of stone of almost any desired size can be obtained. About St. Raphael and Armagh, and at certain points near the coast below L'Islet the beds are highly quartzose, and often have a purplish-red color, which contrasts well with the sombre tint of the typical Sillery rock.

Devonian and Silurian sandstones of Gaspé.

Among the Devonian beds of Gaspé basin and the interior of the peninsula of Gaspé, greyish sandstone forms an important feature, and, where of suitable thickness, should constitute an excellent building stone. As, however, this is not so readily available as the freestones of the Millstone Grit formation on the south side of the Bay Chaleur, it is doubtful if it could compete with these as a source of supply for building blocks of large size. Certain whitish, hard sandstones, highly quartzose, also occur in the Silurian along the base of the Devonian basin, in the interior of Gaspé, and are well seen on the Matane and Metapedia—at the latter place having been quarried some years ago for the Intercolonial railway. They again appear on the shore of Lake Temiscouata, and should furnish a good and lasting stone for building purposes. Between Montreal and Quebec the Trenton limestone is quarried somewhat extensively at several points, as at the village of Industry and at Chevrotière, on the St. Alban road, about four miles from the River St. Lawrence, where very extensive quarries are situated which supply stone to Quebec and Montreal. At Pointe aux Trembles the same formation furnishes stone similar to that of the Montreal quarries, and has been extensively used in Quebec. At Chateau Richer, below that city, several important quarries also exist, from which quantities of stone were obtained for the Lévis forts, as well as for the city of Quebec. Similar limestones occur at St. Paul's Bay, and have been quarried for local use, as have also the beds about Lake St. John. The limestone at Philipsburg has already been referred to. Above Montreal, quarries in the Chazy limestone occur at Caughnawaga, Pointe Claire and St. Genevieve, near the upper end of the island of Montreal. A large portion of the stone for the piers of the Victoria bridge was obtained from the Pointe Claire quarries; from this place some blocks of large size are obtained. Chazy limestones are also found at Grenville and Carillon which have been quarried for building purposes, while the stone for the Carillon and Grenville canal was, for the most part, obtained from quarries in the same formation, situated across the river at Hawksbury. Excellent limestone also occurs in the Island of Anticosti, at the south-west point at Cape James and at Table Head, from which much building material could be easily obtained.

Trenton limestone, north of the St. Lawrence.

Chazy limestone.

Anticosti.

Trachytic rock. The several trappean or trachytic hills, which rise out of the level country east of Montreal, and of which the Montreal Mountain furnishes a very good example, yield at times very good material for ordinary construction work, though some of it is coarse in texture, and, from the lack of quartz, does not resist the influence of the weather as well as could be desired. In many places, however, the rock mass is intersected by joints, and blocks of good size are readily split out. These rocks are very well suited for paving blocks, and for road metal, answering much better for this purpose than the limestone of which the macadam is so generally composed. Quarries for paving stone are opened on the west side of Yamaska Mountain, and for building stone on Shefford Mountain.

In the valley of the Chaudière several of the churches are built largely of drift blocks, which lie scattered quite thickly at some points. These consist of gneiss, quartzite, syenite, crystalline limestone, labradorite, etc., and in the church of St. Joseph, Beauce, many different kinds of these rocks are seen, the whole presenting a pleasing effect. Drift boulders.

Marbles are found in the Laurentian series, and in the newer formations as well, at different points. The Laurentian marbles are quite extensively worked in that portion of Ontario to the south of the Ottawa, at Renfrew, Arnprior and Fitzroy Harbor. From these places large quantities of excellent stone have been obtained, some of which has been employed in the interior construction of the Parliament buildings at Ottawa. In the township of Hull, lot eighteen, range eight, a quarry in Laurentian limestone furnished very good stone, and in Grenville, lot sixteen, range three, works for the preparation of similar rock were also erected. The limestone of the metamorphic rocks of the eastern townships at Stukely has already been referred to. Among marbles of newer horizons the deposit at Dudswell has long been known. This belongs to the Silurian system, and certain beds are entirely composed of organic remains; large corals being abundant, which, when polished, present a beautifully marked surface. Several varieties of this stone are found in this quarry, among others a kind showing bandings and mottlings of yellow upon a dark or black mass, presenting a very attractive appearance when polished. The extent of this quarry is considerable, and several years ago it was opened to a depth of five feet by the removal of the surface bench, the lower portion being found to be comparatively solid and capable of yielding large blocks which readily took a fine polish. Work has, however, been suspended in this quarry for the last two years, owing probably to lack of capital on the part of the company, who were largely engaged in lime burning on a portion of the same formation. Near Philipsburg several of the limestone bands offer a good variety of marble, but little has been done to develop the industry in this direction. On the Chaudière River in Beauce, about three miles above the village of St. Joseph, near the mouth of the Colway, a very pretty reddish variety, veined with calcite, is found, which, when polished, has a rich and handsome appearance, but the band is not very extensive, and a similar variety is found near the St. Francis River, about four miles below Richmond, but nothing has ever been done to test their real value as a source of supply for marble. Marbles of the Upper Ottawa. Dudswell marble.

A very handsome variety of marble is found in the Laurentian at several places, as at Grenville, St. Andre Avelin, and the augmentation of Grenville; the limestone being mixed with greenish or yellowish green serpentine, in clouded markings or in bands. This constitutes the variety known as Eozoon limestone, and when polished the different Grenville marble.

colors and markings of the supposed fossil have a very handsome effect. The Grenville bed has a thickness of some hundreds of feet. Some of the limestones of the Chazy and Trenton are sufficiently metamorphosed to polish well, and very handsome marbles are obtained from some of these in which the organic structure is beautifully displayed. These are found at Caughnawaga, St. Lin, Terrebonne, Montreal, St. Dominique, St. Armand and other places.

Serpentine.

Serpentine.—This rock occurs in connection with the Laurentian limestone of Grenville and at other points already referred to, but more particularly in great masses in the eastern townships, where it is found associated with slates, diorites and sometimes granitic and schistose rocks. It presents several interesting features, not only as a source of supply for asbestus and chromic iron, but as a material for indoor decoration. Unfortunately it is easily affected by atmospheric agencies, and is not therefore adapted for outside work, since the polished surface speedily becomes tarnished by weathering. During the last few years attempts have been made to obtain good sized blocks from the serpentine of the townships, but, while these can be extracted in large masses, the stone appears in many cases to be affected by joints and seams, which, in the dressing, interfere very seriously with the efforts to secure good solid pieces for polished work. Slabs can, however, be readily sawn, which, when well polished, have a very rich and pleasing effect for interior decoration, and present a considerable variety, not only in color, but in the markings. In Vermont these serpentines have for some years been quarried and sold under the head of verde antique marble. In Italy, France and England also, a similar rock is extensively worked for decorative purposes, such as mantels, tables, etc. The Eozoon or serpentine limestone of the Laurentian in which the serpentine which has filled the chambers of the supposed fossil structure, has a yellowish tint, presents when polished a very handsome appearance. The stone from Grenville has been referred to under the head of marbles. A similar rock from Templeton has been worked to some extent by the Canada Granite Company of Ottawa with apparently good results.

Difficulty in getting good blocks.

Eozoon limestone.

Slates.

Slates of good quality are found at many points in Quebec, east of the St. Lawrence, more particularly in connection with the Cambrian rocks, and a number of quarries have been opened at different times. In some of these red, green and purple tinted slates are obtained, but in those at present worked the prevailing shade is dark or bluish grey. These quarries are now confined to only three, viz., one at New Rockland in the township of Melbourne; one at Shipton, known as the Danville School Slate quarry, on lot seven, range four, and in Cleveland, formerly Steele's quarry, but lately re-opened by Mr. J. C. Bedard of Richmond, on lot six, range fifteen, about three miles south-east of Richmond and near the line of the Grand Trunk railway. These three quarries produce slates of the same general color, and are presumably from the same belt of rock or from a repetition of the same by folding, as well as the slates of the old Walton quarry on lot twenty-two, range six, Melbourne, which was worked some years ago, but subsequently abandoned. On the Grand Trunk railway, about four miles east of Acton station, on lot twenty-six, range five, Acton, a quarry in red slates, with large patches of green, is located. This is the Rankin Hill quarry. The rock is said to be easily quarried and belongs to what is called the Sillery portion of the Quebec group. It was opened in 1875 and was worked for two years, when it was closed, owing it is said, to a lack of market and the low price at that time of the output. This quarry had, in 1877, a length of one hundred and fifty feet by sixty in breadth, and with a depth in one place of thirty-five feet, and in 1877 produced about 600 squares of slate.

Three quarries at present worked.

Rankin Hill quarry.

Slates also are found in Kingsey, lot four of the first range; in Orford, lot two, range five, and in Tring and Westbury. Good deposits are also found in Brompton on lot twenty-nine, range five, where there is a quarry from which flagging stone has been obtained; and in Garthby on the road to Ham, about four miles from Garthby station on the Quebec Central railway, lot fifteen, ranges eight and nine, same township, the last in the red and green slates of the Sillery. North of the Chaudière an old slate quarry long abandoned is found on lot two, range ten, of Frampton, in purple rock; and bands of purple, red and green slates occur at many other points in the slaty series to the west of the main anticlinal of crystalline schists, some of which, were the market sufficient, should yield slates of good quality. The largest slate quarry at present in operation in Quebec is that of the New Rockland Company. This was first opened in 1868 and has been worked almost continuously ever since. It is situated on a rise with an elevation of about 500 feet above the St. Francis River, which is four miles distant to the north, and has at present a working bench 200 feet deep. The slate cleaves readily, is very free from pyrites, impervious to water and equal in every respect to the celebrated Welsh slates. The quarry is equipped with the most improved machinery for cutting, sawing and dressing the rock and for making roofing slates of any required size The motive power consists of a turbine wheel, placed in the river half a mile above the works, to which the power is transmitted by cables. Four travelling derricks raise the rock from the pit, while inclined tracks transfer the finished products to a line of narrow gauge railway which connects the quarry with the line of the Grand Trunk railway at a point about three miles south of

Abandoned quarries.

New Rockland.

Plant.

Output.

the Richmond station. The output embraces, in addition to roofing slates, billiard table tops, mantels, wash tubs, etc.; the demand fully keeping pace with the supply. An analysis of the slate was made by Dr. B. J. Harrington of McGill College, and shows the excellent quality of the material to be as follows:—

Analysis.

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

A number of tests were made at the testing laboratory of the Dominion Bridge Company, Lachine, P. Q., on an emery testing machine, the result of which may be given as presenting a fair idea of the character of the slate of this belt,

Slate tests.

1st test. Crushing. Strain perpendicular to the lamination. A 2″ cube failed at 108,570 lbs.=26,574 lbs per square inch.

2nd test. Crushing. Strain perpendicular to lamination. A 2″ cube failed at 129,880 lbs.=32.069 lbs per square inch.

3rd test. Crushing. Strain parallel to the lamination but perpendicular to the grain, i.e. edgewise. A 2″ cube was not crushed at 150,000 lbs. =36,531 lbs per square inch.

4th test. Breaking. Strain perpendicular to the 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 and 1″ square, supported at both ends, and loaded in the centre, failed at 556 lbs.

5th 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, failed at 558 lbs.
Deflection with pressure at 690 lbs was 7-10 of 1″.

The average production per month of this quarry for the past year to the end of September was about 2200 squares of roofing slates, and 3300 feet B. M. of slate slab work. The quarries are worked all the year round and about 200 men are employed. The pit at the deepest end is 200 feet, and a further depth of sixty feet is now being sunk in addition to the widening and lengthening of the quarry as the work of extraction goes on.

To the north-east of this is situated the old Melbourne or Walton quarry, on lot twenty-two, range six, Melbourne, about two miles distant from the St. Francis River. This quarry was opened by the late Mr. Walton in 1860, and was worked for about eighteen years, when it was closed. A very large quantity of slate was extracted of a quality similar to that of the New Rockland quarry, and the workings were of very considerable size, being stated, in the catalogue for the Paris Exhibition, to be 150 feet deep, 300 feet long and 100 broad. The failure of the industry at this place was to a large extent due to the depression of the market at that time, and a lack of capital necessary to carry out the work with the modern equipment necessary. Both these quarries are in contact on the west side with large masses of serpentine. The slates here found are continuous across the River St. Francis into Cleveland and Shipton. The oldest quarry in this belt is that already referred to on lot six, range fifteen, formerly known as the Steele quarry, which was opened in 1854. No returns are to hand from this quarry under its new management, but the quality of the slate extracted is excellent in so far as yet tested. The output of the Danville quarry is as yet almost entirely confined to school slates, for which a ready market is obtained. Walton quarry. Steele or Bedard's quarry. Danville school slate quarry.

It may be said generally of all these slates that their quality is unsurpassed. Their chemical composition is very similar to that of the slates from Angers, in France, which have been in use in buildings in Montreal for considerably more than one hundred years.

Within the last two years a new quarry in purple slates has been opened on lot eighteen, range ten, Brompton Gore. This is about two miles north-west of the lower end of Brompton Lake, and about seven miles south-west from the New Rockland quarry; but no particulars are yet to hand concerning its prospects. The owners are Messrs. Jenkins & Davis. Brompton Gore

The analysis of slates from Kingsey is here submitted, along with that for the Welsh and Angers quarries in France, for the sake of comparison. They are taken from the Report of Progress, 1852-53, and are by Dr. T. S. Hunt.

ANALYSIS OF SLATES.

Analysis.

	Kingsey.	Westbury.	Wales.	Angers.
Silica..................	54·80	65·85	60·50	57·00
Alumina...........	23·15	16·65	19·70	20·10
Prot. Iron...........	9·58	5·31	7·83	10·98
Lime	1·06	0·59	1·12	1·23
Magnesia	2·16	2·95	2·20	3·59
Potash	3·37	3·74	3·18	1·73
Soda	2·22	1·31	2·20	1·30
Water	3·90	3·10	3·30	1·40
	100·24	99·50	100·03	100·13

Flagstones.

Flagstones of varying degrees of excellence are obtained from rocks of different formations. Thus, good flags are to be found in the thin hard bands, interstratified with the dark slates, near Cape Rouge, in the Cambrian rocks, and in the lowest Sillery formation; also in the sandstones of Point Levis, and at Cap à l'Aigle, Murray Bay. In the Cambro-Silurian slates of Brompton and Orford, on the south side of the St. Francis River, and about five miles west of the city of Sherbrooke, several quarries are found, from which large flags were obtained and were used in that city. These have not been worked for some years; while in the Silurian sandstones and calcareous slates on the east side of Lake Memphremagog, between Magog and Georgeville, certain beds yield large and smooth surfaced slabs of almost any required size. Similar stones can also be found near Knowlton Landing, in a band of slates and limestone of the same age, which occurs at that place. Of late years quite extensive quarries of flagstones have been opened in a dark colored limestone at Dudswell, the rock splitting out into sheets of very large size, and having a thickness of from one to eight inches. These were shipped to Montreal, and largely employed there for several years, but within the last year or so do not appear to have given entire satisfaction, and the American stone is again being employed. In Gaspé, the sandy beds of the Devonian also furnish flags of good size and of almost any required thickness, but these have not as yet been worked to any extent. Near St. Maurice, at Three Rivers, the Potsdam sandstones also furnish a considerable thickness of hard flaggy rock, which should possess great durability and be available as a source of supply; as also should much of the rock of the

Lake Memphremagog.

Dudswell.

Gaspé.

St. Maurice.

same formation in the vicinity of the city of Montreal. In the Report of Progress, 1847, page 82, Sir William Logan refers to the mica schists of Sutton Mountain as probably affording good material for this purpose. He says:—"Plates were observed showing a superficies of six feet by three, under six inches thick, and I was informed they might be obtained measuring ten feet by five." Sutton Mountain.

Similar mica schist, or a schistose micaceous gneiss, is found in the Cambrian rocks of the Upper Ottawa, on Lake Temiscamingue, from which good flagstones of large size can be obtained. On the fifth lot of the second range of Inverness, a greyish green talcoid and siliceous slate is found, which was quarried some years ago, and which furnished a very excellent stone; and on the Upper Chaudière the sandy slates of the Cambro-Silurian or Upper Cambrian, both on the Du Loup and Chaudière itself, contain many thin beds of fine dark-blue sandstone, which split out readily and furnish very excellent slabs for this purpose. Lake Temiscamingue Inverness. Chaudière River.

Bricks and Brick Clays.

While in Ontario brick clay of two kinds is found, from which brick of two shades can be made, viz., red and white, in the province of Quebec the deposits principally worked are confined to a marine deposit, known as the Leda clay, and which overlies the boulder clay deposits. These marine clays frequently contain organic remains in the shape of shells, and the bones of fish, as well as of seals and whales; and when burned yield bricks of a red color. They are so extensively distributed throughout the valleys of the St. Lawrence and Ottawa that it is needless to particularize localities. Other deposits of apparently a similar clay, but which have not yet yielded organic remains, are found in the eastern townships, at Sherbrooke, Lennoxville and Ascot, and even at much more elevated points, which also yield an excellent red brick; but no white brick clay has yet been observed, or at least burned. Red brick clay.

An inexhaustible supply of excellent material for the manufacture of brick exists in the waste from the slate quarries. This, when ground, makes a clay which, when properly mixed and burned, yields a brick of much greater value than that obtained from ordinary clay. The Rockland Slate Company, it is understood, had the manufacture of these bricks in contemplation for some time; but has not yet been able, owing to the pressure of other work, to undertake the industry. The most extensive brick yards in the province are those in the vicinity of Montreal, but a clay of the same character is very extensively used at St. Johns for the manufacture of pottery and drain tiles, as well as at St. Sauveur, near Quebec, where also drain tiles are made; but outside the principal cities the industry is not carried on to any extent. Clay from ground slates.

CLASS VIII.

REFRACTORY MATERIALS.

The principal minerals under this heading found in the province of Quebec are plumbago, mica, asbestus, soapstone and potstone and sandstone, of which the three first named are of the most economic importance.

Graphite.

Graphite. Graphite or plumbago is referred to in the earlier reports of the Geological Survey of Canada for 1845-46, by Sir William Logan, as occurring in Grenville, on the south half of lot ten, concession five, "in a vein with felspar, quartz, pyroxene and sphene, with carbonate of lime and serpentine, cutting the white micaceo-plumbaginous limestone of the metamorphic rocks." The deposit was worked some years by the Hon. Mr. Harwood of Vaudreuil, and in the excavation the mineral was found to be confined to three small strings, each about five inches thick, and comprised in a space of four feet and a half. Thin veins were also reported on the thirteenth and fourteenth lots of the fourth range of the same township.

Grenville.

Westmeath. On lot twenty-one, front A, Westmeath, plumbago of excellent quality was seen, but the extent of the deposit could not be ascertained. In the Geological Survey Report for 1847 Dr. Hunt reported plumbago as occurring on the north half of the same lot as Mr. Harwood's mine, in three strings from two to eleven inches wide, which were stated to unite in one vein with a thickness "of eighteen inches, and quite free from any foreign substance." The mineral was described as being quite soft and pure, and the locality as worthy of further exploration. In the Report of Progress for 1853 additional deposits are noted in the north half of the second lot, range ten, of Grenville, and on the fifth lot of range four, Chatham Gore. It is here described as "associated with the Laurentian limestone, and of a grey color and foliated structure, resembling that of Ceylon; its price would not exceed from £3 to £5 per ton when clean." Further reference is made to these areas in the Geology of Canada for 1863, p. 793, and other localities are noted in the vicinity, among which are the township of Lochaber, lot twenty-four, range seven, which furnished some excellent graphite; the seigniory of Petite Nation and in Buckingham. In these two townships this mineral occurs at a great num-

Lochaber.

ber of points, and quite extensive works were erected by the Lochaber Plumbago Company on the twenty-eighth lot of the tenth range for crushing and separating the plumbago from the gangue. These works were under the management of Mr. S. T. Pearce, and a large quantity of good material was obtained and cleaned, not only from the lot mentioned, but from several others in the neighborhood. The graphite occurred principally disseminated in bands of limestone, though well defined veins were also found.

The largest quantity of graphite obtained in this vicinity was apparently from McCoy's mine on lot twenty-four of the eighth range, where the mineral occurs as usual in a coarse grey crystalline limestone, having a breadth of twenty-five to thirty feet; a shaft was sunk on it and from the several veins, which seemed to traverse the rock in all directions, about 620 tons of crude ore for dressing was raised. In the eleventh range of Lochaber, on the line between lots twenty-three and twenty-four, similar ore was found in a band from ten to twelve feet thick, from which about 150 tons, giving about twenty per cent. of pure graphite, were sent to the mill. **McCoy's mine.**

In Buckingham graphite was found at a number of places, both as lenticular masses in the limestone and as disseminated in smaller grains, as well as in veins as already described. Several attempts to work these deposits were made at different times. On the nineteenth lot of the fifth range Mr. Labouglie opened the Ste. Mary's mine from which several tons of pure graphite were obtained, as well as a large quantity of disseminated ore for crushing. About two hundred yards east of this opening the graphite was found over an area thirty feet by eight in a series of reticulating veins, as at McCoy's mine in Lochaber, and about 500 lbs. of pure graphite were obtained without the use of powder. On the twenty-second and twenty-third lots of the fifth range graphite also shows in considerable quantity, occurring in a similar manner, and on the twenty-fourth lot of the same range several shafts were sunk, and over one hundred tons of ore extracted. This is called the St. Louis mine. Veins of graphite also occur in the sixth range, on lots twenty-two and twenty-eight; the thickness of pure graphite being from three to six inches, and in one place from fifteen to twenty inches. Several openings have been made in these veins, but no returns of output are available. **Buckingham. Ste. Mary's mine. St. Louis mine.**

In Wentworth, on the west half of lot one, and the east half of lot two, in the third range, similar outcrops occur, as well as on the twenty-second lot of the seventh range, and on the seventeenth lot of the ninth range. These lots have been acquired by the New England Plumbago Company. **Wentworth.**

LIBRARY
NAT. RES. INTELL. BR.

Mr. Vennor's report, 1873-74.

In the Geological Survey Report for 1873-74 further details of the occurrence of graphite are given by Mr. Vennor, more particularly with reference to the Ottawa county deposits. He states that the mineral occurs "in three distinct forms, 1st, as disseminated scales or plates in the limestone, gneisses, pyroxenites, and quartzites, and even in some of the iron ores, as at Hull; 2nd, as lenticular or disseminated masses, embedded in the limestone, or at the junction of these and the adjoining gneiss and pyroxenite, and 3rd, in the form of true fissure veins, cutting the enclosed strata." Of the relative importance of these different deposits he says: "The first form is that most commonly met with, and it is in the limestone that the graphite is most abundantly disseminated, oftentimes to such an extent as to constitute deposits of great economic value. The second form, viz., that of embedded masses, is of common occurrence, and in a number of localities in Buckingham, Lochaber and Grenville, such deposits have been met with and worked to a small extent. The third, or last form, that of fissure veins, is not so common, and does not appear to be of as great importance as the bedded deposits, although many such veins exist and have been worked to some extent in the townships already named. In these veins the graphite is very brilliant, often lamellar and of great purity."

Disseminated graphite most important.

Of these three modes of occurrence, Mr. Vennor inclines to the belief that the first will prove of the greatest economic importance. In addition to the localities where mining operations have been carried on and already referred to, others are given in this report. Of these, lot twenty-seven, fifth concession of Buckingham was opened by Messrs.

West & Co.'s mine.

West & Co. by a pit ten feet square and ten feet deep on three veins of graphite ranging in thickness from six inches to two feet. From these twenty barrels of pure graphite are reported as having been shipped. On lots fifteen and sixteen of the sixth concession (Crosby Newton's) a little mining was also done. On lot twenty-three, conces-

The Castle property.

sion five, the "Castle property," the size of the veins is not stated; on the west half of lot four, concession seven, graphite also occurs, and on the south half of lot twenty-one, same concession, known as the "Pen-

Pennock's lot.

nock lot," a vein of very fine material, from a foot to a foot and a half in thickness, has been opened and worked to some extent; the quality of the graphite being said to compare favorably with that from Ceylon.

Pugh & Wort's mine.

On the twenty-seventh lot of the sixth concession is the mine of Messrs. Pugh & Wort, consisting of a shaft forty feet deep on a bed of about three feet, which has also been worked by an open cutting for over sixty feet from which a large amount of fine graphite was obtained. In the vicinity of Donaldson's Lake several other openings have been made at different times, and on some of the lots, more especially on lots four and five of the ninth concession, very promising indications were found, but no details of the output are to hand.

LIBRARY
NAT. RES. INTELL. BR.

In the Report of Progress of this Survey for 1875-76 the results of the analysis of four samples of graphite from the township of Buckingham was given; this was followed in the report for the next year, 1876-77, by a very valuable series of analyses by Mr. Hoffmann, including in all eighteen specimens of graphite from Buckingham and Grenville made in order to institute a comparison with the Ceylon, graphite. The Canadian mineral was obtained from various deposits among which were the Montreal Plumbago Mining Co.'s, on the twenty-eighth lot of the sixth range of Buckingham, where a bed of disseminated graphite eight feet in width occurs, the percentage of the graphite in the rock being 29·518; from the twentieth lot of range eight, belonging to the Dominion of Canada Plumbago Company, where there is a large bed of similar character, the percentage of the graphite being 23·798; and from the twenty-second, and twenty-third lots of the sixth range, belonging both to the Buckingham Mining Company, which contained 22·385 and 30·516 per cent of graphite. The percentage of rock matter insoluble in hydrochloric acid from the first three samples averaged 55·094; and of rock matter soluble in hydrochloric acid, 19·430. In the last sample the soluble rock matter was 2·475 per cent, the insoluble 66·874 per cent. Seven specimens of dressed graphite from the Dominion of Canada Plumbago Company were examined, and the amount of ash determined. The samples were of different grades, and the ash ranged in amount from 17·682 to 3·638 per cent. All the samples contained certain proportions of carbonate of lime and oxide of iron, features objectionable in the manufacture of crucibles; but these, together with other injurious foreign matters, were removed by digesting the graphite with hydrochloric acid, so that the resulting graphite, according to Mr. Hoffmann's exhaustive tests, contained nothing that would in any way be prejudicial to the manufacture of crucibles from the purified material.

Mr. Hoffmann's analysis, 1876-77

Excellent quality of Canadian graphite.

Four assays of vein graphite were also made; two from Buckingham, a foliated vein occurring on lots twenty-one and twenty two, seventh range, containing 99·675 per cent carbon, with ·147 of ash, and a columnar variety from the twenty-seventh lot of the sixth range which contained 97·626 per cent carbon and 1·780 ash; and two from Grenville; a foliated variety from the north half of the second range of the augmentation, formerly mined to a small extent, which contained carbon 99·815 per cent, with only ·076 ash, and a columnar variety from lot one of the sixth range of the augmentation which showed carbon 99·757, and ash 0·135; nearly sixty per cent of the latter being silica.

Analysis by Mr. Hoffmann.

Respecting the character of the Canadian graphite as determined by Mr. Hoffmann, he remarks that "From these experiments it will be

Conclusions of Mr. Hoffmann.

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." Mr. Hoffmann further remarks that "prepared according to the present process, the dressed graphite, obtained from the beds of the disseminated mineral, is apt to contain more or less carbonate of soda and oxide of iron." He, however, points out that these can be easily removed by a simple process, and the graphite be left "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."

Mr. Torrance's report.

Mr. Torrance, in the Report of the Geological Survey for 1882-83, in referring to the quality of the Canadian plumbago for the market, cites the opinions of those who have used it, to the effect, that its bad reputation abroad is due to the uncertain quality of the article shipped, and to the fact that it contained certain impurities pointed out already in the report of Mr. Hoffmann as easily removable, but which apparently had not been done by the company which worked the mines. The hydrochloric treatment is also referred to, and Mr. Torrance says that "until acid chambers are erected in Ottawa county, or at Montreal, the best plan of working the plumbago deposits would be to dress the plumbago at the mines as completely as mechanical skill can accomplish, and then ship it to Brockville in barrels for the further treatment with acid, before its export;" and further, that "so long as the price of dressed plumbago does not fall below forty dollars per ton, many of our Canadian deposits could be profitably worked, always provided that they are managed by competent engineers. No mining company need hope to succeed in Canada, or any other part of the world, unless its manager has had a careful technical training, or the ore is of a phenomenal richness."

Present condition of the industry.

No graphite has been mined in Ottawa county now for several years. The property formerly owned by the Dominion of Canada Plumbago Company has lately passed into the hands of Mr. W. H. Walker, of Ottawa. The areas embraced in this property, which amounts to about 2,000 acres, are the north half of lots nineteen and twenty-one, range twenty-three, Buckingham; lot twenty-four, range seven; lot nineteen, range eight; the south half of lots twenty and twenty-one, range eight; the south half of lot nineteen, range nine, and lot twenty-one, range nine. A large amount of work was done here in former years; but at present the industry is confined to the utilization of the refuse of the mine for the manufacture of stove polish, much of which is obtained by draining a lake on the property.

Recently a vein of disseminated graphite about three feet thick has been found, according to Mr. Willimott, on lot nine of range eleven, Hull, near Cantley, on land owned by Mr. Davis of that place. This has not yet been opened. The property in Grenville, lot ten, range five, formerly known as the "Miller Mine," has recently been bought by Messrs. Rae & Co., of Montreal. The veins, of which there are five, occur in a band of white crystalline limestone. They have a breadth of five to eight feet, and have provided a fair amount of graphite. The mine has been opened for sixty feet in length to a depth of thirty feet, but nothing is at present being done at the place.

Hull.

The Miller mine, Grenville.

MICA.

At present there are no deposits of this mineral being worked in Quebec. The most important location probably is that of Villeneuve, lots thirty and thirty-one, range one, which has lately been acquired by Messrs. Franchotte & Co. of Buckingham. A considerable quantity has been mined at different times, but the deposit is now said by Mr. Willimott, who has lately visited the spot, to be worked not for the mica but for felspar, which is employed in the manufacture of porcelain. Among other localities referred to in the Geology of Canada, 1863, in which mica occurs in sufficiently large masses for economic purposes, is the ninth lot of the sixth range, Grenville, from which one crystal was obtained furnishing sheets twenty-four by fourteen inches. Also on the tenth lot of the fifth range, and on the first lot of the tenth range. Mica has also been reported within the last four or five years from the north side of the Gulf of St. Lawrence, in the Watsheeshoo peninsula, and some very fair sample sheets have been exhibited as coming from this area. The rocks are of the usual character of the Laurentian found in Grenville and Buckingham, and it is said the deposit bids fair to be of considerable importance, though no reliable details are to hand.

Villeneuve mica mine.

Grenville.

North side of the Gulf of St. Lawrence.

ASBESTUS.

There is probably no mineral in Canada which has assumed so much economic importance in so short a time as asbestus. Prior to 1880 its use in this country was comparatively limited, while the value of the imports into the United States for that year, according to the mineral statistics of that country, was less than $10,000. Although the presence of this mineral in Canada has been known for more than forty years, reference being made to it in the Report of the Geological

First reference by the Geological Survey.

Survey for 1847-48 as occurring with the serpentines of the magnesian belt in Bolton, but little value was attached to the discovery, the uses for the mineral and the market being exceedingly limited. At the exhibition in London in 1862 a specimen of asbestus from the seigniory of St. Joseph was on view, which probably came from outcrops of serpentine on the Des Plantes River, or the Bras, between St. Joseph and St. Francis villages; but while the extension of the belt of serpentine rocks in which this mineral is known to occur had been traced with some care from the Vermont boundary in the township of Potton to and beyond the Chaudière River, the deposits of asbestus observed were comparatively limited. In the United States veins, generally of short and harsh fibre, were found at several points, and a considerable quantity of a tremolitic variety was mined, which, while ill-adapted for the purposes to which asbestus is now generally applied, was used for the manufacture of fire-proof paints, cements, etc. The chief source of supply for fibrous asbestus was the mines of Italy, where deposits of irregular extent occur the mineral often possessing a long and silky fibre which well adapted it for spinning, and from this source the material for fire-proof curtains and such like manufactures was obtained. But in 1877-78 asbestus was discovered in the serpentine hills of Thetford and Coleraine; the size of the veins, often several inches thick, leading to the expectation that deposits of value might exist there, though their true importance was not ascertained for several years. The credit of the discovery in this locality is claimed by Mr. Robert Ward, though by others it is stated that the first find was made by a French Canadian named Fecteau. Following closely upon the discovery several parties secured areas both at Thetford and Black Lake in Coleraine township on the line of the Quebec Central railway, which for some miles, or from Coleraine station to a short distance beyond Thetford station, runs between high ridges of serpentine, in which, the timber having been burned off, the veins were observed at the surface by the weathering and felting of the mineral on the surface of the bare rock. In the first year of mining operations, 1878, only fifty tons were taken out, for which it was difficult to find a ready sale at remunerative figures. The value of the mineral was, however, speedily ascertained, and in a short time additional areas were secured from the Government. The land was considered of no value, either for agricultural or any other purpose, and the mining was rapidly extended. The principal areas in which the asbestus bearing serpentine was found to occur were on lots twenty-six, twenty-seven and twenty-eight, near the line between ranges five and six of Thetford; and, in the township of Coleraine, near the Black Lake station, four miles south-west of Thetford station, in an area previously unsurveyed,

Exhibited in London, 1862.

Asbestus in the United States.

Italian asbestus.

Discovery of the Thetford deposits.

Beginning of the industry.

Mining areas.

but adjoining, on the south-west, range B, and called block A, as also on lots twenty-seven and twenty-eight, range B, and on lot thirty-two, range C.

Mining mass to the south-west.

All these areas were speedily secured, as well as most of the serpentine-bearing ground extending south-eastward from the Quebec Central railway toward Caribou Lake from and along what was known as the Poudrier road for several miles. In the south-west portion of Coleraine, and in the portion of Ireland adjoining, a large ridge of serpentine extends from Black Lake to the Wolfestown road, where it apparently terminates, the road to Wolfestown passing through a deep depression; but a second mountain mass of similar rock rises directly beyond the road, and extends for some miles in a south-westerly direction into the townships of Garthby and Ham. Upon the first of these two ridges, or that south-west of Black Lake, four mines have been lately opened, while in the ridge beyond the Wolfestown road the first works of the Bell Company of London were commenced in 1875 on lots twenty-three and twenty-four of range two of Wolfestown. Further west also, on the south-west face of the same hill, some three miles distant from the Bell Company's opening, other explorations have lately been made, but these have not, in so far as yet learned, given such promising results as those of Thetford and Coleraine.

Rock of the areas.

All these mining locations are situated on areas of serpentine which is associated with green, grey, black or reddish slates, and quartzose sandstones and conglomerates. The serpentine is more particularly related to considerable masses of dioritic and whitish granitic rock, and is apparently due to the alteration of portions of these masses. The country is very rough and unpromising for anything other than mining enterprises. These slates and associated rocks for the most part are supposed to belong to the Cambrian system, though the serpentine is sometimes connected with areas of older rocks, such as chloritic and talcose schists, and considerable masses of soapstone. In the serpentines which are found with the older rocks the asbestus appears to be in very limited quantity, and no attempt has yet been made to work any such deposit.

Asbestus of Ottawa county.

In connection with the Laurentian rocks of Ottawa county the serpentinous limestones sometimes carry veins of a pale yellowish asbestus, generally of short fibre, but at times having a length of three-fourths to one inch. In some pieces of rock several of these, six, eight or more, are found, occupying a breadth of ten to twelve inches, the thickness of the veins ranging from one-fourth of an inch upward. Few attempts have, in so far as can be learned, been made to work these asbestus veins, some of which, as in Templeton, range seven, lot two, might, if they were continuous to any extent, afford material of second and third quality, the fibre having scarcely a sufficient length to class it as first. Both the serpentine and asbestus of the Laurentian rocks differ in quality from that of the eastern townships, as might indeed be supposed from their mode of occurrence and from the associated rocks. In connection with some of the phosphate deposits, as at the Emerald mine on the Du Lievre in Buckingham, considerable masses of the variety of asbestus known as mountain cork are found, but this has as yet no economic value.

Unlike that of the townships.

Growth of the industry.

The history of the asbestus industry has already been very fully given in the Report of Progress of this survey for 1886 and 1887-88, as well as in various articles in the Ottawa Mining Review. The growth of this industry has been constant and rapid, as can be seen by the greatly increased output from year to year; that for 1889 reaching over 6,000 tons. There is also a great and constantly increasing demand for the material itself—a demand in fact so great that, with the present appliances and conditions of mining, the supply cannot keep pace with it. The reputation which the Canadian asbestus has already acquired in foreign markets is such that the principal manufacturers have either already obtained asbestus producing areas of their own, or are striving to purchase them. Of those the most prominent already in the field are the Bell Company, of London; the United Asbestus Company, also of London, and the American Asbestus Company, controlled by the Wertheims, of Frankfort, Germany.

The Thetford mines.

The companies now working at Thetford, are the King Bros., on lot twenty-six, range five; the Bell Company, on east half of lot twenty-seven, same range; Ross, Ward & Co., on west half of same lot and range; Irving Johnston & Co., on lot twenty-seven, range six; the Thetford Asbestus Mining Co. (A. H. Murphy & Co.), on lot twenty-eight, range six; and the King Bros. also on lot twenty-eight, range five—on which some new development work is being carried on. The four mines of King Bros., the Bell Company, Irving, Johnston & Co. and Ross, Ward & Co. are all situated on parts of a small knoll of serpentine lying directly to the south-east of the Quebec Central railway, which traverses the area. The serpentine, however, extends to the Thetford River, about a fourth of a mile to the north-west of the railroad. Some of the openings are situated to the west side of the railway, but the greatest amount of asbestus is taken from open pits in the sides and from the top of the knoll mentioned.

Extent of the serpentine at Thetford.

It seems not improbable that the whole of these magnesian rocks are of the pre-Cambrian age. They constitute "The Volcanic Group" Report of the Geological Survey for 1877-78 No fossils. have been found in them, and their mineral character seems to ally them more closely to the pre-Cambrian (Huronian system) than it does to any known Cambrian terrane.—*A. R.C. Selwyn.*

In Coleraine township, adjoining Thetford, Messrs. Lucke, Mitchell & Co. have a mine on lots thirty-two and thirty-one of range C, also traversed by the Quebec Central railway, and showing excellent fibre. In range A of this township prospecting work has been done on lots twenty-seven, twenty-eight and twenty-nine by Dr. James Reed, and some good veins of asbestus disclosed, and mining has lately commenced on these. On lot twenty-six H. W. Johns several years ago made an opening in the face of the hill, about one-fourth of a mile east of the Poudrier road, and found some small veins, but no further attempt to prove this property has since been made. In range B, lot thirty-two, Mr. Williams of the Rockland Slate Quarry opened up a pit in 1888 on land leased from Mr. A. H. Murphy from which about thirty tons mostly of second and third grades were obtained. On lots twenty-seven and twenty-eight, the south half of which was formerly Dr. Reed's, and was obtained two years ago by the American Asbestus Co., and the north half (which was formerly Hayden's) by the Bell Co., work has been going forward very extensively, especially on the former. Further to the rear, on lot twenty-four, Mr. D. Blacklock of Glasgow, Scotland, opened several pits in 1889, but the quantity of asbestus found was not great, the veins being of short fibre. **Mining companies in Coleraine township.**

The principal workings of the Black Lake district are situated on block A, adjacent to the south line of range B, and are the Scottish-Canadian, formerly the Eureka and Emilie mines; the United Asbestus Company, of London, formerly the Frechette-Douville; and the Anglo-Canadian, controlled by Hopper, Irwin & Co., of Montreal. To the south-west of this last and directly adjoining is the property of the Laurier Mining Company of Arthabasca, and further down the line of the Quebec Central, nearly one mile from the Anglo-Canadian, is the property of Loomis and Johnston, opened in 1888, which is flanked on the north-east by that of Wood & Co., and on the south-west by that of the Black Lake Asbestus Mining Co. Across the upper end of Black Lake Messrs. Grundy and Steele of Sherbrooke have opened an area on the southern flank of the Silver Mountain. Further to the south-west, on the southern extremity of the great Coleraine and Ireland serpentine ridge, Messrs. Fenwick and Sclater own the Megantic mine, situated one mile and a half north-west of Coleraine station on the Quebec Central, and adjoining this on the north-east is the area of Lambly & Company of Inverness; the latter commencing work in 1889. **The Black Lake mines.** **New companies**

On lots twenty-four and twenty-five of the third range of Ireland Messrs. King Bros. have commenced operations, with good prospects, on the western flank of the serpentine ridge. The former workings of the Bell Company are situated on the north end of the Wolfestown and **Ireland—King Bros. mine.**

Garthby serpentine ridge, on lots twenty-three and twenty-four of Wolfestown, range two. These have not been operated since 1888. On the south-west extremity of this ridge, on lot twenty-four, range four, further openings were made in 1885, but soon discontinued. Among other companies, who have taken up asbestus locations and carried on mining operations, are the White's Asbestus, 1889, who own several widely-scattered areas in Garthby and Coleraine; the McDonald Bros., of Sherbrooke, who worked for some time on lot eight, range twelve, Coleraine, near Little Lake St. Francis, but apparently without much success; and the Brompton Lake Mining Company, formed in Montreal in 1889, who last year acquired the old Noel mine, on lot twenty-six, range nine, Brompton, near the lower end of the lake on the east side. This property was first opened by Mr. Noel, of Richmond, in 1886, who sold to Messrs. McDonald Bros., of Sherbrooke, by whom it was sold last year to the present company. Sufficient work has not yet been done to pronounce definitely upon its real value; but a somewhat extensive plant is now being placed there, and its importance, as an asbestus belt, will soon be known.

Wolfestown

Garthby.

White's Asbestus Co.

Brompton Lake Mining Co.

Bolton.

Further to the south-west, on lot eight, range seven, Bolton, a company attempted last year to work asbestus in a knoll of serpentine, one of a chain which extends for several miles between Trousers Lake and Eastman. The indications of large and profitable veins were, however, very few. Some small local veins of one-fourth to half an inch only were found, and the company abandoned operations early in the season. This is the only attempt to work asbestus in the south-western area, that is south of Orford Mountain, but on one of the outcrops on the Montreal road, about one-eighth of a mile west of Long Lake, in North Stukely, several shallow pits were sunk in a soft, shattered slaty serpentine, where a small vein of a fourth of an inch only was visible. The serpentines are in contact with the black and grey slates a few feet south of the opening, and, with the exception of the small vein noted on the road, no other indications of asbestus were visible. This serpentine differs in character from that of the areas worked in Coleraine and Thetford, being for the most part slaty and much scattered, while that of Thetford is generally massive or traversed by large joints.

North Stukely.

Shipton. Jeffrey's mine.

The most westerly area in which asbestus is mined is at Jeffrey's location, four miles east of Danville village, on lot nine, range three, Shipton. The asbestus here occurs in a rounded knoll, one of a series which extends from Melbourne through Cleveland into the south-east corner of Tingwick, and is the only one in which valuable veins have yet been found in this direction. This was first worked in 1884, and has yielded a large amount of asbestus of excellent quality, though the veins are not of large size. In Melbourne, on the south side of St. Francis River, near the slate quarries, the hills of serpentine contain small veins of asbestus, but these have never been found of sufficient size to extract with profit. So also in Cleveland, near the slate quarry of Mr. J. S. Bedard, small veins can be seen, but no attempt has yet been made to work them.

Melbourne.

Cleveland.

Much of the serpentine of the smaller areas in Potton, Sutton, Bolton and Orford is as yet covered by forest growth, or by drift, so that while the search has hitherto been unsuccessful in finding large deposits like those of Thetford and the vicinity, it is possible that such areas may exist.

Area north of the Thetford mines.

To the north of the Thetford mines serpentine occurs at several places, and has been already opened to some extent. In the fourth range of Thetford, on lots sixteen, seventeen and eighteen, knolls are found containing both chromic iron ore and asbestus; the latter in veins of half an inch to an inch; the former of a quality, in so far as tested, too poor for shipment to a foreign market. Near Robertson station, on lot thirteen, range five, several outcrops of serpentine are visible, and on the road from Broughton station to Harvey Hill a number of knolls of serpentine and soapstone are seen. In some of these, small veins of asbestus have been recognized, but none of sufficient size to be as yet economically available. Near East Broughton station, Quebec Central railway, on lot fourteen, range seven, Broughton, another area occurs in which the Broughton mine is situated.

Broughton mine.

Leeds.

In Leeds also, near Kinnear's Mills, several outcrops of serpentine are found, but these appear to be barren of asbestus, and in the concession of St. Catherine, on the road leading east from St. Sylvester, a knoll of some acres in extent has been mined by Mr. Fahey of the latter place, but without obtaining anything of importance.

St. Sylvester.

Thetford.

East of the line of the Quebec Central railway serpentine occurs in Thetford, on lots ten and eleven, range seven; lots fourteen, fifteen and sixteen, range eight; lots fourteen and fifteen, range nine; and five, seven, nine, ten, range ten. These areas have been examined by Mr. Obalski, but no important veins discovered. In Adstock considerable areas of serpentine occur in the south-west corner of the township adjoining Thetford, but these also seem to be, for the most part at least, in the barren belt.

Adstock.

Little Lake St. Francis.

As regards the serpentines of Little Lake St. Francis, while there is apparently a considerable development in this direction, much of it appears to be too hard and siliceous to be asbestus producing, and no veins of any value have yet been observed in this quarter, though the ground has been thoroughly prospected.

Tring.

In the township of Tring several outcrops occur. That on the thirteenth lot of the first range was opened several years ago, but only small and irregular veins were found. In the vicinity of St. Victor de Tring similar outcrops are seen, but the veins are small, being only a fourth of an inch or so in length of fibre. On the Bras du Sud-Ouest, a

The Chaudière River.

branch of the Chaudière, a mass of serpentine occurs at the falls, about three miles from the mouth, but though carefully prospected, has also as yet yielded nothing of importance; and on the Des Plantes, near the road to St. Francis from St. Joseph, several openings were made, some years ago, but the veins found were small and not continuous for any distance. This serpentine has the soft greasy look of much of that in the Orford and Bolton area, and is very much shattered. At the falls

Des Plantes River.

of the Des Plantes, between one and two miles from the mouth of the river, a considerable bed of serpentine occurs, apparently of the barren sort; and near the boundary between Vaudreuil and St. Joseph, about four miles from the Chandière, an area of similar rock contains a large deposit of titaniferous iron ore, but has not yet been prospected for asbestus, or if so, none is yet reported. On the east side of the Moose

Cranbourne.

Mountain, in Cranbourne, on lot twenty-three, range five, on the west side of the Etchemin River, a small area occurs with the trappean rocks, but no veins larger than half an inch in thickness have yet been seen.

Rolette and Talon.

Several small areas occur in the township of Rolette, range four, and Talon, range six,; but of these not much is known. No asbestus has yet been reported; the country in this direction being almost entirely unopened.

Gaspé Peninsula.

In the Gaspé Peninsula the great serpentine areas of Mount Albert and the South Mountain, which mark the western prolongation of the Mount Albert ridge to the Salmon Branch of the Cascapedia, have long been known. The western portion is too hard and siliceous to give

Mount Albert.

much promise of asbestus, but some portions of the Mount Albert areas have shown small veins along with deposits of chromic iron. In the eastern portion of the peninsula, at Mount Serpentine, on the Dartmouth River, a few miles from its mouth, a band of this rock associated with hornblende rock occurs, in which some small veins of asbestus were observed by Mr. Obalski; but owing to the covering of soil and forest, the full extent of the deposit could not be ascertained. This mountain, which rises, according to Mr. Obalski, to a height of

Mount Serpentine.

1,600 feet above the sea, was named Mount Serpentine by an officer of the Geological Survey thirty years ago. It is surrounded by the sandy and calcareous beds of the Siluro-Devonian system of that region, and probably marks the most easterly exposure of the older rocks of the Green Mountain range.

In the south-eastern part of the province areas of serpentine are few, the only one reported being in Gayhurst; but the exact location is not known, the difficulty of access being considerable. Several samples of short-fibred asbestus said to be from this locality were sent to the Geological Survey office several years ago; but nothing definite has been heard on the subject since. The quality of the sample sent does not indicate it to be of much economic importance, while the present inaccessibility and distance from the railway would seriously interfere with its development, even though the veins were of considerable size. A somewhat peculiar development of asbestus is found in the serpentine of Big Island, Nicolet Lake, in South Ham. Explorations were carried on there for some weeks in 1885-86, but no large veins of good fibre were obtained. The property was carefully examined by Mr. C. W. Willimott, in 1882, who reports that four varieties of the mineral occur. The first, or workable asbestus, is found in veins, the fibre of which is rarely half an inch in length, and not easily separable; the second was the coarse variety, the fibre having sometimes a length of three feet, which is apparently of very little economic value. The third variety is somewhat finer in texture, and like that which occurs along the joints of the serpentine in the mines worked elsewhere; while the fourth is a steatitic rock, in masses containing concretionary pellets of asbestus, the centres of which show a nucleus of serpentine. In the serpentine of the west shore of the lake, a large and important vein of magnetite, containing a small percentage of chromite, is found. No attempt has yet been made to work the asbestus of this district, though some money has been spent in developing a large stratum of soapstone in the vicinity, near the south end of the lake.

Gayhurst.

South Ham. Nicolet Lake.

From a careful examination of the serpentine, extending over a stretch of country for some hundreds of miles, several varieties of the rock can apparently be recognized, differing in importance as sources of supply for asbestus. Two of these varities seem to be very nearly barren, viz., the hard reddish-brown siliceous rock, often of a greyish color on fresh fracture, similar to much of the Wolfestown ridge, and to that portion of Coleraine lying in the vicinity of Caribou Lake, Lake St. Francis and Adstock, as well as in the Shickshock mountains. Areas of this hard barren looking rock, of considerable extent, occur in the heart of the productive belt itself, at Thetford and Black Lake. Small, but very irregularly distributed veins are frequently seen in this rock, but they are not thick enough to repay the cost of their extraction. The second variety, which has likewise been found generally barren, is the slaty rock seen about the south side of Long Lake in Orford, and in Bolton and Potton. This rock frequently has a peculiar

Different kinds of serpentine.

Barren rock.

greasy, or talcose aspect, and generally is much shattered. Here small veins also occur, sometimes only a few inches in length, but no well defined veins have yet been seen in this rock. In areas of serpentine associated with soapstone in quantity veins of asbestus of workable size are generally absent, though the Broughton mine furnishes an exception; the hanging wall being for some distance composed of soapstone, the foot wall of serpentine, but the deposit was, in this area confined to but one vein, as far as yet ascertained. About Long, Webster, Orford, Brompton and other lakes to the north of the Orford Mountain ridge, the serpentine is largely associated with masses of dioritic rock. This admixture is well seen about Long and Brompton Lakes; on the west side of the latter several high hills, known as Bear and Carbuncle mountains, rising from 500 to 750 feet above the surface of the lake. These serpentines have been very carefully explored for asbestus; but as yet have not yielded any satisfactory results.

Serpentines north of Oxford Mountain.

Irregularity of the asbestus veins.

The irregularity of the asbestus veins, even in those areas where most abundant, should not be lost sight of. The serpentine is very greatly affected by fissures, some of which constitute faults of considerable extent. These intersect the rock in every direction, and not only frequently destroy the value of the veins by crushing or cutting them off directly, but are a great source of danger in working the quarries, especially where these have reached a considerable depth, as is the case now with most of the workings, both at Thetford and Black Lake. An unlucky blast may send hundreds of tons of rock into the pit at a moment's notice, as happened last year in the King Bros.' mine at Thetford by which great loss of life would have resulted, had not the men, a short time before the slide occurred, left the pit. The sides of these fissures, or faults, are generally smooth and slippery, and along the joints there are long strips of fibrous serpentine styled hornblende by the miners, which can be stripped off in pieces several feet in length. The occurrence of the veins of asbestus in the mines now being worked is by no means uniform—large portions are intersected by veins in all directions, some of which reach a width of four inches or more, and pass through a band of this sort to a fissure, where they end against a wall of apparently barren rock. In nearly all the mines, dykes of a whitish-grey granulitic rock penetrate the serpentine, shattering and otherwise altering the sides adjoining, and in some of these mines have exerted a bad effect upon the veins of asbestus; while in others, the rock in their vicinity is so shaken and seamy that water enters in such quantity as to require heavy pumping to keep the pits clear.

Danger from rock slides.

Faulted nature of the serpentine.

Although these mines have been in operation scarcely more than ten years, so rapid has been the increase in the demand and, in consequence, the output, that the present conditions of mining as contrasted with those of even five years ago are completely changed, and in no case have the necessary provisions been made for a future regular supply. Owing to the fact, at Thetford more particularly, that the principal workings are located in a small knoll of serpentine surrounded largely by drift-covered rock of uncertain value, when first worked the large amount of waste rock which goes to the dump has been left in too close proximity to the pits. This, so long as the pits were not of too great depth to be easily worked and drained, or the demand was not too great to be easily supplied, did not so much matter, but the demand has increased so rapidly, that it is with difficulty met with the present appliances, and the inconvenience experienced from the inauguration of such a system of mining and disposition of waste rock is becoming so great as to necessitate a radical change in this respect, and that very speedily. It will soon be found impossible to carry the system of quarry working to a much greater depth, owing to the danger arising from slides, and from the cramped character of the openings. The plan, which should have been adopted at first, of removing the waste material to some portion of the area of no economic value will, therefore, have to be adopted, and the sooner the better, since, at the present rate of output, each additional year but adds to the trouble by increasing the amount of rock which must at last require to be removed.

Character of the workings at Thetford.

The Black Lake areas are in this respect rather more fortunately situated, since the principal mines are on the face of a bold ridge, and there are areas of barren rock or granitic masses at a convenient distance on which the refuse can be dumped; although here, at several of the mines, the same difficulty is experienced as at Thetford.

The Black Lake mines.

The output of Canadian asbestus when graded is divisible into four portions, numbers one, two and three and waste. The first includes the long fine silky fibre, over one inch or thereabouts in length or a little less, well adapted for spinning and manufacture into yarn, rope and similar products. The price of this fibre has rapidly advanced from eighty dollars, at which it was quoted three years ago, to one hundred and seventy or more, with an upward tendency. For many purposes it is found to be quite equal to the Italian product, while for others it is even regarded as superior. The second grade includes much good fibre, but shorter and from smaller veins; the third kind includes material very often with but little continuous fibre, or discolored and with the vein matter broken by bits of rock or grains of iron ore, while the waste includes a considerable quantity of fibre and other asbestus-like material that accumulates about the pits and sheds.

Four qualities of asbestus.

Price.

Grading of output.

The lower grades, which do not possess the requisite length of fibre for spinning into yarn, are used for felting, while the still lower grades are ground and manufactured into paints, etc.

Economic value of the material.

The great value of the material, as every one at all interested now knows, consists in its capacity for resisting heat without changing its character, certain grades having successfully withstood a temperature of 4500° to 5000° Fahr. The most important of the manufactures made from the material are paints of different colors (the colors being due to the admixture of other materials with the ground asbestus), roofing and other felts, as for lining safes, ranges, etc., asbestus paper, mill board, rope, yarn, packing, etc. Of these, the paints, while not regarded as perfectly fire-proof, are largely used both for inside work and for roofs, having the power of resisting sparks or light flames; the felting is employed for the covering of steam pipes, boilers, stills, furnaces, etc.; the yarn, either as packing or rope, for packing steam cylinder pistons, flange joints, hot air-joints, cylinder heads and for other purposes, not only about steam engines, but in gas piping; mill board is also largely employed for the same purposes. Sometimes in weaving the asbestus into rope, fine copper or brass wires are incorporated therein to give it greater firmness or strength. In its manufacture, the asbestus is first torn asunder, teased out, carded, spun and woven either into sheet or rope, which varies in size up to several inches in diameter.

Uses to which applied.

Superiority of the Canadian mineral.

The great excellence of the Canadian mineral is now universally acknowledged, and the fact that the serpentine of Canada contains the largest and most readily available quantity of this mineral at present known, places these mines in the province of Quebec in a very desirable position. For although its presence is known at many points in the United States, the amount is in most cases not sufficient to warrant the necessary outlay in opening up the deposits. The amount of asbestus produced in the United States in 1883 and 1884 averaged about 1000 tons, which decreased in 1886 to 200 tons, the market being largely supplied by the Canadian mineral.

In order to give a better idea of the rapidity of the growth of this industry, the figures of the output from its inception may be stated, the data being obtained from the managers of the several mines, and published in the Geological Survey Report for 1887.—

Growth of the industry.

OUTPUT.	TONS.	VALUE.
1878	50	
1879	300	19,500
1880	380	24,700
1881	540	35,100
1882	810	52,650

1883	955	68,750
1884	1141	75,097
1885	2440	142,441
1886	3458	206,251
1887	4219	
1888	4404	255,007
1889	6014	424,350

From information kindly furnished me by Mr. Wm. King, and others, the following dates are given for the opening of the several mines at Thetford and Black Lake :—

Dates of the several mining companies.

Boston Co., on Ward's opening	1878
Johnston & Co	1878
King Bros.	1879
Mr. Noel	1880
Mr. Lionais (Anglo Canadian)	1883
Jeffrey's, Danville	1884
The Bell mine, Wolfestown.	1885
Mr. Lionais (Scottish Canadian)	1885
Douville (United Asbestus Co.)	1886
Fenwick & Sclater, Coleraine	1887
A. H. Murphy	1887
Lucke & Mitchell	1889
Lambly & Co., Coleraine	1889

Soapstone.

Soapstone, or steatite, is a rock largely composed of a talc which is rarely found in the rocks of the Laurentian of Canada, but occurs chiefly in connection with the slates and schists of the eastern townships, often in association with serpentine. An analysis of this rock from Potton township, made by Dr. Hunt, shows the composition to be a hydrous silicate of magnesia; the composition varying somewhat in different specimens—being in one case silica 59.60, magnesia 29.15, protoxide of iron 4.50, alumina 0.40, oxide of nickel, traces, and volatile matter 4.40=97.95. A second variety contained a marked decrease in the percentage of silica and magnesia, but had a considerable amount of lime with peroxide of iron and alumina. The rock is soft and is easily cut or sawn into any required shape, and as it is of a highly refractory nature it is admirably adapted for linings for stoves, furnaces and such like uses. Certain pure varieties are in demand for the manufacture of gas burners, while, when ground and purified, it answers admirably as a lubricant. It is also used, when finely ground, as a filler for paper, and enters into the composition of certain paints, being said, when mixed with oil and white lead,

Mode of occurrence.

Analysis.

Uses.

to form a durable compound of very considerable value for ordinary work.

Distribution.

Though soapstone occurs at many points throughout the belt of magnesian rocks of the townships, it is at present but little worked. In Bolton and Potton it has in past years been quarried for local uses, but the only deposit now being utilized for purposes of shipment is on the road from Coleraine to Wolfestown Corner, at the crossing of the White River, on lot nineteen, range two, Wolfestown. This is owned by Fenwick & Sclater of Montreal, formerly by Mr. Calvin Carter. According to Mr. Obalski's report this company took out and shipped to Montreal during the past year one hundred and fifty tons. It is there ground in a cyclone pulverizer and used for paints and as a lubricant. The value of the mineral at the Coleraine station on the Quebec Central railway is from six to eight dollars per ton. The bed of soapstone which is worked is near the contact of the crystalline schists and lower black Cambrian slates, and has a width of from one to ten feet where quarried on the bank of the stream.

Fenwick & Sclater's mine. Wolfestown.

Clark's mine. South Ham.

In the township of Ham large quantities of this rock are found on lots forty-three and forty-four, range one, owned by the late Mr. E. Clark of Sherbrooke, and on lots forty-nine and fifty same range, owned by Dr. Reed. Mr. Clark opened the deposit on his property to some extent several years ago; but, as the distance to the railway is considerable, very little was shipped. In Hatley, on the west side of the Massawippi Lake, on lots nineteen, twenty and twenty-one, range five, it occurs in areas of considerable extent, and much of it is of excellent quality. It has been quarried to some extent, but for local purposes only.

Broughton.

A very pure soapstone, to a limited extent, is found at the Broughton asbestus mine, on lot fourteen, range seven, which has been shipped; and on the road from Broughton station, and the Quebec Central railway to Harvey Hill, the rock appears in a number of knolls, and is of good quality, massive, but not so translucent as that of the Broughton mine.

Potton.

The principal masses in Potton occur on lot twenty-four, range six, and on lot twenty of the fifth range, where a band of three feet thick is seen. In Bolton it is found on lot twenty-four, range six, in several bands interstratified with chlorite and dolomite, the soapstone beds being from three to five feet thick; also on lot sixteen, range five, and on lot seventeen, range nine, where it is connected with the bed of magnesite already described. In Sutton it is found on lot twelve, range seven, but is here not of very pure quality, being mixed with crystals of bitter spar, pyrites and a little chromic iron ore. This impure variety is also found near Knowlton, and in Bolton, in bands of

Bolton.

Sutton.

great size, reaching a width of from twenty-five to fifty yards. On the fourth lot of the fourth range of this township it contains asbestus, actinolite and talc. These minerals have not yet been found in this direction in sufficient quantity to be commercially valuable.

Steatite also occurs at the falls of the Bras in the Chaudière district, about three miles from its mouth, along with the serpentine of that locality, and with dolomites in slates. It is not, however, sufficiently pure to be of great importance for the purposes for which it is generally employed at present. The Chaudière River.

Potstone, or compact chlorite, is found also at several places in the magnesian belt, more particularly in the townships of Bolton, Potton and Broughton. It differs from the soapstone in the smaller percentage of silica, and the greater quantity of alumina and water. It is soft like the preceding, and can be easily cut or turned into different shapes, forming culinary vessels of great usefulness. A large bed is found in Bolton, on lot twenty-six, range two, having a reported thickness of twenty feet; also on lot twenty-six, range six of Potton, and on lot four of the twelfth range of Broughton. It occurs also in Garthby, but has not been worked at any of these localities, except very locally. The assay of the rock from Potton, by Dr. Hunt, gives silica 29.60, magnesia 25.95, protoxide of iron 14.49, alumina 19.70, water 11.30=101.04. Potstone. Analysis.

Among the other refractory materials found in the province, though not at present utilized to any considerable extent, may be mentioned a mica rock in Shipton, lot eighteen, range five, resembling in some respects a potstone, being a compact hydrous mica, but which has not been quarried, or at least recently. A fire clay from Joliette was also exhibited at the London Exhibition of 1886, by Mr. Dupuis, who, however, did not furnish any details as to its mode of occurrence or exact locality. Refractory sandstones for furnace linings have been obtained for many years in the vicinity of Three Rivers, and were used as hearths for the St. Maurice forges. These are apparently from the flaggy beds of the Postdam formation, and have been referred to elsewhere. The same formation in Ontario has furnished similar refractory slabs, which have also been used in blast furnaces. Mica rock, Shipton. Refractory sandstone.

CLASS IX.

GRINDING AND POLISHING MATERIALS.

Grindstones. These occur in various forms and at a number of places. They embrace grindstones for cutlery and edge tools, millstones, whetstones and infusorial earth, with marls from which whiting can be obtained.

Grindstones are rarely manufactured in the province, the superiority of those from the sandstones and grits of New Brunswick and Nova Scotia, together with the low rate of water carriage, being such as to give them the preference. Certain bands of the Chazy formation on the Ottawa, however, produce grindstones that answer well for edge tools; and some of the finer varieties of the Sillery sandstones might be found suitable for this purpose.

Millstones. Millstone rock is found in the Laurentian series on the first lot of the sixth range of Grenville. It is a sort of cellular chert occurring in veins in the syenite, which extend from the lot mentioned to the third lot of the fifth range. The stone much resembles the French buhrstone in character, and is said to be equally adapted for the manufacture of millstones, though it is somewhat difficult of extraction. In certain parts of the country some of the bands of the gneiss of the Laurentian are found to answer very well. Along the contact of the Trenton formation with the Laurentian a band of quartz conglomerate seen at many places below Quebec is found to yield good millstones; and on the Chaudière a granitoid gneissic rock associated with the serpentine of that district between St. Joseph and St. Francis has been used successfully for years.

Whetstone. There are whetstone bands on Whetstone Island, Memphremagog Lake; on lot four, range nine, Stanstead; near the upper end of Massawippi lake, on the west side; on lot twenty-three, range six, Bolton; in lot seven, range two, Kingsey; and lot nine, eighteenth range of Orford; as well as at other points in the slate and serpentine belt of the eastern townships. Honestone. A quarry of honestone has more recently been opened in Ham by Mr. E. Richard of Arthabaska. Though but little attention seems to be directed to the whetstones of this district at present, there is no apparent reason why they should not be worked at a profit. The rock is, for the most part, a fine grained, micaceous and siliceous slate or schist, and some of the bands yield a stone of a very fine quality; while certain bands of mica schist associated with the Scythestones, pre-Cambrian rocks of the Sutton Mountain axis should also be well adapted to the manufacture of scythe stones, &c.

Polishing powders, deposits of infusorial earth or tripoli c, are known at but few places. On the north side of the St. Lawrence, in range seven, Gosford, near the north branch of the Ste. Anne river, on land of Mr. Lorette, a small area is reported by Mr. A. P. Low, of about one acre in extent; and samples of excellent quality have been received from some point near Quebec, but the exact location has not been disclosed. A sample has been forwarded by Mr. Obalski from the Rev. Mr. Gerin Lajoie, curé of St. Justin, Maskinonge county, Three Rivers. A polishing powder is also prepared in Westbury township, but the material from which it is derived is at present unknown. Infusorial earth.

Whiting can be prepared from shell marl, the deposits of which have already been alluded to, by simply mixing the marl with water and allowing it to settle in vats. As these deposits of marl are numerous, and the price of good whiting from six to ten dollars per ton, it should be manufactured at a profit. Most of the whiting of commerce is, however, prepared from ground chalk. The marl is manufactured into whiting in Hastings county, Ontario, by W. G. Allen & Sons of Marlbank. Whiting.

CLASS X.

MINERALS APPLICABLE TO JEWELRY AND THE FINE ARTS.

Under the heading of Materials for Ornamental Purposes, attention is directed in the Geology of Canada, 1863, to the occurrence of various minerals, sometimes occurring in large masses as the phorpyries, serpentines, and labradorites, but in others in comparatively limited quantity. These, when cut and polished, furnish stones well adapted for ornamentation on the large scale, as for table tops, mantels, etc., while of some of the rarer minerals it may be said that at times specimens of great beauty occur, which when cut and polished, constitute gems of considerable value. Attention has been called to this branch of industry by the establishment in Ottawa, within the last year, of the lapidary firm of C. P. Willimott & Co., which, in showing what material Canada can furnish for decorative purposes, is doing a very excellent work.

While precious stones, properly speaking, cannot be said to be found in the province of Quebec, some of the quartz veins which traverse the Laurentian rocks of the townships of Hull and Wakefield, and presumably of other localities which have not yet been closely examined, yield small pieces or pellets which separate easily from the surrounding quartz mass. These, when cut, furnish beautiful stones of the class Quartz veins.

Quartz Asteria. called by Dana "Quartz Asteria," and by Tiffany "Star Quartz," from the peculiarity possessed by the cut specimen of showing a star of six rays. When the cut stone is turned, these six rays have the property of merging into one somewhat resembling a cat's eye. In the same quartz vein from which these specimens are obtained are also found specimens of a bluish amazon stone, while from other portions the variety known as the hair stone is obtained, a greenish transparent quartz penetrated by hair-like filaments of actinolite.

Hair stone.

Agates. Of agates, while it may be said that these occur in the district, the specimens obtained are generally of inferior quality, not comparing with those from Lake Superior or Nova Scotia.

Jasper. Jasper occurs in veins or beds in the township of Hull, the principal workable deposit being a vein from one to two feet thick of red and yellow and red mottled shades, which when polished presents a very handsome appearance. Blocks of large size can be obtained from this locality. The porphyry of Grenville and of Chatham has been described in the earlier reports of the survey. Of these, it is remarked in the Geology of Canada, 1863, p. 832, that on the fourth lot of the sixth range of Grenville there is "a great mass of this porphyry which varies in color from leek-green to blackish-green, and is marked with red, brown and black spots. It is very compact and has a conchoidal fracture. This green porphyry is here about fifty feet in breadth, and to the northward it passes into a chocolate-brown variety, which is still more abundant. Specimens of several varieties of these porphyries have been cut, all of which receive a fine polish, and are very beautiful. They may be obtained in large blocks, and do not appear to be much harder than the granites of Aberdeen and of other regions which are now cut and polished on a large scale, while they would far surpass the latter for beauty."

Porphyry.

Garnets. Garnets are found in the Laurentian rocks in considerable quantity, but rarely of a quality suitable for cutting for gems. Chrome garnet is found in the eastern townships, but not in crystals or size sufficiently large for cutting. Crystals of garnet have also been reported from the township of Wakefield, and this locality also affords small crystals of a lemon or brownish-yellow variety, which when polished are very transparent and brilliant.

Tourmaline. Tourmaline occurs generally in long crystals imbedded in the vein matter of the rocks of Wakefield, and is generally not of a quality fitted for gems, but occasionally pieces are found sufficiently clear for this purpose.

Peristerite. Several varieties of felspar are known. A mixture of albite and quartz, called peristerite, occurs at Villeneuve, in which the felspar has a beautiful play of color. A bluish variety of the albite is said to have the same hardness as the Ceylon moonstone, and furnishes gems equal in appearance to those from Ceylon, the reflection being blue instead of white. Of the orthoclase variety, that known as adularia furnishes handsome gems equalling the Ceylon stone in beauty. **Moonstone.**

Labradorite. Labradorite, or Labrador-felspar, presents, when polished, beautiful opalescent tints of blue, green, gold and purple. Though there are great masses and areas of Labrador rock, but a small proportion of the mass is available for the cutting of ornamental stones, the beautifully tinted variety generally occurring as small imbedded portions. Towards the peninsula of Labrador, from which the rock takes its name, large masses of the precious variety are known to exist at certain points, among which may be mentioned Paul's Island in the Strait of Belleisle. This, when cut, forms, from its flashing tints, a very handsome stone, either for gems, or for interior decorative work.

Amazon stone. The Amazon stone, which was for some years supposed to be confined to Colorado, has recently been found in the townships of Hull and Wakefield. It occurs in a coarse granite vein as large imperfect crystals, the angles in most cases being rounded. The stone is, however, quite equal in tint to that originally obtained from the Pacific slope.

Scapolite. Among other minerals may be mentioned Scapolite, found in Grenville, and from which large slabs of a beautiful yellow can be obtained; Rensællerite or Pyrallolite, also from Grenville, which will yield either slabs or columns, and which, when dressed, are exceedingly handsome ornamental stones. The serpentine has already been referred to. The so-called Quebec diamonds, which are occasionally cut and polished, are merely crystals of quartz, which are often found of large size; while along the shore of Bay of Chaleurs and Gaspé Basin beautifully colored pebbles of Jasper and other stones, which have been derived from the disintegration of the Devonian conglomerates of those shores can be picked up in great numbers, and are susceptible of a high polish. **Quartz crystals.**

CLASS XI.

MISCELLANEOUS.

In addition to the minerals of economic importanee described in the preceding pages, several others already indirectly alluded to may be mentioned. Of these, the most important are those applicable to the manufacture of porcelain and of glass, and for the lining of furnaces, as well as for moulding sands, &c.

Felspar. Villeneuve mine.

The deposit of felspar from the Villeneuve mica mine, on lots thirty-one and thirty-two, range one, Villeneuve, occurs in a vein of considerable size, which has been traced for several hundred yards. This has been mined and shipped to England and the United States, and has been used in the manufacture of porcelain, for which it appears well adapted. From the report of Mr. Obalski, M.E., Quebec, in the report of the Crown Lands Department of that province, 1889, we find that this rock is a nearly pure or orthoclase felspar, the analysis of two samples being given, thus:—

Silica	64·7	63·96
Alumina	18·4	19·16
Potash and Soda	....	16·88
Iron	....	traces.
Magnesia	0·3	.....

The amount of felspar shipped from this mine for the past year was 250 tons, according to Mr. Obalski's report; but according to the Mining Review the amount produced was 411 tons.

Sandstone for glass-making.

In the Geology of Canada, 1863, p. 798-800, reference is made to the presence of sandstones suitable for glass-making, and for the linings of blast furnaces or other refractory purposes. Of the former, deposits of sandstones of the Potsdam formation are found on Isle Perrot (Vaudreuil), at Lachute, Ste. Scholastique and Beauharnois. These are very free from iron, and have been employed in the manufacture of glass in former years both at the old works near St. Johns and at Vaudreuil. The blast furnaces of St. Maurice and Batiscan obtained their linings from beds of sandstones of the same age as the above, which were found to answer admirably. In Pittsburg, Frontenac county, Ontario, a friable bed of this sandstone is easily powdered, and is shipped to Montreal and Toronto, where it is used to protect the sides and bottom of furnaces,* and which is worth in Montreal about three dollars per ton.

Sandstone for furnace lining.

Sulphuric Acid.

Sulphuric acid works, Capelton.

The only works at present in operation in Quebec are those belonging to G; H. Nichols & Co., Capelton. Though only in operation about three years, the amount of acid produced during the past year was over ten million pounds. The acid at this place is made from the pyrites of the copper mines adjacent to the works, and in connection therewith, the same firm has introduced the manufacture of superphosphate of lime from the phosphate or apatite of the Ottawa

* See Geology of Canada, 1863, p. 800.

district. This industry has rapidly increased since its inception, and promises to develop shortly into one of the most important in Canada. It is understood that a powerful English company is shortly to commence the manufacture of phosphate on a large scale by erecting works near Buckingham and at Capelton also.

The Ottawa county phosphate is also employed to some extent in the fertilizer works owned by Mr. R. J. Brodie & Co., at Smith's Falls, though the acid used is manufactured by the firm from sulphur obtained from Italy and from Japan. Brodie's works, Smith's Falls.

In connection with the deposits of peat in the St. Lawrence Valley, a new industry which has lately been developed in New Brunswick, where peat bogs are also found, viz., the preparation of moss litter for stable use, is worthy of consideration. The process is referred to by Mr. R. Chalmers in his summary report for 1889. The material owes much of its value to the great power of absorption it possesses when dry. The top of the peat bog is removed, with the living growth of bushes, &c., and the second layer or that lying upon the fuel peat, also. This latter is passed through a set of rollers by which a greater part of the contained water is extracted, the remainder being removed by evaporation, after which it is packed in bales for shipment, the market at present being principally in the United States. The price per ton of this moss litter is, according to Mr. Chalmers, from $15.00 to $17.00. As a litter for stable bedding it is of great value, absorbing all the liquid matter and ammonia, while it is much more cleanly than most of the preparations heretofore employed for this purpose. A large market should be created for this material when once its excellent properties are recognized. Peat moss litter.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR AND DEPUTY HEAD.

REPORT

ON THE

SURFACE GEOLOGY

OF

SOUTHERN NEW BRUNSWICK

TO ACCOMPANY ¼ SHEET MAPS 1 S.W., 1 S.E. and 1 N.E.

BY

ROBERT CHALMERS, F.G.S.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
WILLIAM FOSTER BROWN & CO.
1890.

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

Director of the Geological and Natural History Survey of Canada.

SIR,—I have the honour to lay before you herewith my report on the Surface Geology of Southern New Brunswick, accompanied by the three ¼-sheet maps, Nos. 1 S.W., 1 S.E. and 1 N.E., illustrative thereof. These sheets embrace the counties of Charlotte, St. John, Kings, the chief part of Queens, and smaller portions of Albert, Westmoreland and Sunbury. This report embodies the results of investigations carried on in this area during the three seasons of 1887, 1888 and 1889.

My best thanks are due to F. W. Cram, Manager of the New Brunswick Railway, and F. W. Holt, C. E., formerly Supt. of the Grand Southern (now the Shore Line) Railway, for passes over their lines during the summer of 1887. To the latter gentleman I am also indebted for a correct plan and profiles of the Shore Line Railway and for much valuable information. G. Murdoch, C.E., St. John City Observatory, and Dr. S. T. Gove, St. Andrews Meteorological Station, have kindly furnished me with lists of barometric readings taken at these places during the three seasons mentioned. To Mr. Murdoch I am under special obligations in this matter. Wm. Murdoch, C.E. of the St. John City Water Supply, has given me valuable aid in regard to the topography and elevations in the vicinity of that city. To P. S. Archibald, Chief Engineer Intercolonial Railway, Moncton, I desire to render special thanks for railway plans, sections of borings, etc.; and to T. M. Williamson, C.E., Grand Lake Coal Company, for a plan of the New Brunswick Central Railway. To W. N. Gould, Sussex, Jas. A. Sinnott, Apohaqui, and J. R. Smith, St. John, my acknowledgments are due for information respecting the brine and medicinal springs of Kings county. Chas. N. Skinner, M.P., St. John, has also done me service in pointing out localities of materials of economic importance. To the many other kind friends who have from time to time aided me I wish to return my most sincere thanks.

I have the honour to be,

Sir,

Your obedient servant,

ROBERT CHALMERS.

OTTAWA, May, 1890.

NOTE,—The bearings in this report are given with reference to the true meridian unless it is otherwise stated; and the elevations are above high tide level.

REPORT

ON THE

SURFACE GEOLOGY

OF

SOUTHERN NEW BRUNSWICK,

To Accompany ¼ Sheet Maps 1 S. W., 1 S. E. and 1 N. E.,

BY

ROBERT CHALMERS, F.G.S.A.

The part of the Province of New Brunswick to which the present report relates is that bordering the Bay of Fundy, extending from the St. Croix River or international boundary on the west, to Chiegnecto Bay on the east, and including the counties of Charlotte, St. John, Kings, the chief part of Queens, and portions of Albert, Westmoreland and Sunbury. The surface of a considerable part of this region, more especially that lying within thirty miles of the coast, is highly diversified by mountains and plateaux, and intersected by deep valleys occupied by lakes or rivers. Within this area lie the ridges of pre-Cambrian and other crystalline rocks which come up from beneath the great Carboniferous overlap. The easternmost of these pre-Cambrian belts rises into an extensive plateau, the general height of which is from 1000 to 1100 feet above sea level, with numerous culminating ridges and peaks 1200 to 1500 feet high. The westernmost ridges are less elevated and are much intersected by river valleys. The chain which these ridges taken together form, subsides or becomes gradually lower as we approach the international line, and inosculates with the hilly, undulating region stretching across the province to the north-west of the Carboniferous area referred to. Several notable peaks, such as Ben Lomond and Bloomsbury Mountain east of the St. John; Bald and Prospect Mountains and Eagle Cliffs, etc., in the vicinity of the Nerepis River; Mount Pleasant, and Porcupine and Red Rock Mountains

Area examined.

Topographical features of the hilly regions.

further west in Charlotte county, loom up conspicuously above the general level of this elevated coast region; but the greater portion of it in the vicinity of the St. John River and west of that, lies below the 800 or 900 feet contour line; while valleys, mostly transverse to the general direction, intersect it, along which the principal rivers flow at levels seldom exceeding 200 or 300 feet above the sea. The topographic and orographic features of this chain of highlands have been graphically described by Messrs. Bailey and Matthew in Report of Progress, Geol. Surv. of Can., 1870-71.

Topographical features of Carboniferous area.

To the north of the elevated belt of country referred to lies the great Carboniferous area, occupying a low basin which is apparently level, or slightly undulating, but, nevertheless, rises gently towards the north-west margin, thus forming an inclined plane sloping towards the south-east at a low angle. In the southern and central parts much of this area lies below the 200 feet contour line. A low water-shed divides the drainage flowing into the Straits of Northumberland from that tributary to the St. John. The general features are, however, tame and monotonous, and large portions of the area are barren.

General features of region.

Presenting, as the region under consideration does, therefore, a surface of such irregular and varied features and character, and underlaid by rocks of different ages and different degrees of hardness, it naturally affords varied superficial phenomena and an excellent field for the study of surface geology. The evidence of powerful and long continued erosion, especially from subærial, fluviatile and marine agencies, of ice-action, of the transportation and accumulation of material by the slow, secular and never-ceasing operations of nature which exist around us, are everywhere manifest. The residual boulder-clays, gravels, sands, etc., have, below the 200 feet contour line, been subjected to the powerful currents of the Bay of Fundy, which are exceptional in character and unknown in other parts of eastern Canada, and which have produced some remarkable, and, it may be said, unique deposits.

Character of investigations.

The investigations respecting the surface geology of this region, carried on during the past three seasons, have revealed a number of new facts in regard to the glaciation, the boulder-clays, the formation of lakes, the drainage systems, etc., which, when correlated, enable me, to some extent, to modify interpretations of facts previously discovered. In the prosecution of the work all accessible parts of the country were explored, every road was travelled over, rivers and lakes examined by boat or otherwise, a great number of the hills and mountains ascended and their heights measured with aneroid, the larger islands all visited, and as careful an examination made of the surface features of the region, its deposits, its agricultural character, forest growth, etc., as time and other circumstances would permit.

Assistants. In 1887 I carried on the work alone; in 1888 I was assisted by Mr. Arthur H. Beers, a student of McGill College, Montreal, and in 1889 by Mr. Edward W. Swinyard, of Ottawa, and for five or six weeks by Mr. W. J. Wilson, of St. John, N.B. Mr. W. is an amateur geologist and botanist and did good work while with me.

Former investigations. The surface geology of a considerable part of the region was investigated, to some extent, by Mr. G. F. Matthew a number of years ago and the results published in Report of Progress, Geol. Surv. Can. 1877-78, report EE. Prof. H. Y. Hind also made some observations here and discusses the phenomena relating to water-falls, lake-basins, terraces, etc., in *A Preliminary Report on the Geology of New Brunswick*, 1865.

Denuding Agencies Which Affected the Region.

Denudation of region. The surface of this part of the province, especially of the hilly broken tract traversed by the pre-Carboniferous bands of rocks, bears evidence, as already stated, of having been profoundly eroded during and since the Post-Tertiary period, and doubtless also in preceding geological ages. Indeed, the existing features are the result of a long series of denuding processes of various kinds, subærial, fluviatile, glacial and marine, some of which have been in operation since the dry land first appeared. The immense quantities of debris, boulders, gravels, sands, etc., which cumber the surface everywhere, and half-fill the valleys, sufficiently attest this. The degradation which the old pre-Cambrian ridges have undergone is enormous. The decay of these rocks and the gradual evolution of topographic forms resulting therefrom, such as mountains, valleys, scarps and defiles, the formation of later geological deposits from the waste materials, whether along the coast, or in river valleys or lake basins, present a "wonderful chronicle of long-continued and oft-repeated" operations. This denudation, or waste of the land, is seen not to have been uniform over the whole surface, however, but greatest on slopes and in river valleys, and least upon level grounds. Evidence of this is found in the great quantities of coarse gritty debris derived from the older crystaline rocks scattered about in certain localities, the prevalence of which is a distinct feature of the superficial deposits of this district. The causes which produced these have, on the higher grounds, *i.e.*, above the 220 feet contour line, been chiefly subærial, below that level, subærial and marine. During the great Post-Tertiary subsidence the tides of the

Bay of Fundy were doubtless very powerful, and must have swept up and down the coast and some of the interior valleys, especially that of the Petitcodiac and Kennebeckasis rivers, with great force. But much of this denudation must have been pre-glacial. The deep-seated decay of the older belts of rocks referred to, the atmospheric erosion producing rounded summit and deep ravine, and the general moulding and sculpturing of the more prominent topographic forms, undoubtedly took place previous to the advent of the Ice Age.

Elevation of the Region in the Later Tertiary Period and Oscillations of Level Since.

Later Tertiary elevation of region.

Comparing this region, as it is at present, with the condition in which it must have been during the later Tertiary period, when the river valleys were empty, the coastal parts exhibit the appearance of a partially submerged country. This was referred to incidentally in my preliminary report, Annual Report Geol. Surv. of Can., 1885. The mouths, or estuarine portions, of nearly all the rivers appear partially filled up, notably the Petitcodiac, Shepody, St. John, Musquash, etc. The valley of the St. John, which is occupied by tidal waters as far up as the Keswick River, contains a great mass of sediment carried down by the river itself, or thrown into it by tributaries, the whole being levelled off at a height nearly equal to that of spring floods. This is particularly noticeable in the part of its course lying in Queens and Sunbury counties, and especially at the mouths of Grand and Washademoak lakes. Evidently a filling up of the river valley, to a large extent, has taken place all along this part of it in post-glacial and even in recent times, as well as during the glacial period. In the lower part of this valley, and in that of the Kennebeckasis, depressions exist, according to the Admiralty Surveys, which are about 200 feet below the surface of their waters, or below high tide level in the Bay of Fundy, (opposite Indiantown 198 feet; immediately above the "falls" 122 to 204 feet; Grand Bay, deepest part 130 feet; Long Reach, deepest part 126 feet; Kennebeckasis Bay, or River, deepest part, about 200 feet). In the Tertiary period the St. John probably flowed along the bottom of this depression, as there seems reason to believe this was part of the original channel, the outlet, or mouth of the river being by way of Fairville and Manawagonish Cove. It seems also probable, that the land was in pre-glacial times at least, that much higher than at present (200 feet), as we know of no other way in which these channels could have been eroded except by the force of running water, being narrow, and occupying a deep valley between steep cliffs.* These and other depressions along the lower St. John and Kennebeckasis must have been silted up considerably during the Post-Tertiary period and since, however, so that it is quite possible the elevation of the region, in Tertiary times, was even greater than that stated above. But assuming that it was about 200 feet, the topographic features of the St. John valley and its tributaries as far up as Frederiction or Keswick River must have been widely different in the later Tertiary from those which now exist. The valley would be much deeper, how much we can hardly say, but the river would doubtless flow over a rocky or gravelly bed along the floor of the valley nearly to its mouth. The lake-like expansion along its course had then no existence, nor had Grand and Washademoak lakes or Belleisle Bay yet appeared on the scene. The rivers which now empty into the northern ends of these would then flow directly into the St. John. Along the coast there would be still greater changes. The Bay of Fundy would, at that time, be much smaller, and the coast line present a different configuration. Chiegnecto Bay and the Basin of Minas would have no existence. The upper end of the Bay of Fundy would be somewhere in the vicinity of Isle Haut. Grand Manan would still be an island, but the area occupied by Passamaquoddy Bay would be above high tide level, and a nearly level plain, with two or three river courses through it, while Deer and Campobello islands would form part of the mainland. The configuration and topographic features of the interior country would also be markedly different. The river valleys which are now partially filled with detritus, would then be largely denuded of it, especially in the lower reaches, and be much deeper than at present, and on the hill tops and plains a thick mass of decayed rock material would lie undisturbed, mantling and concealing the rocks. This condition of things would accordingly tend to make the elevations higher and the valleys deeper than they are now relatively to each other, and on the whole the contours of the surface would be considerably different from those which obtain at present. Glaciation and other modes of denudation have brought about a levelling down of the inequalities of surface, reducing the heights of the hills and filling up the valleys, more especially in regions partially submerged or sunken since, such as those along our coasts.

General configuration of Bay of Fundy region in later Tertiary period.

* Mr. Wm. Murdoch, C. E., St. John, has suggested to me that the inflow of the tidal waters through the narrow gorge forming the mouth of the St. John, which is sufficiently rapid at spring tides to be designated a "fall up river," may have been instrumental in wearing out and deepening the channel referred to. I agree with him, but, nevertheless, regard this channel, or river passage, above Indiantown as having existed previous to the Ice Age, and, of course, before the gorge at the "falls," now forming the mouth of the river, became eroded.

Change of level in the Post-Tertiary period.

The Post-Tertiary oscillations of level, or those which have occurred since the later Tertiary elevation referred to, as evidenced in the marine fossil remains, terraces, and ancient sea beaches along our coasts, etc., have been discussed by the writer in previous reports. There was first a subsidence, which seems to have commenced in the glacial period, continuing till its close or later, the land in this region sinking about 220 feet below its present level relative to the present high tides of the Bay of Fundy.* When this subsidence had reached its maximum the coast districts were partially submerged and the isthmus of Chiegnecto almost wholly. Powerful currents must then have swept up and down the bay, distributing the debris and re-arranging it into kames, Leda clays, etc. One arm of the bay would form a strait along the Petitcodiac and Kennebeckasis valleys, making the longitudinal tract lying to the south-east an island. Large portions of Charlotte county would be submerged. The extensive gravel terraces east of the Magaguadavic River and in Pennfield would then be laid down, also those in the Kennebeckasis valley and in different parts of St. John county. A number of these mark the upper limit of the submergence, and will be referred to further on. Whether the sea occupied the St. John valley in Queens, Sunbury and York counties, or the fresh waters were ponded back by obstructions at the mouth of the river, or along its lower reaches, as they now are, is a question which will be discussed in the sequel. No marine fossils have been detected above the mouth of the Kennebeckasis. This was a period of great denudation in the submerged districts, and has left distinct traces of itself in the great banks, or ridges and terraces, of coarse gravel, etc., to which Mr. Matthew gave the name of Syrtensian deposits.

Following this subsidence was a slow upward movement of the land during which fossiliferous Leda clays and Saxicava sands were deposited. Extensive terracing took place during this period, and much denudation from rivers and marine currents. The emergence of the coast district continued till the land was, perhaps, about 80 feet above the existing high tide level, as evidenced by a peat or forest bed beneath the Tantramar marsh at the head of the Bay of Fundy,† and by the drowned peat beds along the coast elsewhere.‡ Since then, of course, the peat

* Prof. G. H. Stone, of the U. S. Geological Survey, has found evidence in Maine of a similar subsidence in the Post-Tertiary period to the depth of 200 to 230 feet below the present sea level, his observations and mine fully agreeing on this point. See American Journal of Science and Arts, vol. XI, No. 236, Aug., 1890, for an article by Prof. Stone on the *Classification of the Glacial Sediments of Maine*, in which this fact is stated.

† See Summary Report of the Director of the Geol. and Nat. Hist. Survey of Canada for the year 1889, page 29.

‡ Mr. F. W. Holt, C. E., informs me that in making a survey of St. John harbour he found a rocky floor or platform 78 to 80 feet below high tide level, which he thought might have been a shore or land surface at the time of the elevation of the region referred to.

beds have grown and a second slow subsidence set in and has been in progress until recently. The coast district would appear now, however, to be stationary or nearly so, in evidence of which the levels of the salt marshes, dunes, etc., around the coasts may be adduced. The deep shore lines or benches worn into the solid rocks also testify to the same fact, as these must have been exposed to the erosive action of the sea at this level for a long time. This question will, however, be referred to later on. Change of level in the Recent period.

Rivers and Lakes.

All the larger river valleys and lake basins, leaving out of consideration the superficial materials occupying them, appear to be of pre-glacial origin. The highland range near the coast, already described, formed a water-shed, the drainage waters escaping to the Bay of Fundy on the one hand and to the St. John and Kennebeckasis valleys on the other. And while most of the river courses are transverse to the general direction of these ridges and have, especially in the western part, cut deep valleys or passes across them, a few extend longitudinally thereto. In the eastern part of St. John and southern part of Kings counties, we have examples of river courses approximately parallel to those of the ridges. The Nerepis, the Long Reach and Belleisle Bay and creek, Kennebeckasis Bay and river, Loch Lomond and the upper part of Hammond River, etc., are all of this class. These are probably the oldest of the drainage systems, as they appear to have cut deeper valleys than the rivers running transversely, and are now partly drift-filled. Origin of river valleys and lake basins.

The courses of many of the rivers have been altered during the glacial period by the deposition of boulder-clay in their valleys, and, in the case of the St. John partly by the half-submerged condition of the district along its lower reaches, as already referred to, causing an accumulation of marine beds around its mouth. But this river seems to have had many a struggle even before the Post-Tertiary period to keep the lower part of its course open. The upheavals of the crystaline coast ridges, whenever they took place, must have, at times, proved barriers to its free outlet long before the advent of the Ice Age. This is shown by its course from Belleisle Bay downwards, first along the Long Reach, which is part of the Belleisle valley, and secondly along the ancient valley of the Nerepis from their confluence down to Grand Bay. Indeed, from the point where it enters the area of the pre-Carboniferous rocks, the St. John seems to have no old channel of its own, but to be a trespasser on those of smaller rivers, now tributary Alterations in river valleys in Glacial period, etc.

to it. The wonder is that, instead of forcing its passage through these crystalline ridges in the zigzag course it has followed, it did not take a much easier one to the north-east from Grand or Washadamoak lake to the head of the Bay of Fundy or to the Straits of Northumberland. What determined the course of the St. John through the district referred to by such a difficult and zigzag route? The only answer that can be given to this question at present is that it would seem the relative levels of the Carboniferous and pre-Carboniferous areas were somewhat different in that early age from those which now obtain.

Outlet of the St. John.

In regard to the outlet of the St. John in pre-glacial or later Tertiary times, it would appear, so far as observations have been made, that it followed the present course as far down as Indiantown and Fairville, as already stated, thence making a detour to the south by an old valley, now drift-filled, to Manawagonish Cove or Taylor's Island. Evidence of a former outlet is also seen at Drury's Cove, in Kennebeckasis Bay, thence by the Marsh and Courtenay Bay, but this must have been in post-glacial times and when the land was rising during the Leda clay and Saxicawa sand period. At the latter stage of its history the St. John had probably several outlets—one at Drury's Cove, another at the "falls," where the present outlet is, a third at Fairville, the latter, however, soon becoming closed, and a fourth by way of South Bay and Mill Cove, *i.e.*, the cove east of Pisarinco. The barriers of boulder-clay and marine deposits which existed around its mouth at this period, held in a great fresh-water lake extending along the valley of the St. John as far up as Keswick River and beyond it, of which Grand and Washadamoak lakes, Belleisle Bay, etc., are remnants. In Queens and Sunbury counties this lake attained wide dimensions, covering all the country occupied with intervales and islands. Finally, the outlet at the "falls," which was being cut through solid rock, obtained the ascendancy, and became the only one, erosion proceeding since at a somewhat slow rate owing to the fact that it is only at ebb tides that there is really a fall of water sufficient to cause any.

Ancient course of Magaguadavic.

The Magaguadavic may be cited as another instance of a river in this district which had a different pre-glacial outlet. There is evidence to show that it flowed, from a point above the upper falls, through the basin of Lake Utopia and by way of L'Etang inlet. The upper and lower falls are due to its subsequent diversion from that course. Lake Utopia, 53 feet high, is held in by a kame blocking up the ancient river valley between it and L'Etang. At Flume Falls there has likewise been a blocking up of the old channel and the formation of a new one in solid rock.

Hammond River is another which has also had its course changed very considerably, only the upper part really following the original valley. In pre-glacial times it seems to have flowed along the valley in which Loch Lomond lies, and thence, perhaps, down Little River valley. The Mispec is, therefore, a new and probably a post-glacial river. Changes in courses of rivers.

The Kennebeckasis, in its upper reaches, and the Petitcodiac are post-glacial rivers. They now flow in opposite directions along valleys where, if rivers existed in pre-glacial times, their courses were obliterated during the post-Tertiary submergence, the entire valley between Moncton and St. John being then a strait. If the Kennebeckasis had a pre-glacial existence, North River, which now forms one of the upper branches of the Petitcodiac, probably flowed into and formed part of it.

The rivers flowing into Belleisle Bay, Washadamoak and Grand lakes, are now only the upper parts of what they were in pre-glacial ages. When the land stood higher then, they all emptied directly into the St. John.

The larger rivers of the region, such as the St. John, Magaguadavic, Digdeguash, St. Croix, etc., are of great age, judging from the fact that they have wide and deep valleys cut transversely through the ridges of crystalline rocks already described. The Magaguadavic, New and Lepreau must have carried their sources backward through these rocks for long distances in pre-glacial times, and have had lake basins along their courses. It is not improbable that portions of the drainage areas at or near their sources had the surplus waters carried in other directions in these early ages, perhaps towards the St. John River, as the Oromocto lakes are now doing. A slight differential change of level, or a dam across the head of Oromocto River would now readily cause Oromocto lake to flow into the Magaguadavic River instead of towards the St. John. (See Report of Progress, Geol. Surv. Can., 1882-84, page 18 G.G.) Age of the rivers in the region.

A rather singular feature of the rivers here is that many of them have falls at or near their mouths which are, in most cases, stopped by the high tides. This peculiarity of the St. John has been already noted (Annual Report, Geol. Surv. Can., 1885, page 15, G.G.); but the St. Croix, Bocabec, Digdeguash, Magaguadavic, New, Lepreau, Mispec, etc., exhibit similar phenomena, and at ebb tides pour out their waters over ledges of greater or less height into tidal estuaries. The St. John "falls" are not, therefore, singular, having analogous falls, although on a smaller scale, in nearly all the rivers on the north side of the Bay of Fundy. Water-falls in rivers.

A good deal of evidence has been obtained showing that some of the

Draining out of lakes.

rivers, at least, have drained out lakes along their courses even in post-glacial times. The Magaguadavic has drained out one lake above Flume Falls, that is, at Brockaway settlement, and another just above the lower fall near St. George, of which Lake Utopia is a remnant. The Digdeguash has drained out a lake which occupied its valley at Dyer's crossing. The Mispec is now draining out Loch Lomond, which formerly spread over a considerably larger area to the south and east, and was 50 to 70 feet higher than at present, as evidenced by terraces and deltas in several places. The Kennebeckasis has drained out a lake at Sussex Vale, and the St. John has partially drained out its lower reaches, and if the land were to take an upward movement would have the task of still further lowering its waters from Fredericton to its mouth, and also those of Grand and Washadamoak lakes, Belleisle Bay, etc.

Lakes.

In the study of the lakes of this region they may, in their physiographic aspects, be regarded simply as river-expansions, or as reservoirs at or near the sources of rivers, and therefore parts of the rivers draining them. They are all small and their basins seem to be wholly due to the surface denudation which has taken place in the Post-Tertiary and preceding ages.

Classes of lakes.

All the lakes here may be divided into two classes, viz., (1) those occupying rock basins, and, (2) those held in partly by rocky rims and partly by drift (boulder-clay, stratified beds, etc.) The latter are known as drift-dammed lakes.

Rock-rimmed lakes.

Lakes of the first class occur on the pre-Cambrian belt and are quite small. Lily Lake near St. John is a type. Others lying to the north-east are of similar origin. Reference was made to them in the Annual Report, Geol. Surv. Can., 1885, page 17, G.G., and their mode of origin discussed. They simply occupy basins or hollows in which rock decay had penetrated more deeply than in other surrounding and harder rocks, and from which the decayed material was scooped out by glaciers during the Ice Age. Striæ are usually found on their borders, testifying to this fact. In some instances small lakes on the pre-Cambrian plateau in the eastern part of Kings county were seen to have their deeper portion rock-rimmed, but were raised to a higher level by drift material damming them also.

Drift-dammed lakes.

The principal lakes of the district, however, belong to the second class. These are almost always met with in old pre-glacial valleys of denudation, which have become partially blocked up with boulder-clay, capped, in some places, with stratified deposits. A brief description of this class of lakes is given by the writer in the Report of Progress, Geol. Surv. Can., 1882-84, part G.G., which is, generally speaking, applicable to all those which have come under observation in southern New Brunswick. Chamcook, Utopia, Ludgate and Spruce lakes and Loch Lomond are thus held in, but Grand and Washadamoak lakes, which are really parts of the St. John waters, are separated from these only by recent alluvial deposits. Originally, no doubt, they were bays or arms of that river, but flats or intervals were formed across their mouths chiefly by sediments carried down by the St. John, thus enclosing them. A similar flat is now being thrown across the mouth of Belleisle Bay, and a rise of the land of a few feet, or rather a falling of the St. John River would also separate that bay into a lake.

Lakes below 220 foot level.

In regard to the drift-dammed lakes lying below the 220 feet contour line, some of them would seem to be wholly held in by banks of stratified materials laid down by the currents of the Bay of Fundy, and are really, therefore, of marine origin. It is not always possible to tell, however, whether the embankments or dams holding them in have till in the bottom or not. Some of these lakes are becoming shallower and more circumscribed in area from infilling by detritus and by the formation of deltas, as well as by the wearing down of their outlets.

Around the margin of Spruce and Ludgate lakes rows or trains of boulders and debris were observed which have evidently been pushed up by lake ice. Banks of gravel around other lakes were also noted which have, doubtless, been similarly formed. On the north-west side of Grand Lake beaches of sand and gravel, thrown into ridges by the waves and currents, are in process of formation, and lagoons and coves are thus almost closed off from the lake.

The great number of small lakes which dot the surface of the region about the head-waters of Musquash, Lepreau and New rivers is a somewhat remarkable feature. The region here would seem to be a comparatively undrained one. The small volume of the rivers, their consequent feeble erosive power, and the hardness of the rocks, are such that the rivers have been unable, since the glacial period, to cut channels sufficiently deep to drain off these lakes. These rivers and lakes are therefore in much the same condition as in their early post-glacial history, and will necessarily remain so for a long time owing to the slow wearing processes going on.

Nearly all the lakes of this class are slowly being reduced in volume owing to infilling with detritus and the wearing away of the barriers holding them in. Eventually they also will all be drained out.

Lakes on water-sheds.

A few lakes on the water-sheds, having very little drainage into or out of them, are exceptions to this rule, or at least apparently so, the process of wearing down their outlets being a very slow one. The level of these is, in fact, nearly stationary at present, the rain-fall on the one hand, and the drainage and evaporation on the other, about balancing each other.

Physical Features of the Bay of Fundy.

Features of Bay of Fundy.

In a description of the surface geology of this region the physical features of such a singular body of water as the Bay of Fundy cannot be passed over without a few remarks. Its wonderful tides and currents, so often referred to by travellers and scientific men, are among the dynamic forces which, during the Post-Tertiary submergence of the country below the 220 feet contour line, have given the coast district its present features and character. The bold cliffs, headlands and rock-bound shores evidence intense erosion from these even at the present day. A study of these sterile iron-bound coast features, and of the causes which have produced them would elucidate many points in the Post-Tertiary history of the region.

Tides.

The tides of the Bay of Fundy, owing to its funnel shape, rise higher and higher as it narrows from west to east. Off Brier Island, Nova Scotia, and between that and the Old Proprietor ledge, near Grand Manan Island, New Brunswick, they rise from 16 to 22 feet; at Point Lepreau, from 21 to 25 feet; at St. John harbour, 22 to 28 feet; off Quaco, 21 to 31 feet; off Cape Enragé, 32 to 41 feet, and in the mouth of Petitcodiac River, 36 to 46 feet. In Cumberland Basin ordinary tides rise 35 to 46 feet, and spring tides 50 feet. In Cobequid Bay, N.S., they reach their extreme height,—off Noel River rising from 31 to 53 feet.

Tidal erosion.

The tidal oscillations on either side of the isthmus of Chiegnecto are peculiar and noteworthy. At times the sea in Cumberland Basin is fully 18½ feet higher than it is at Baie Verte, in the Straits of Northumberland, while at ebb tide the water in Baie Verte is 19½ feet higher than in Cumberland Basin. It appears, however, that the beds of Cumberland Basin and the Straits of Northumberland are nearly on the same level.* The tidal flux and reflux in the Bay of Fundy keep the waters continually in motion and turbid, and the scour on the bottom must be enormous. Notwithstanding this erosion, however, the bay is comparatively shallow and uniform in depth, the bottom, which must have a great thickness of detritus spread over it, forming a plain with a gradual descent towards the mouth. The chief denudation which the waters of the bay now exert is on the coast border and littoral zone. This is attested by the bold precipices, rocky promontories, and islands,

* See Bulletin Nat. Hist. Soc. of N. B., Vol. V, Art. III, Physical Features and Geology of Chiegnecto Isthmus. By Alex. Munro, C. E.

and the extensive reefs in numerous places along the shores. Mr. G. F. Matthew, in the report already cited (Report of Progress, Geol. Surv. Can., 1877-78, part E.E.), describes certain features of the bottom of the bay which show how the materials worn off the coast-border and those carried into it by the rivers are distributed by the tidal currents.

During the great Post-Tertiary subsidence, when the land in this region stood 220 feet below its present level, the tidal currents would pass over the isthmus of Chiegnecto, as has been already stated, and their erosive power must then have been very great. The bay itself, in some places, and the parallel valleys then submerged, such as the Petitcodiac and Kennebeckasis in New Brunswick and those of Annapolis and St. Mary's Bay in Nova Scotia, were partially eroded at least, and deepened during this period. Tida currents.

The formation of salt marshes in many places around the Bay of Fundy, and more especially the extensive ones at its head, is due to the tides. It would seem to be the incoming tides that stir up the material of the muddy flats and carry it to a higher level. Before the ebb tides begin to run out, a greater or less quantity is deposited. These salt marshes are thus raised to the level of the highest tides. The sediments composing them have been derived, to a large extent, from the destruction of the Carboniferous rocks which occur at the eastern end of the bay and in the Chiegnecto isthmus, while those of St. John, Musquash, etc., are from local detritus. For full details regarding the character and formation of salt marshes see Dawson's *Acadian Geology*, second edition. Formation of salt marshes.

Classification of the Surface Deposits Found in this Region.

The following is a tabular view of the deposits recognized in the region under discussion : Classification of deposits.

M 3.

RECENT DEPOSITS.

Fresh-water. (a)	*Marine.* (b)
1. Decayed vegetable matter, or vegetable mould.	1. Estuarine flats.
2. Peat bogs.	2. Salt marshes (alluvium).
3. Lacustrine deposits, shell-marl, infusorial earth, etc.	3. Dunes.
4. River flats (intervales), alluvium.	

M 2.

STRATIFIED SANDS, GRAVELS AND CLAYS.

(a)	(b)
1. River and lake terraces, and kames of river valleys and lake basins. 2. Stratified inland gravel, sand and clay, and kames of the higher levels.	Saxicava sand and Leda clay, and kames of the lower levels (marine).

M 1.

GLACIAL DEPOSITS.

Boulder-clay or till, moraines, boulders, erratics, etc.

PRE-GLACIAL.

Rock debris *in situ* (boulders, gravel, sand, etc.)

Remarks on the classification.

In regard to the above classification it seems necessary to state that it is, to a certain extent, artificial, as it is often impossible to draw any line of demarkation between the sub-divisions of some of the groups, as, for example, between the deposits included under M 2 (a), etc. As stated in *Geology of Canada*, 1863, page 887, these and other members of the higher groups may be, in many cases, equivalents, or, so far as known, without regular chronological sequence. There is usually, however, a distinct line, showing a clear physical break, between the till or boulder clay and the overlying deposits, *i.e.*, between divisions M 1 and M 2; but in those above that line, except in the beds which are strictly marine and contain fossils, the order of superposition and lines of separation cannot be well defined. In division M 2 the marine deposits (Leda clay and Saxicava sand) are traceable with tolerable exactness and easily distinguished both from those of divisions M 1 underneath and M 3 overlying them, although often overlapped on the higher border and along river valleys by fresh-water gravels, sands, etc. It is in the fresh-water deposits, so-called, that the confusion in the classification exists. They often merge into each other; and, indeed, the fluviatile and lacustrine beds especially, may be considered as constituting an almost continuous and unbroken series, through erosion and transportation, from the summit of the boulder-clay upwards to the most recent deposits. The remarkable development of the fresh-water gravels and sands in the geological interval between the glacial and recent periods in this district warrants us in classifying them, provisionally, as we have done, *i.e.*, as approximately contemporaneous in origin with the Leda clay and Saxicava sand series, their formation in the recent period (division M 3) being inconsiderable. Hence the division of these fresh-water deposits into M 2 (a) and M 3 (a), which, in the absence of fossils, is necessarily provisional and arbitrary.

For further remarks on the classification adopted see my preliminary report, page 7 G.G. (Annual Report, Geol. Surv. Can., 1885).

PRE-GLACIAL ROCK DEBRIS, GRAVELS, ETC.

Pre-glacial materials.

Pre-glacial beds, consisting of boulders and gravels *in situ*, or loose residuary materials in the form of rotted rock, although met with in different parts of Eastern Canada, have not received that careful study which their importance demands. Their relation to the rocks underneath, but more especially to the boulder-clay or till which is frequently found overlying them, and in a large measure derived from them, is a subject of much interest, the investigation of which would elucidate some points in connexion with the origin of the glacial deposits. In the region under consideration the occurrence of these residuary gravels, etc., in a great number of isolated belts and patches of variable thickness and extent in all parts of it, shows that they must have formed, in pre-glacial ages, an almost universal covering of the solid rocks. Upon the pre-Cambrian belts they consist of coarse, angular materials holding pebbles and boulders of all sizes of the same kind of rock as that underlying them. On the Cambro-Silurian and Silurian the debris is somewhat finer, for the most part, and where the rocks are slaty or fissile it often occurs in thin laminæ or scaley fragments of all sizes lying in the same position as the original strata. Overlying the Carboniferous sandstone it is more gravelly, sometimes sandy, but always contains larger fragments of the harder, undecomposed portions of these, of angular shape, "kernels" of the original rock, lying undisturbed in the more or less decomposed deposits. All the materials, indeed, large and small, whatever kind of rock-formation they may be derived from, are angular, nowhere appearing as if they had been subjected to erosion of one particle against another, or to any action other than atmospheric.

Mode of occurrence of.

The mode of occurrence of these deposits in fragmentary masses indicates that they must have suffered great denudation, and that large portions of them have been entirely swept away. In pre-glacial times denudation would take place, to some extent, from subaerial and fluviatile agencies; following this would be glacial denudation, and, perhaps, along and near the coast of Northumberland Straits and the head of the Bay of Fundy, iceberg action. Then when the Post-Tertiary subsidence set in great denudation would occur in the submerged tracts from the sweeping tides of the Bay of Fundy; while in those parts of the country above the 220 feet contour line, the waters resulting from the melting of the ice of the glacial period, acting on these decayed rock materials wherever exposed, would erode and reduce their bulk very materially. The wonder is, therefore, that we find as many remnants of them as we do. The erosion from glacier-ice has, however, been more local than general, and seems to have been much more sweeping and effective upon southern than upon northern slopes. For example, it is in the drainage basin of the Petitcodiac River and more especially at or near the sources of its tributaries that the heaviest beds of rotted rock *in situ* occur. On the northern and north-western flanks and summits of the pre-Cambrian plateau, about the head waters of Turtle Creek and Coverdale River, also on the north slope of Caledonia Mountain, decayed rock *in situ* is met with in great quantities. These facts are taken in proof that no general ice-covering ever swept over eastern New Brunswick from the north or north-west impinging against these mountains. Details regarding this will be adduced in the sequel.

The pre-glacial decayed rock materials are the chief source of the boulder-clays, gravels, and all other stratified deposits.

Colour.

In regard to the colour of these subærial beds, a question which has recently been discussed by geologists in other countries, it is found to be the same, generally speaking, as the weathered rock surfaces or boulders of the rocks from which they were derived. At Mascareen, Charlotte county, however, where a band of Silurian rocks occurs these residual deposits were seen to have a bright ferruginous appearance. But as we have only the remnants of what must once have been a general sheet in southern New Brunswick, no comparison of value can be drawn between their character and colour here, and those of similar materials in non-glaciated regions.

Localities where observed.

Decayed rock debris was observed in the following places :—

On Grand Manan Island gravels of this kind occur in several places on the south-east slope, where considerable tracts show no traces of ice action.

On Hanson road, north of St. Stephen, along the south-east side of a low hill, a bed of rotted rock was seen. Pits have been excavated in the hill side, whence great quantities of gravel have been taken for repairing the roads and streets. It was also observed on the southern and eastern slopes of a number of ridgest o the north and north-east of St. Stephen, notably Old Ridge, Scotch Ridge, etc. At the latter place it is 3 to 4 feet deep.

It occurs also at Mascareen, as referred to above, and along the coats between Beaver and Deadman's harbours.

In numerous places in the eastern part of St. John county, on the Bay of Fundy slope, decomposed rock *in situ*, unmixed with transported material, was observed. The rock bosses protruding through it were unglaciated.

On the slopes of hills near Moosehorn Brook, Kings county, along the road on the north side of Musquash Brook, near Apohaqui, also along the valley of Ward's Creek, and on the low ridge at Ratter's Corner, decayed rock *in situ* and unglaciated surfaces are common.

In Filamaro settlement, on the road from Shepody road to Alma, and in New Ireland in many places similar phenomena occur.

Along the north-west flank and brow of the pre-Cambrian plateau in the vicinity of Goshen, Elgin Corner, Hillside, Pollett River, etc., and eastward to the border of sheet 1 N. E. at Caledonia Mountain, including Golden Mountain, Mapleton, head of Little River (Coverdale), Prosser Brook, Berryton, Irving settlement, etc., thick beds of rock debris *in situ* were found everywhere. The rock exposures have broken, jagged faces. Boulders from the pre-Cambrian have been scattered northwardly over the slopes.

On the opposite or northern side of the Petitcodiac valley, in the vicinity of Dunsinane, Cornhill, Fawcett's and Bennett's Brooks, North River, Butternut Ridge, Lewis and Steeves Mountains, etc., the slopes are in numerous places clad with deep beds of decayed rock *in situ*. At Springhill, on the sloping bank of a brook a fine example of rotted rock with 6 to 12 inches of the upper part stratified, probably by atmospheric action, was seen. No till was noticed, but well rounded granite bou ders occur in places. Wherever the subærial debris is met with in this section it affords evidence that glacier-ice has been too light and ineffective to scrape the rocks bare. These soft Carboniferous rocks must have been buried under an enormous mass of their own debris, however, previous to the ice age.

In the valley of Belleisle Bay and Creek, materials of this character were also found. At Kars, along the road from The Point to Henderson settlement, on Spragg's Brook road, on the summit of Bull Moose Hill, and to the east of Carsonville, they were met with in greater or less abundance.

In the valleys of Washadamoak Lake and Canaan River similar beds occur, more especially along the northern side of the divide between the lake mentioned and Belleisle Bay, and also at Belyea's Cove, Albright's Brook, at Irish settlement, Thorntown, North Forks of Canaan River, etc.

Around Grand Lake they were also detected in numerous places, but usually in thin beds, apparently having been much denuded. They were, however, observed on both of the so-called Ranges on the east side of the lake, also at Salmon Bay on the west side, etc.

On the west side of Maquapit Lake, decayed rock *in situ* was found with transported boulders on the surface.

Along the St. John Valley these materials occur on both slopes in a great many localities. On the west side non-glaciated surfaces with rotted rock were observed between The Mistake and Hampstead and beyond it; and similar phenomena were noted on the east side below the mouth of Jones' Brook. Indeed, the non-glaciated character of much of the slopes in the St. John valley between the mouth of the Wasadamoak and its confluence with the Nerepis is a remarkable and noteworthy feature.

The peninsula between Tennant's Cove and Jones' Brook is covered in places with rotted rock; it was also observed near Golding's Corner and south of Bald Hill, etc.

These decayed rock materials, it will thus be seen, cover a considerable portion of the surface of this region, more especially east of the St. John River, although occurring as they do in detached and irregularly denuded beds.

M 1. Glacial Deposits.

Boulder-Clay or Till.

Boulder-clay. Boulder-clay or till occurs almost everywhere in the region in deposits of greater or less thickness and extent. Generally speaking, it is more abundant in the south-western part, that is, in Charlotte and St. John counties, than in the north-eastern; although heavy beds were observed in Albert county, on the coast of the Bay of Fundy. Its occurrence in irregular, sporadic, lenticular sheets, which seldom exceed five to ten feet in thickness, leads me to infer that there was no universal, connected deposit of it from the ice of the glacial period here, and that such beds as were laid down have since been greatly denuded. The thickest deposits met with were in western Charlotte; at St. John harbour, where it is 50 to 60 feet deep, and at Alma, on the coast of Albert county. In the flat interior country it is invariably thin.

Different kinds. A close study of the boulder-clays in this region during the past three years has led me to the conclusion that they have been produced in two or three different ways, and that it may be necessary to modify our views slightly regarding their origin. So far as my observations extend they seem to have been formed as follows:—(1) By land ice, (2) by icebergs, these two producing similar deposits; and, (3) by the kneading and compacting of ordinary decayed rock material *in situ* by ice passing over it, or by the weight of snow pressing down upon it in glacial times and since, while saturated with water; and in some instances, where the beds are thin, by a mechanical assorting of the clays, gravels, etc., in the manner that hardpan is formed. The first two usually contain transported and glaciated materials, the last does not, although these are often found upon its surface. A fourth kind of deposit which resembles boulder-clay, but occurs in limited quantities, is that of landslips. It is met with along the base of cliffs and of mountains, and is without glaciated boulders Striæ may sometimes have been produced by landslips.

The definition of boulder-clay usually given, viz., that it is an unstratified mass of clay, gravel and sand, containing scratched and transported boulders, deposited by land-ice or icebergs, will require a slight extension to include those above described. The differentiation of the boulder-clays given here is, however, merely tentative, the subject being still under investigation. Those classed under divisions (2) and (3) are only sparingly met with in the region. Boulder-clay which has been produced, to all appearance, by land ice, is the predominating kind. Its materials are largely of local origin, but are intermingled with boulders and debris, which have been transported limited distances. In western Charlotte, north of St. Stephen, and between the St. Croix and Magaguadavic rivers it occurs in the form of "drumlius," or rather has been thrown down on the northern slopes and summits of a number of hills or short ridges, which evidently have rock *in situ* underneath, as glaciated bosses protrude through it here and there. The till upon these is hard, tough and compact, and consists largely of materials derived from the Devonian and Cambro-Silurian rocks of the district. Evidently the ice of the glacial period which moved over these ridges kneaded and packed it. The south sides of these hills are often plentifully strewn with boulders, and in some places rotted rock *in situ* was seen. Drumlius occur also on the east side of Lake Utopia. Definition of. Drumlius, where observed.

The prominence of these hills is, however, in some cases, due to post-glacial denudation and deepening of intervening valleys since by streams and by the sea.

How did it happen that the till was deposited as we now find it on these ridges? This is an unsolved problem; but in the locality in question its occurrence is owing partly to the topography and partly, perhaps, to peculiarities in the movements of the ice. The region forms an inclined plane with rolling hills. Down this plane the ice must have descended with great momentum, impinging heavily against these hills. Impeded, and, perhaps, partially broken up, it appears then to have dropped a part of its burden of till, moraine stuff, etc. The inequali- Probable origin of.

ties of surface upon these low hills served, in some measure, to protect the till from denudation by the ice coming afterwards, while it kneaded and packed it in passing over.

Boulder-clay near mouth of St. John.

A remarkable deposit of boulder-clay has been thrown down south of the hills lying just west of the mouth of the St. John River, and now forms the bank of the bay-shore from Carleton to Sand Cove. At Negrotown Point it is 40 to 50 feet high above the beach. For the most part it is a pell-mell mass of boulders, clay, gravel and sand, but, nevertheless, in one or two places, shows stratification or bedding. Just west of the breakwater two irregular, wavy, lenticular seams of clay occur in it. At the Fern Ledges, however, a bed of stratified clay 9 feet thick is found in the till 10 feet above the foot of the bank. It is also lenticular in form, although the western end is obscured by falling debris, and consists of a tough, reddish-brown brick clay, containing a few small angular pebbles, but no boulders. The strata are distinct and regular, although not finely laminated, and dip slightly to the north or away from the shore. No fossils could he found in it. On top of this stratified mass lie 40 feet or more of coarse, gravelly boulder-clay. The thickness of the stratified bed may be greater than stated, its base being concealed by a *talus* of boulders and by the beach sands. The photograph exhibits the position of the stratified portion.

Stratified clay in.

How occurring.

In regard to the mode of occurrence of these stratified beds in the till it is evident the materials composing them were laid down at or near the then existing coast, and subjected to the action of currents from the land ; or else they were deposited in the sea along the margin of the ice mass. Under any other view it will be difficult to account for their stratification. Their presence in the heart of the boulder-clay beds here tends, moreover, to show that the whole mass cannot have been thrown down at once, but was formed by successive deposits or increments. That the stratified deposits are really part of the till there is no doubt, the overlying unstratified mass, absence of fossils, irregularity of stratification, etc., all point to this conclusion.

Boulder-clay at Alma.

The other noteworthy deposit of till referred to was observed at Alma, Albert county. Cuttings made there in the construction of the Albert Southern railway afford interesting and instructive examples of the till and overlying deposits. In a terrace on the east side of the mouth of Upper Salmon River, one of these cuttings exhibits the following series in descending order:—

	FEET.
1. Gravel. coarse and pebbly, but becoming rather finer below. Mostly oxidized, especially upper half................	6 to 8
2. Sand with irregular strata of gravel, somewhat similar to above, the whole unoxidized........................	2 to 4

FROM A PHOTOGRAPH PRESENTED BY HERBERT CHIPMAN TILLEY, DEC., 1890.

BOULDER-CLAY BANK, 60 FT. HIGH, AT FERN LEDGES, LANCASTER, ST. JOHN COUNTY.

SHOWING INTERCALATED BED OF STRATIFIED CLAY.

3. Gravel, not so coarse as uppermost bed, unoxidized, and interstratified with layers of sand........................ 4 to 5
4. Fine grey beach sand, not oxidized........................ 3 to 4
5. Till, compact and hard, with scratched pebbles and glaciated boulders, but none large; all apparently belonging to rocks of the vicinity, and more or less rounded; the whole mass bluish-grey and unoxidized. Thickness unknown, bottom not reached.

The terrace is 40 to 50 feet above high tide level.

A few hundred yards further up stream in the same terrace, another cutting shows the stratified beds to be wholly denuded, leaving the till exposed. Here in an exposure from 10 to 12 feet deep, we find a good example of what has been called the upper till resting on the lower. It is, however, really a part of the same deposit oxidized. But there is this peculiarity about it that the upper, or oxidized part, contains less clayey matter than the lower unoxidized mass. The latter is bluish-grey, the upper yellow or brown. While portions of the upper part are friable and loose, the bulk of it is, nevertheless, a tough, compact, clayey material, and contains well scratched boulders similar to those in the lower. The line of demarkation between the two *i.e.*, between the oxidized and unoxidized portions, is an irregular one, not strictly horizontal, although perfectly well defined. All things considered there seems no doubt that the whole is one deposit.

All the till of this part of the coast area, and it occurs in heavy beds between Alma and Albert, is made up of rotted rock which has been transported limited distances by ice of the glacial period and partly worked over and kneaded. There is some evidence here of iceberg action on the lower grounds, more especially in the vicinity of Germantown Lake, and some of the beds of till there may have been produced by the grinding of these on the decayed rock material in their passage along the valley in which this lake lies.

Boulder-clay in the interior.

Back from the coast of the region, till is found in numerous places, besides upon the hills lying between the St. Croix and Magaguadavic rivers, already noted. Pleasant and Flume ridges are capped with till, and it also occurs on the hillsides in Piskahegan settlement. At South Oromocto Lake, and at other places nearer the coast, notably Ludgate and Spruce lakes, it is also found. In Petersville, Queen's county, it was observed mantling some of the hills and slopes, especially near Clone's P. O., and at Jerusalem, Hibernia, Summer Hill and other localities between these and Gagetown.

Around the mouth of the St. John River large quantities of till have been thrown down which, as already stated, have formed dams, holding

East of St. John.

up the river and diverting it from its pre-glacial outlet. East of St. John the summits and slopes of the ridges are, wherever there are any traces of glaciation, mantled with till. Upon the elevations between the Intercolonial railway and the Bay of Fundy, till was observed in a great number of localities, *e. g.*, on the Kent settlement road, and between Elgin Corner and the Shepody road in several places, also in numerous parts of the plateau between Hammond River and the coast. No foreign boulders were, however, found on this plateau. At Mapleton till and rotted rock *in situ* were observed in juxtaposition. The hills and ridges extending from Sussex Vale, or from the head of the Kennebeckasis River to Hampton, and, indeed, to St. John, are nearly all capped with till, which is, however, in many cases, overlain with stratified materials.

West of Intercolonial railway.

Along the ridge, or series of ridges, lying west of the Intercolonial railway and between it and the valley of Belleisle Bay and creek, till was met with in a number of localities both on the summits and slopes, and occasionally in the form of low mounds or hummocks in the valleys. West of Sussex Vale drumlius occur at the mouth of Smith's Creek. Deposits of till were found near North River, Petitcodiac, and at Cornhill and towards Anagance, also on Jordan Mountain and vicinity. In some places in the Petitcodiac valley the till deposits may have been produced by icebergs. Farther to the south-west along the ridge referred to, viz., in Case settlement, near Belleisle Corner and north-west of Hampton, patches of till were observed, also in a number of places in the Kingston peninsula. In the latter district, however, it was found that some of the hills showed no till on their summits or flanks, but rather were capped with beds, partially stratified, apparently due to atmospheric action, while in other places rotted rock appeared *in situ*. A detailed study of ice erosion here shows that some areas only are glaciated, while others are not. Of course, till is only found in glaciated districts, except such as will be described as belonging to division 3. But it would almost seem as if it had been formed in some places, not only by the weight of the ice and snow, but even by subærial agencies.

Forming drift-dam.

Mounds of till at Passekeag station, Intercolonial railway, indicate that it probably occupied the valley of the Kennebeckasis here once in early post-glacial times to the extent of blocking or damming it, and causing a lake to be held in to the north-east. Terraces above this, on both sides of the valley, point to this conclusion.

On the belt of land between Belleisle valley and that of the Washademoak and Canaan River, the glacial deposits are, similarly to those found upon the two series of ridges just described, of a detached and sporadic character. Here and there patches of all sizes and shapes, both upon the higher and lower grounds, are unglaciated and without boulder-clay. Along this belt, commencing at the north-west end, we find till at Lewis Mountain, Steeves settlement, Butternut Ridge and at Springhill. Farther west, at Northrup settlement, till covers a considerable area, and it was observed also upon Snider and Kierstead mountains. Its occurrence was also noted at east Scotch settlement, at Scotch Corner, in the vicinity of Bald Hill and Golding's Corner, also at Shannon settlement and on the north side of Albright's Brook, etc. On the west side of Jones' Brook till mantles the entire slope in a deep bed.

On both sides of Washadamoak Lake, and also eastward along Canaan River nearly as far as New Canaan, till was observed in numerous localities.

Upon the ridge between Washadamoak and Grand lakes till was seen in many places; also around Grand Lake it occurs in thin, scattered sheets, usually, however, covered with stratified deposits.

Localities of till formed *in situ*.

The occurrence of till of the kind described under division 3 is, as previously stated, by no means common. As noted on page 22 it is regarded as a deposit formed *in situ* about the close of the glacial period by the weight of ice and snow compacting the original decayed rock material while it was saturated with water, and probably by other causes not yet understood. It is therefore different from the ordinary till, inasmuch as it contains no transported or glaciated boulders, but is wholly composed of the underlying or subjacent rotted rock, with sometimes transported boulders on the surface. The materials are usually angular, but, nevertheless, form a compact, unstratified mass, in every way resembling till. No striæ were observed on the rock surfaces under it.

Where found.

Deposits of this character were met with chiefly in the upper part of the Petitcodiac valley, also about some of the headwaters of the Salmon or Kennebeckasis River. West of the Intercolonial railway they occur at Graves settlement, at Cornhill, and southward towards Anagance station, also on the ridge between the latter and Smith's Creek.

On the east side of the Petitcodiac valley similar beds were noticed along Little River (Coverdale) in many places; also on the northern slope of Caledonia Mountain, near the head of Turtle Creek. Till of a like character was also seen on the Kent settlement road near the south branch of Prosser Brook, and in a number of other places.

The deposits of this kind of till, it will be seen, occur, for the most part, on the divide between the Petitcodiac and Kennebeckasis waters and about the sources of several of their affluents. The region here has been less denuded by the ice of the glacial period, and by the rivers and streams than, perhaps, elsewhere east of the St. John. Indeed, as a rule, the slopes facing the Gulf of St. Lawrence are, everywhere in New Brunswick, less glaciated and denuded, than southward facing ones. This is especially noticeable on the northern and north-eastern side of the water-shed referred to. The preservation of the beds in question is, therefore, largely a result of this condition of things.

Moraines and Kames of the Higher Grounds.

Moraines.

Moraines were observed only in a few localities in the area under review, and such as came under notice are small. In a district like this, in which local glaciers seem to have played so important a part, their almost entire absence is a remarkable circumstance. It is possible, however, that a number of the hummocks and ridges of till are morainic in the bottom, the moraine matter being concealed by a covering of later deposits. The following are the only mounds and ridges observed which may properly be classed as moraines:

A mound on Gagetown flats, opposite the village of Gagetown, called locally "Mount Ararat." Height 50 feet.

Mounds on flats just above the mouth of Tennant's Cove.

These are described by Prof. H. Y. Hind on page 208 of the report already cited, viz., *A Preliminary Report on the Geology of New Brunswick*, 1865.

A moraine, or perhaps it may be a lake kame, occurs on the north side of Otter Lake, St. John county. It is a winding ridge of till packed with boulders of various sizes from 3 to 12 inches in diameter. Either it has been formed by a local glacier, or by lake ice. Height above sea level 345 feet. Mr. Matthew describes it in the report referred to (Report of Progress, Geol. Surv. Can., 1877-78,) part EE., as a kame, and gives measurements made by Prof. Bailey.

Kames.

The kames of the higher grounds are those referred to in former reports under the head of Class I. Before describing them here it is necessary, perhaps, in view of the additional data obtained in this region regarding kames in general, to revise the classification adopted in my preliminary report (Annnal Report, Geol. Surv. Can., 1885,) to a slight extent. The following differentiation of the groups is, however, only tentative, but is, nevertheless, for the present, deemed sufficient to explain the characteristics and modes of occurrence of all the kames found in southern New Brunswick.

Kames are found in all parts of the region, but are better developed in Charlotte county than elsewhere. Commencing in the eastern part of the area and proceeding westward, we might say that kames increase in number and size as we approach the international boundary, that is, those produced by other than marine agencies. And if we proceeded further westward into Maine we would find, according to Prof. G. H. Stone, that they are still more extensively developed there, and in their linear and topographic features remind geologists of the *osar* of Sweden and other European countries. In Charlotte county, as stated, several large kames occur in the Magaguadavic valley, also along the Digdeguash river and between the latter and the St. Croix. None exceeding a few miles in length were met with, however, although, by supposing those along the Magaguadavic to have been formerly connected and since denuded, they would form a continuous kame from Brockaway settlement, at the northern border of Charlotte county, nearly to the head of Lake Utopia. But the view which I take of the origin of this class of kames, and which will be discussed in the sequel, does not require this hypothesis.

Classification of Kames.

In treating of kames in former reports I have classified those met with in New Brunswick into three groups, as follows: (1) Kames on the higher levels, *i.e.*, above the 200 feet contour line; (2) kames found in river valleys, and (3) kames partly or wholly of marine origin and which always lie below the 200 feet contour line above sea level. This classification still holds good except that kames found on the borders of lakes will now be placed in a separate group, being regarded as solely of lacustrine origin. As a result of careful study during the past three years, I have found that all kames met with in the Maritime Provinces can therefore be provisionally classed into the following groups, distinguished according to locality, elevation above sea level, physical and external characteristics, geological structure, relation to the stratified gravel deposits, etc.

Class I.

1. Kames on the higher levels, or water-sheds, and at the sources, or along the upper part of rivers where there are dead waters. These are always found above the 200 feet contour line and are not confined to narrow valleys. Occurring, as they do, invariably in the form of gravel ridges with steep sides, tortuous courses, often narrow sharp crests, peaty areas on one or both sides, and with spurs or branches diverging from the main ridge, they are conspicuous features in the landscape and at once arrest attention. Hollows, or "kettle holes," as they are called, are usually found in them. They are morainic in part, or contain more or less till in the bottom; but the upper parts consist of stratified gravels and sands, which have, where the kame is narrow, an anticlinal structure.

No satisfactory theory regarding the origin of this class of kames has yet been propounded. Their partially morainic character would indicate a glacial origin. If so they would appear to have been formed during the melting of the ice of the glacial age, when the rivers and streams, along whose upper reaches they now extend, were let loose from that long reign of frost and ice and began the work of re-opening their ancient, partially blocked-up channels. This view derives support from their sinuous, river-like courses and other characteristics. The swampy or peaty tracts on one or both sides are caused by the kame itself damming the drainage of the district.

Class II. 2. Kames found on the margins of lakes either existing or extinct. These occur on the borders of many of the lakes above the 220 feet contour line, and, in a few instances beside lakes below it. Lake kames often resemble those of Class 1 both in the materials composing them and in external features. Sometimes, however, they are quite different, being wide, hummocky, and without the regular ridge-like form so characteristic of the first group. They are undoubtedly of lacustrine origin, having been formed by currents, waves, winds, and by the shove of the lake ice around the shores. Where they are high they indicate a falling, or draining out of the lake. Kames now being formed on the west side of Grand Lake, at Sypher's Cove and at the Keyhole, also at Jemseg River, are of this class.

Class III. 3. Kames occurring in river valleys. These are found in valleys at all elevations, but usually in a more perfect condition above the 220 feet level than below it, *i.e.*, they have suffered more denudation on the lower levels. In all cases, however, they are merely residual portions of terraces which have escaped erosion as the river cut down into the gravels, sands, etc., and its channel shifted from one side of the valley to the other. This class of kames and the accompanying terraces are described in some detail in Report of Progress, Geol. Surv. Can., 1882-83-84, page 20 G.G., and in a foot note on page 41 G.G. They will be more fully discussed in this report when I come to describe the river terraces.

Class IV. 4. Kames partly or wholly of marine origin. These occur along the coast in the area lying below the 220 feet contour line above sea level. Usually they are long, wide and flat, and are sometimes flanked by marine fossiliferous terraces, Leda clay and Saxicava sand. They have doubtless been produced, to a considerable extent, by marine currents, or the tidal currents of the Bay of Fundy, denuding pre-existing beds of till, rotted rock, etc., in the districts submerged during the great Post-Tertiary subsidence; but in some instances, rivers, or currents of water from the land, would seem to have played an important part in furnishing the materials. They will be further described in the following pages when I come to treat of the Leda clay and Saxicava sand with which they are associated.

In treating of the kames of Class 1, that is, kames on the higher levels, which are, in some cases, associated with moraines, I shall here note the localities of the more important ones occurring in the region.

A characteristic kame is found in western Charlotte, stretching from Lynnfield to Pinkerton, about 4 miles, in nearly a straight line, the road between these two places following the summit. Height above sea level at southern end 364 feet, at northern end 391 feet, above the level of the district 10 feet. Average width 50 to 60 feet, but spreading out to 75 or 150 feet in places. General course S. E. (see map). Kame nearly parallel to course of glacial striæ in this part of the country. Branches run off to the south-west and to the east at wide angles. Peat bogs lie on either side along nearly its whole course, and a wide gravel terrace at northern end. It is composed of rounded pebbles and gravel belonging chiefly to local rocks. This kame lies on a water-shed in the central part of a low, wide valley, which is drained into the north-west branch of Digdeguash River. The generally level character of the tract in which it occurs precludes the idea of its being due to denudation. **Localities of Class I.**

Another similar kame of smaller dimensions was observed in the same district between Moore's Mills and Oak Hill. It is about a mile long and has a peat bog also on the east side. Height 330 feet.

A kame occurs on the road leading from Sussex to Berwick, Kings county (see map). Height about 250 feet. This, however, may be a lake kame formed on the border of a small lake now extinct.

Another of these high-level kames is met with on the road leading from Dutch valley to Sand's Lake, Salmon River, eastern Kings county, near the cross road going to Long settlement. Height 775 feet. This kame (see map), with the associated hummocks of gravel, occupies the water-shed between the sources of Salmon River and Trout Brook, and may really be due to denudation.

Boulders and Erratics, etc.

This is pre-eminently a boulder-strewn region. Everywhere, both on the higher and lower grounds, boulders of granite, gneiss, mica-schist, felsite, diorite, slate, trap of various kinds, occasionally lower Carboniferous conglomerate, etc., are profusely scattered about. The larger boulders are, of course, more numerous on the ridges and crystalline belts, which seem to have been the centres of distribution. The pre-Cambrian ridges in eastern Kings and Albert counties, and, **Boulders.**

indeed, all along the Bay of Fundy, sent boulders and debris off their slopes both northward and southward. West of the St. John River, in the neighborhood of Hardscrabble and Olinville, boulders of diorite and trap from the hills to the south, were found scattered about in considerable numbers in certain spots, while the striæ in these localities showed unmistakably that glaciers had moved southwardly over the same district. How were these boulders carried in this direction? Perhaps, by ice in the earlier stage of the glacial period, when a thick covering of debris lay upon the rock surface, preventing its leaving any traces of its movement; or it may have been at the close of the same period, as the ice-sheets dwindled down and became so small that they followed the northward direction of the slope. In the latter case, however, striæ, showing northward movement, ought to have been left in some places. From all the facts observed regarding these boulders, however, the theory of their northward transportation by atmospheric action alone, as the decayed rock materials were being worn away, seems the most probable. But further study is required on this point. Along the northern flanks of the ridges overlapped by the Carboniferous sediments, it was noticed that while boulders from the crystalline belts were found to have been carried northward over the low-lying Carboniferous area, as just stated, few, if any, from the latter rocks would seem to have been transported southwards to the summits of the former. In every locality, both on the higher grounds and the lower, however, boulders belonging to the underlying or subjacent rocks were most abundant. The great majority of those embedded in the deposits are also local, the far-travelled ones being, as a rule, on the surface.

Northward transportation of.

Boulders on surface of Carboniferous area.

Upon the surface of that part of the Carboniferous area within the maps there are here, as well as in other parts of the province, great numbers of boulders or erratics strewn about, consisting of granite, gneiss, diorite, felsite, etc., in addition to those of local origin. Most of the boulders met with upon the southern overlapping margin of that area have probably been carried northward from the ridges, as already shown; but those found upon it to the north of the Intercolonial railway and the St. John River, appear to belong to rocks in the interior of the province lying to the north-west of the great Carboniferous plain. The latter are, however, most abundant in river valleys and on the margins of the lakes. Upon the slopes on both sides of Grand and Washadamoak lakes, boulders of the kind described are plentifully strewn about both above and below the 220 feet contour line. Near Grand Point, on the west side of the first mentioned lake, granite and diorite blocks from one to five feet in diameter are found scattered over the sand beaches, having been moved about by lake ice and partly, perhaps, by the waves during storms. Of the transported boulders found upon the Carboniferous area referred to, granite is the prevailing kind, indeed, these are the most abundant all over the region. In dimensions they vary from eight or ten feet in diameter downwards. They are always well rounded and commonly found on the surface. Diorite and felsite are next in abundance, gneiss and other kinds rarer. These old, rounded, crystalline blocks must have a wonderful history. They seem to have been knocked about hither and thither for an almost interminable period, and are the survivors, so to speak, of a host of their kind which invaded the region long ages ago and have been battling with the elements of destruction since. How many of their fellows have fallen in the fight and been ground to dust, disappearing forever from the scene! The old travelled boulders of the region met with now are, therefore, the remaining select few—the "survivors of the fittest." They are here because they have been better able to withstand the processes of disintegration going on around us.

Kinds of boulders.

Some of the effects of river action in the distribution of boulders are also well exhibited in this region. The ice which every winter forms upon the surface of these inland bodies of fresh water, is a powerful dynamic agent in this respect. Evidence of this can be seen in many places along river valleys, etc. At Harding's Point, at the foot of Long Reach on the St. John River, and at Gorham's Bluff at the entrance to Belleisle Bay, trains of transported boulders resembling moraines have been thrown up on the beaches by river ice and wave action. These are, of course, the accumulations of years. In certain river valleys in Charlotte county the bottoms are literally paved with boulders. In these the rivers have presumably carried away much of the finer materials, leaving the boulders thus exposed. But the larger number must have been brought thither from higher levels by various agencies, chiefly river ice, strong currents, spring floods, etc., while gravitation itself must have been largely instrumental, in a hilly broken region such as this, in causing many boulders to roll down off the slopes into the valleys, as they became exposed from the wear or waste of the surface.

River action on boulder dispersion.

Along coasts and in areas submerged during the Post-Tertiary period various distributing agencies have been in active operation, rendering boulder dispersion on these lower levels a somewhat complex problem. In addition to the glacier and river action which took place prior to this period, we have, during the submergence, that of icebergs and marine currents, although in the particular region under consideration the action of floating ice has not been as potent as elsewhere. Nevertheless, in the Petitcodiac valley, as already indicated, some facts were

Marine action.

observed which are more readily explicable on the theory that icebergs invaded it while it was a strait, during the Post-Tertiary subsidence, than in any other way. At Germantown Lake, near the coast of the Bay of Fundy, and in a valley lying parallel thereto, there seems also to be evidence of iceberg action, or drift ice, striæ there having apparently been produced by ice which moved both up and down the valley. Great transportation of boulders would, no doubt, take place from the action of these in the area then submerged.

Driftage of boulders. In the clays and gravels immediately to the west of the mouth of the St. John, boulders of red granite were met with which have puzzled me to account for. As the parent rock of these is found only in a belt stretching from the Nerepis River to St. George and the Digdeguash River, they give some idea of the driftage of boulders, etc., which has taken place. It is probable those in question were first carried down to the coast from the parent rock by one of the rivers falling into the bay to the west of the St. John, viz., the Musquash, Lepreau, New or Magaguadavic, and subsequently drifted eastward by tidal currents.

Causes of boulder dispersion. The causes of the wide spread distribution of boulders in the region under discussion are, therefore, manifold. Of these the most powerful, as it has been the most long-continued, is atmospheric denudation. The agencies which have unceasingly, for long ages, been at work in wearing away and reducing the surface of the land, and transporting the materials to the lower levels and ultimately to the sea, viz., air, frost, snow, rain and the rivers; these have probably, I say, been the means of more boulder dispersion than all others combined. Under the operation of these forces as the finer materials are loosened and carried down to the valleys, so are boulders moved, slowly it may be, but surely, a few inches this year, a short space next, and so on, until, after the lapse of ages, they are found far away from their original home. Especially is this mode of transportation of potent effect in a region where inequalities of surface are so marked and the climatic conditions so variable as in southern New Brunswick. The tendency of atmospheric degradation, as is well known, being to wear away and reduce the materials, large and small, the movement of boulders, from higher to lower levels, when once they become rounded and weather-worn, as most of the crystalline ones are, is a comparatively easy matter. A slight denudation of the gravel, clay or sand from under them will cause them to turn over, partly or wholly, and the next or succeeding step in the process of surface degradation will cause the movement to be repeated, and so on. The transportation of boulders from the crystalline ridges of southern New Brunswick northward to lower levels has, in my opinion, been largely effected in this way.

Causes which operated in region.

We have evidence then that the following causes of boulder distribution were in operation in this region:—1. Upon the more elevated parts, (a) atmospheric degradation as just described, (b) glacial denudation, by which is meant not only the transportation of boulders by the ice itself, but also by the floods resulting from its melting when retiring, and (c) river and lake action, especially that of river and lake ice and floods. 2. Upon the areas below the 220 feet level, which were submerged during the Post-Tertiary period, we have evidence of other causes in addition to those above mentioned, viz., (d), iceberg action, or that of floating ice, although icebergs, from the peculiar topographic features of the region do not seem to have been as influential here as in other parts of the province, and moreover, would disperse boulders only over limited areas, and (e), marine currents, especially the tidal currents of the Bay of Fundy, and wave action along the shores.

Conclusion respecting boulder dispersion.

The facts which have just been discussed, and others which might be adduced, have led me to the following general conclusion, viz., that boulder dispersion, especially from the older crystalline ridges of southern New Brunswick, commenced long before the Post-Tertiary period, perhaps, even before the Tertiary, at all events as soon as the land rose for the last time above the sea and the rocks became sufficiently disintegrated from atmospheric action to yield debris and boulders to the processes of dispersion going on. This wear or waste of the surface, which includes all the loose materials upon it, boulders as well as other matter, has been proceeding incessantly since. The elevation of these ridges, relatively to the adjacent districts, having doubtless been greater in Tertiary, and probably also in Post-Tertiary times than at present, their rock surfaces would afford more scope for subærial action and waste. The immense quantities of their own debris which cumber their slopes, and the generally bare and denuded condition of their summits, sufficiently attest this. Aud this accords with the general results observed regarding the immense denudation to which the surface of the country has been subjected, as referred to on a previous page, the ultimate tendency of which is to reduce the elevations to the same level as the plains.

Methods of studying dispersion.

The question of boulder distribution it seems to me, therefore, requires to be studied according to new methods and on new lines of investigation. Instead of confining the work of dispersion entirely to the Post-Tertiary period, as has been done, it will be seen that it must have been going on for a much longer time. Dispersion from atmospheric action has been incessantly in operation from the last time the land emerged from beneath the sea down to the present day. This mode of dispersion has been increased and intensified by (1) the dif-

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ferent relative elevations of the region which doubtless obtained in preglacial and early Post-Tertiary times from those now existing; (2) by the powerful and exceptional glacial action of the ice age; (3) by fluvial action *e.g.* that of rivers and lakes, and (4) by marine action in areas submerged during the Post-Tertiary subsidence. It is evident the theories now generally held by geologists regarding the dispersion of boulders are insufficient to account for all the phenomena. The subject is one replete with interest to the student of surface geology.

Glacial Striæ.

List of Striæ. The following list of striæ includes all those observed in the region during the past three years, for the first time, and not previously recorded in the Reports of the Geol. Survey. The bearings are all referred to the true meridian, and the elevations to the mean tide level of the Bay of Fundy.

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	Charlotte County.			
1	On St. Andrew's road at first brook W. of Little Lepreau River............	S. 25° W.	S.	75
2	On W. slope of a ridge, E. side of New River, on St. Andrew's road.......	S. 5° W.	S.	175
3	E. of Little Popelogan R. on St. Andrew's road........................	S. 20° E.	S.	275
4	At mouth of Popelogan River..........	S. 20° E.	S.	
5	One to two miles E. of Crow Harbour, on shore road........................	S. 10° E.		
6	At Crow Harbour........................	S. 5° W.		
7	At same place, other striæ............	S. 10° to 15° W.		
8	At Sand Cove.........................	S. 40° to 50° E.		
9	On Pennfield and Beaver Harbour road.	S. 50° E.		
10	On E. side L'Etang Inlet, near mouth..	S. 60° E.	S.	
11	At Upper or N. end of L'Etang Inlêt, E. side..........................	S.		
	(See map for difference in courses of striæ here and at mouth of L'Etang.)			
12	On W. side of L'Etang Inlet, at foot of road..........................	S. 80° E.	S. E.	
13	At Back Bay, near L'Etang..........	S. 70° E.	S. E.	
	All the striæ between Passamaquoddy Bay and L'Étang, near the coast have a great amount of easting. Why is this?			
14	Below McLean's, Letite...............	S. 70° E.	S. E.	
15	At McLean's, Letite..................	S. 70° E.		
16	E. side, mouth of Magaguadavic River.	S. 70° to 78° E.	S. E.	
17	On W. side Bocabec Lake.............	S. 50° E.		

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	Charlotte County—*Continued.*			
18	N. of St. Andrews	S. 40° E.	S.	100
19	Near S. branch Oromocto Lake	S. 20° E.		
20	On branch road to N. end of this lake	S.		
21	S. of Gaspereau sta., N. B. Ry. on road to S. branch Oromocto Lake	S. 10° E.	N.	265
22	On E. bank Magaguadavic R., at Piskahegan bridge	S. 35° E.		
23	At Upper Falls, Magaguadavic, E. side, in numerous places	S. 50° E.	S.	125 to 150
24	At S. end of Lever settlement	S. 40° E.	S.	100
25	On N. brow of Tower Hill	S. 50° E.	S.	400
26	At Lynnfield	S. 55° to 60° E.	S.	415
27	On road from St. Stephen to Basswood Ridge, at second cross roads	S. 60° E.	S.	100
28	On road N. of Oak Bay, at first cross roads; slope towards Oak Bay	S. 30° E.	S.	200
29	At The Ledge, below St. Stephen	S. 30° to 40° E.		
30	Near N. end of Pomeroy Ridge	S. 50° E.	S.	150
31	On road along St. Croix towards Sprague's Falls	S. 35° E.		
32	In another place along same road	S. 35° to 40° E.		
33	On E. side Moannes Stream, numerous	S. 30° to 35° E.	S.	175
34	On first cross road W. of Gilchrist settlement	S. 40° E.	S.	225
35	Along S. W. side Deer Island, at various heights	S. 60° to 65° E.		
36	North Harbour, Deer Island	S. 50° E.		
37	Lord's Cove, Deer I. and towards Leonardville	S. 55° to 65° E.		
38	At Chocolate and Cumming's Coves, Deer I	S. 20° to 30° E.		
39	In other places at S. W. end of Deer I.	S. to S. 10° to 15° E.		
40	On N.W. side Campobello, below Welchpool	S. 20° to 70° E.		
41	Near Wilson's Beach	S. 50° to 65° E		
42	W. of above, near cross road to Herring Cove	S. 30° E.		
43	Near Swallow Tail Light House, Grand Manan, Grooves and *roches moutonnees*	S. 70° to 75° E.	S. E.	
44	At mouth of brook half way between Seal Cove and Southern Head, on ledge at shore	E.	E.	
45	Between North Head and Grand Harbour in numerous places, Grooves and *roches moutonnees*	E.		

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	St. John County.			
46	On county line road, Mace's Bay.	S. 10° W.		75
47	E. of Lepreau. All rocks E. of Lepreau estuary intensely glaciated.........	S. 10° W.		
48	On ridge W. side Musquash River, on an E. slope.......	N. 80° E.		225
49	On St. Andrew's road, between Ludgate Lake and Musquash River.........	S. to S. 10° E.		
50	At Pisarinco, in several places.........	S. 20° E.		
51	At Milledgeville and Boar's Head......	S. 15° W.		
52	At Sand Cove, (Fern Ledges, Lancaster) on shore........................	S. 65° E.		
53	On point of rocks (Fern Ledges) nearest Sand Cove and on W. side of ledge..	S. 60° to 65° E.		
54	On E. side of same ledge.............	S. 30° E.		
55	About 100 yards further E. on summit of another ledge................	S: 20° E.		
56	At middle Fern Ledge (there being three) two sets....................	{ S. 60° E. S. 20° E.		
57	Just W. of easternmost ledge in several places......	S. 10° E.		
	At the Fern Ledges, Lancaster, we have the remarkable phenomena of striæ on the W. side of a point of rocks on the shore bearing S. 60° to 65° E., while on the E. side of the same point, and not more than 100 yards distant therefrom, striæ are found trending S. 10° to 20° E. These ice marks have undoubtedly been made by local glaciers, or icebergs, or coast ice. Those on the opposite slopes referred to, instead of running down hill, supposing the striating agent to have moved towards the bay, rather run up hill diagonally, which leads me to think they must have been produced by shore ice shoved against the land.			
58	On the road from Portland to Kennebeckasis River, passing through Highland Park, and near the bank of the river, striæ were seen on the same ledge with three different courses, viz......	{ S. S. 15° W. & S. 50° W.		
	The two last (S. 15° W. and S. 50° W.) are quite distinct, the S. course not being so well marked. It is apparently the oldest and has been partly obliterated by the ice which produced the later striæ.			
59	On Black River road on slope facing the W.......	S. 30° W.		250
60	In another place on summit of hill, before reaching Mispec valley........	S. 15° to 20° W.		340
61	In valley before reaching Cape Spencer.	S. 50° to 55° W.		

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	St. John County—*Continued.*			
62	Along road at West Bay beach, slope towards Bay of Fundy............	S. 40° E.		240
63	Near head of Porter's Brook, at Henry Lake	S. 20° E.	N. W.	500
64	On S. side of Hammond River, E. of Damascus road bridge............	S. 20° E.	N. W.	575
65	At Mark's Lake	S.	S. E.	400
66	On hills behind Melvin's Beach on road to third concession. Slope facing bay.	S. 40° E.		500
67	On road from Quaco to Melvin's Beach, in several places	S. 20° to 25° E.		500
68	On Salmon River road............ ...	S. 20° E.		
	Kings County.			
69	On second cross road below Jones' Creek, Westfield, on S. facing slope near Devil's Back..................	S. 35° W.		150
70	Still nearer cross road mentioned......	S.		100
71	In first back settlement below Westfeld sta., N. B. Ry. Striæ numerous.	S. 40° E.	N. W.	300
72	On Midland road, Kingston peninsula, near first cross roads S. of Kingston Corner...........................	S. 20° E.		300
73	On hill just N. of Clifton, on summit ...	S.		250
74	On Midland road, just S. of road crossing it from Elmsdale. Striæ indistinct	S. 30° E.		300
75	On same cross road going from Elmsdale, between Midland road and Kennebeckasis R.....................	S. 5° E.		350
76	On road from Kingston along shore to Long Point.........................	S. 10° E.		
77	On Midland road, S. of Erb settlement and just E. of Urquhart's, on W. facing slope. Striæ parallel to valley here......	S. 10° W.		
78	N. of Kingston village, just at border of map, on road going to five cross roads. Glaciated surfaces in several places here	S. 5° to 10° E.		250 to 300
79	Going in from five cross roads on direct road to Kennebeckasis, on highest part of road, (land sloping from here to Kennebeckasis valley.) Striæ.	S. 5° to 10° E.		350
80	On road from five cross roads going direct to Belleisle Bay, at first cross road to right on brow of hill facing bay............................	S. 20° E.	N. W.	275
81	On straight road from Passekeag sta. to Belleisle Corner, just on brow of hill W. of Kennebeckasis valley. Slope to S	S. 10° E.	S.	420

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	KINGS COUNTY—*Continued.*			
82	On same road, on slope of hill facing Midland road..........................	S. 20° E.	N. W.	400
83	On same road, on brow of hill before reaching Belleisle Corner, Striæ, numerous. Slope to N............	S. 20° E.	N.	150
84	Going to N. E. from Belleisle Corner on S. side of creek, toward Case settlement, after passing first branch of Belleise Ck., and taking left hand road. Striæ....................	S. 5° E.	N.	260
85	On road from Belleisle Corner to Norton, on highest ground east of branch of Belleisle Ck., last mentioned: striæ abundant........................	S. 20° E.	N. W.	275
86	On road going from Norton to Case settlement, striæ abundant...........	S. 5° E.		250 to 400
87	N. of Central railway crossing, Case settlement road, on E. facing slope, numerous.......................	S. 5° E.		
	Ice evidently moved down this slope through gap in hills where Central railway line passes into Kennebecksis valley.			
88	Between Case settlement and Norton sta., striæ abundant....	S. 20° E.	S. E.	250 to 300
	In lower part of Kingston peninsula, along both sides of Milkish Creek, and in valleys of the hilly tract between it and Long Reach, striæ are parallel to valleys, or nearly so, perhaps with a slight easting in places from that course. They are quite abundant here. On higher N. and N. W. facing slopes, striæ have much more easting than in valleys, bearings generally being from S. to S. 20° E. in most instances.			
89	Going in on road at S. W. end of Dickie Mt., near where it joins road going from Belleisle Cor., towards Caldwell's Brk., two sets of striæ. S. course, deep ruts; S. 30° E. set finer and more numerous. Apparently latest..........................	S. to S. 30° E.		160
90	On Dickie Mt., two sets................	{ S. 20° E. / S. 50° E.	N. W.	500
91	In Case settlement, on road going thence to Norton and Belleisle Cor. road, forming with two others a right-angled triangle.....................	S. 5° to 20° E.	S. E.	450
92	At crossing of Central railway, Case settlement road, on water-shed........	S. 15° E.		200
93	On straight road through Case settlement to Studholm's Millstream, at height of land....................	S. to S. 5° E.	N.	535

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	Kings County—*Continued.*			
	It would appear from last striæ that whole valley of Belleisle Creek and Studholm's Millstream must have been occupied with a glacial mass which overflowed in this direction.			
94	Going in from Belleisle Crk. on straight road N. E. of Scovil's Brook, at third cross road, striæ, with same course as adjacent valley of stream..........	S.		500
95	On road (Midland road) going across from end of last mentioned road to Scotch settlement corner; striæ abundant............................	S. 20° E.	N.	600
96	At junction of this Midland road with road along Northrup's Brook........	S. 20° E.	S. E.	580
	These striæ (Nos. 95 and 96) are on or near the water-shed between Belleisle and Washadamoak valleys, and have probably been produced by ice which gathered upon it. If by ice coming from Washadamoak and Grand lakes there ought to be grey sandstone boulders here, which there are not. The ice producing striæ No. 96, appears to have just moved off the water-shed referred to and gone down the valley of Northrup's Brook. There is a long slope in this valley, and the ice must have received considerable impetus therefrom. Glaciers have apparently moved across Belleisle valley diagonally. If these were local they seem to have been shed off the crystalline or highest part of the water-shed between Washadamoak and Belleisle valleys. On the N. W. face of the steeper hills lying to the S. E. of Belleisle valley there is, however, no glaciation; but on summits and S. E. slopes striæ are usually found, while ice seems to have been pushed up the valleys between these hills from the Belleisle basin in a S. direction. The ice on the low tracts here has nearly everywhere partaken of the same general movement.			
97	On White Mt., on a rocky boss on the breast road, *roches moutonnées* on N.W. side, broken off on N. E. Glacier which produced these must have had its source N. W. of Grand Lake valley..............................	S. E.	N.W.	710

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	KINGS COUNTY—*Continued.*			
98	On cross road, going from Nauwigewauk sta., I. C. Ry., to Hammond River...	S. 40° E.	N. W.	385
99	On Wanamake Hill, on the main road..	S. 5° W.	N.	625
100	On E. side of De Forest Lake	S. 5° W. to S.	N.	
101	At junction of Poodiac road and road going to Ratter's Corner, Numerous.	S. 15° E.	S. E.	950
102	In several places on cross road, between Ratter's Corner and Ward's Creek...	S. 15° E.		
103	On road leading from Poodiac road to Ratter's Corner....................	S. 20° E.	N.	600
104	On road leading from Musquash Brook to Ward's Creek, in several places.....	S. 20° E.	N.	
105	On road from Bloomfield to head of Salt Springs Creek, on summit of hill. Striæ on northward facing slope.....	S. 20° E.	N.	750
106	At Long settlement, on S.E. slope, on hill top	S. 60° E.	S. E.	1200
	A small local glacier evidently produced these striæ.			
107	Going out along Ward's Creek from Sussex and taking road across to left from mill to Markhamville road, on latter road. Striæ.................	S. 15° E.	N.	450
	QUEENS COUNTY.			
108	A short distance from Blue Mt., on road leading to Mahood's Corner (80 rods from Mt.).............................	S. 45° E.	W.	
109	On road from Blue Mt. to St. John River, which strikes river about 1½ miles above Oak Point.......................	S. 23° E.	S. E.	
110	On road between Broke Neck and Blue Mts...............................	S. 25° E.	N.	
111	On short road running N. and S. past Geo. Lowery's, Jerusalem	S. 30° E.	N.	
112	Near Saml. Machum's, Jerusalem......	S. 35° E.	N. E.	
113	One mile W. of Mahood's Cor. Indistinct	S. 35° E.	N.	
114	On Simpson's barrens, 1 mile from Gagetown road, same road as No. 113....	S. 41° E.	N. W.	
115	On road from Hibernia to Gagetown and about ¾ mile N. of Otnabog River...	S. 33° E.	S.	
116	On Hibernia road, ½ mile S. E. of brook running into Otnabog River........	S. 45° E.	N.	
117	On Simpson's road, 60 rods from Gagetown road (Chas. Magaw's).........	S. 40° E.	N. W.	
118	Near Clones P. O., Gagetown road......	S. 26° E.	N.	
119	On road running parallel to Washademoak Lake, 2 miles above Narrows.	S. 15° E.	N. E.	

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	Queens County—*Continued.*			
120	At junction of road from Mill Cove, Grand Lake, with road going from Den Brook to Narrows, Washadamoak	S. 15° E.	N.	
121	On W. side Washadamoak, 2 miles below Cole's Island..................	S. 15° E.	S.	
122	On direct road from Gagetown to Clones, on highest ground at Summer Hill and vicinity......................	S. 20° E.	N.	400 to 500
123	Along St. John River, 1 to 2 miles above Golding's Corner, two sets....	{ S.30° to 40° W. S. 20° E.	N.	50 to 75
	The S. 30° W. set exhibits the deepest ruts, but the other, S. 20° E., striæ are most abundant, and the ice producing them has apparently done most of the wearing and polishing. These striæ are evidently the latest. The ice in both cases has been guided by the main topographic features; *e. g.* in the S. 30° to 40° W. movement, by the ridges on the E. side of the St. John and the Washadamoak valleys, and in the S. 20° E. movement by the St. John valley itself.			
124	Going out on straight road N. from Golding's Corner, on slope towards St. John R. (hence their great westing) Striæ	S. 60° W.	W.	75 to 100
125	At foot of Bald Hill (W. side), near Golding's Cor., on N. facing slope....	S. 10° E.	N.	375
	Ice here has apparently run up N. slope of hill to top, about 600 or 700 feet above sea level.			
126	Between Albright's Brook and Belyea's Cove, on lake road. Indistinct......	S. 60° to 65° W.	W.	160
127	On road E. side Washadamoak Lake, just N. of Lewis Cove. Stoss-side doubtful, but probably N., although abrupt on that side	S. 5° E.		150
128	On road going from Narrows to Belleisle Creek, near Washadamoak Lake, and on brow of hill facing it............	S. 10° to 20° E.		160
	Large glaciated surface here, which has evidently been but lightly ground over with ice.			
129	On same road farther from lake........	S. 15° to 20° E.		150
	Ice which produced these evidently came from the N. Boulders embedded in deposits here have upper surfaces striated in same direction as solid rocks.			
130	Still farther from lake on same road, on slope facing lake; numerous..........	S. 5° to 10° E.		160

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	Queens County—*Continued.*			
131	On highest ground between N. E. branch and Washadamoak Lake, on same road, on N. facing slope,............	S. 35° to 40° E.		260
	On a boulder embedded in gravel here, striæ, S. 20° E.			
132	On road going from Narrows to Thorntown, E. side Washadamoak Lake. Numerous all along road............	S. 5° to 20° E.		
133	On back road going from Narrows to Thorntown. Numerous.............	S. 20° E.	W.	280
134	On road going from Cody's to Salmon Creek........	S. 20° E.	N. W.	260 to 300
135	In another place further back on same road	S. 20° E.	N. W.	500
136	On road from Salmon Creek to Cornwall	S. 20° E.	N.	500
137	On road from Long's Creek to Cornwall. Abundant......................	S. 25° E.	N. W.	250
138	On S. E. side Washadamoak Lake, near Cole's Island.....................	S. 20° E.	N. W.	90
	Is not the nearly uniform direction of the striæ on the Carboniferous area here due to the fact that a large flat sheet would be likely to form on this comparatively even surface and move over it without much obstruction?			
139	In Goshen settlement.................	S. 15° E.	N.	300
	Albert County.			
140	Near Hillside P. O. Stoss-side apparently N........................	S. 5° W.		650
141	Still nearer P. O., at foot of hill or slope facing N., or down Little River valley	S. 15° E.	N.	600
142	In another place, just S. of cross roads at foot of hill.......................	S. 10° E.	N.	
	Ice producing these has apparently moved from the N., but, after all, this is doubtful. For, immediately to the W. and S. of the striæ, rocks *in situ* stand up with unglaciated surfaces facing the N., while in one case a knob seemed rounded and worn smooth on the S. side. A small valley to the E. of the road along which these striæ occur has evidently been occupied with a local glacier which moved down the slope from the S., producing the striæ noted. Several sets of striæ at small angles occur on these rock surfaces as if they had been ground over by a number of successive ice-masses, or perhaps by successive portions of the same mass.			

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	Albert County—*Continued.*			
143	Going in along road south-eastward from four cross roads on Golden Mt., to where it bifurcates, on W. branch just beyond forks..................	S. 30° E.		1100
	Ice here has apparently moved off the slope down a ravine into Hillside valley.			
144	Going from four corners last mentioned on Golden Mt., along direct road to Elgin Corner, a short distance from point last mentioned, striæ.........	N. 20° W.	N. W.	1120
	Ledge abrupt on both N. and S. sides, but as this is on brow of Golden Mt. facing great Carboniferous plain to the N., which lies several hundred feet lower, the ice movement has probably been northward. The striæ in several places along this road support this view. The glaciation has, however, been light, the inequalities of the rock surface not even being worn away. Very little overlapping of debris, or few boulders moved either way at contact of pre-Cambrian and Carboniferous rocks. The prevailing transportation was, however, down hill from the older crystalline belt. Besides the striæ just recorded, others occur along road towards Elgin Cor. Farther S., next to these, striæ were seen which have been caused by ice coming from a flat summit a few hundred yards to the N. of the same road. A little nearer Elgin others, again, were observed which have been produced by ice that came from a ridge to the N. W. of Pollett River. Still nearer Elgin, on brow of hill, slickensides were noticed.			
	The phenomena along the Golden Mt. and Mapleton roads are very instructive as showing the slight action of ice here. Whatever ice there was seems to have been only local.			
145	Above Little River P. O., in valley of Little River, Coverdale.............	N. 50° E.	N. E.	325
146	In another place further down Little River, and below P. O..............	N. 30° E.		
147	On road from Turtle Creek to Salisbury, on highest ground..................	N. 50° to 55° E.	N. E.	225
	Ice in these places has moved north-eastwardly down Little River valley.			

No.	LOCALITIES.	COURSES.	General slope of surface.	Approximate height in feet.
	ALBERT COUNTY—*Continued.*			
148	On road between Pollett River Mills and Petitcodiac sta., in several places. Undoubted evidence of north-eastward ice movement.	N. 50° E.	N. E.	220 & upwards
149	Just S. E. of Petitcodiac sta., near first crossing of Albert Ry. and the straight road going S. E. from I. C. Ry.......... .... Ice doubtless moved north-eastwardly here.	N. 45° E.	N. E.	175
150	On Turtle Creek road, N. of Baltimore Oil Works, on bank of creek. Stoss-side plainly S. E. General slope northward......................	N. 60° W.		520
151	On Salisbury and Hillsboro road, about 3 miles E. of Turtle Creek bridge; two sets........................ Unmistakable evidence in both these places of N. W. ice movement.	{ N. 55° W. N. 60° W.	N. W.	450
152	On road going from Church's Corner to Shepody road, about 1 mile from latter. General slope towards Bay of Fundy.........................	S. 2° E.	S.	1000
153	Going eastward from junction of these roads along Shepody road, near next cross road. Abundant............ General slope towards Bay of Fundy.	S. 30° E.	S. E.	1050
154	In New Ireland, on Shepody road. Common, but glaciation light....... General slope towards Bay of Fundy.	S. 30° E.	S. E.	1100
155	Going from Alma towards Albert and taking first cross road to left leading to Shepody road, then taking left of the cross roads and continuing towards Shepody road, near latter, striæ.............................. Much glaciation and till here.	S. 30° E.	N. W.	950
156	On right hand, or northernmost of these two forking cross roads, just before reaching lake, striæ.............. General slope here towards Bay of Fundy. The evidences of glaciation show ice to have been entirely local, and that it has moved from local gathering grounds on the plateau southward, impinging against low ridges along its southern border before descending the slope towards the Bay of Fundy, in some cases following river valleys and depressions.	S. 30° to 35° E.		1100

No.	Localities.	Courses.	General slope of surface.	Approximate height in feet.
	Albert County—*Continued.*			
157	Going from Alma to Albert, near junction of main road with Brookville road, and near Germantown Lake, striæ. Abundant...........	N. 85° E.		200 ?
158	Half a mile or so from last mentioned striæ up Brookville road, on low southward facing slope.............	N. 85° E.		
	These striæ have been produced either by eastward moving land ice or by icebergs floating westward and impinging against the base of the hill here. The abundance of the striæ, however, and their parallelism to the valley rather point to the fact of their having been caused by the latter.			
	Westmoreland County.			
159	On road going from Pollett River sta., I. C. Ry., north-westward to North River, 1 to 2 miles from railway, and just before reaching first brook......	N. 85° E.	E.	175
	A local glacier has evidently moved down valley of stream flowing into the Petitcodiac.			

Conclusions Regarding Glacial Phenomena in Southern New Brunswick.

General discussion of glacier movements.

The glaciation of the region under discussion exhibits some remarkable and complex features. The diverse courses of striæ, the frequent occurrence and extent of non-glaciated as well as glaciated surfaces, the widespread distribution of boulders and of boulder-clay or till, are phenomena met with everywhere, which often puzzle the geologist to explain. Along the coastal area, west of the St. John River, the rock surface in many places seems to have been very generally eroded by ice, much more so as a rule than inland. In the northern part of Charlotte county, between the St. Croix and Magaguadavic rivers, the district, as already stated, has a south-eastward slope, forming an inclined plane. Down this the ice from the water-shed between the St. John River and the Bay of Fundy, moved with great momentum, impinging heavily against the hills near the coast and grinding and pol-

Charlotte county.

ishing them in a remarkable manner.* And while, in the interior, ice-movements have been guided by the prevailing slopes and the courses of the valleys, along the coast there were numerous deviations which seem explicable only on the supposition that the ice thinned out and became broken up into small local glaciers in its passage through the hills referred to. Passamaquoddy Bay, which is 20 to 30 fathoms deep, has, however, been occupied with a glacier which overrode and scored the rocks on Deer Island and Letite peninsula 200 to 250 feet above sea level. Probably at that time the land stood higher relatively to the sea than at present Some peculiar features of the striation of the rocks south and east of this bay may be noted. The south-western part of Deer Island is striated in the direction of S. to S. 10° E.; but as we go north-eastward the striæ exhibit more and more easting, till near the north-eastern part of the island they bear S. 30° to 65° E. The north-west side seems also more glaciated than the south-east side. Ice appears, however, to have ground over a large part of its surface.

Deer Island.

Letite.

Crossing over to the Letite peninsula on the east of this bay we find the striæ to have still more easting, veering round to S. 70° to 75° E. and near the mouth of Magaguadavic River to S. 80° E.

Correlating the courses of striæ on Deer Island and Letite the question suggests itself has not Passamaquoddy Bay been filled with a body of ice which by expansion or movement outward, southward and eastward, towards a lower level through existing passages and by overriding Deer Island, Letite, etc., thus produced the divergent striation observed. To enable it to effect this, pressure and the flow of ice coming down the slope referred to from the north-west must have led to its accumulation in Passamaquoddy basin, where it was held in by Deer and Campobello islands and the Letite peninsula. These acted as barriers against its free exit into the Bay of Fundy until it accumulated in sufficient thickness to enable it to over-ride them, as indicated by the striæ noted above.

Grand Manan.

The island of Grand Manan exhibits phenomena on the west side of the main axial ridge which indicate that it has probably been overridden by a glacier from the mainland, while the eastward slope appears to have nourished some small local glaciers of its own. The steep, wall-like appearance of its west side, rising 300 to 400 feet high, and the depth of the passage between it and the mainland, 45 to 50 fathoms, and 8 to 10 miles wide, would almost preclude the idea of ice having over-ridden the island from the north-west; but there seems no

* Chamcook Mountain, about four miles north of St. Andrews, rises 637 feet above the sea, and about 400 feet above the surrounding district. Its summit and sides have been heavily glaciated by ice, which moved nearly S. 40° E.

other mode of accounting for the glaciation and transportation thither of granite and diorite boulders. If Grand Manan has been glaciated from the mainland the western side must have suffered a tremendous amount of lateral erosion from the sea since. Upon the surface of the island, however, ice erosion appears to have been less, so far as observations extend, than upon the West Isles or mainland. Indistinct striæ were noted near Swallow Tail Lighthouse and on the road to North Head, at the latter place having a course about due east. The glaciation everywhere has apparently been light, the rock surfaces not having been sufficiently worn down to deface pre-existing fractures and joints, the jagged, projecting points merely being rubbed off, while in numerous places they occur with a broken angular appearance showing no evidence whatever of ice action. A large part of the eastern slope of the island, indeed, seems to be unglaciated. On the lower levels, *i. e.*, below the 220 feet contour line, boulders of granite, diorite, etc., are common, much more so than upon the higher parts. These may have been brought thither by floating ice.

Striæ on east side of island.

Along the lower part of the St. John valley, including the district drained by its affluents and the lakes and bays connected therewith, the ice has, generally speaking, followed the courses of the main river. Some local deflections are, however, observable, caused, no doubt, by the hills and ridges, but the main trend was to points between south and south-east. In the Grand and Washadamoak lake district, the striæ on the lower levels, it is true, show a slight westing, caused, doubtless, by the position of the valleys occupied by these bodies of water with respect to the St. John valley. This course is also noticed in a few places further down, near the eastern bank of the St. John, as at Golding's Corner, along the Long Reach, and in the Kingston peninsula, etc., and also in a few instances on the west side.

Glaciation of lower part of St. John valley.

Among the coast hills from the Magaguadavic eastward to Black River, St. John county, and, indeed, as far as the hills and ridges which lie to the north-west of Quaco, the influence of local topographic features upon ice-movements has been very marked. These hills and ridges are intersected by river valleys, etc., and the ice which impinged against them from the north found outlet in many cases through the gaps and passes to the Bay of Fundy, while other portions of the ice must have been shoved up on the northern flanks of these ridges, and in some instances, have over-ridden them. Wide deviations in the courses of the striæ immediately to the south of these hills, indicate the varying movements of the local glaciers before their final disappearance on the shores of the Bay of Fundy. This is especially noticeable immediately on both sides of the mouth of the St. John, as in the

Glaciation among coast hills east of Magaguadavic.

parish of Lancaster; along the lower Kennebeckasis near Milledgeville; on the Black River road, and before reaching Mispec valley, etc.

Divergent striæ.

In a few places divergent courses of striæ were seen upon the same rock surface, as at or near Sand Cove, Kennebeckasis (see list of striæ No. 58), which are 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.

Striation on summit of pre-Cambrian plateau.

The striation upon the summit of the pre-Cambrian plateau lying east of St. John, evidently produced by local glaciers which gathered upon it, clearly indicates ice movements towards the open waters of the Bay of Fundy in a southerly or south-easterly direction. Ice action here has, however, been comparatively light. No boulders but those belonging to local rocks are met with upon the plateau.

Local glaciers in Petitcodiac valley.

In the basin drained by the Petitcodiac River and its tributaries there seems to have been a local glacier, or, perhaps, an independent system of local glaciers flowing into it from the west, south-west and south, which followed the valley north-eastwardly towards the head of the Bay of Fundy, or, possibly flowed towards the Straits of Northumberland. The glaciation here has also been very light, as evidenced by the great masses of decayed rock lying undisturbed in numerous places. Boulders of crystalline rocks are strewn over this area. The south-east side of the Petitcodiac valley is occupied with those which have been carried northward from the pre-Cambrian plateau lying between this and the Bay of Fundy, as previously stated, while the area on the north-west side is strewn broadcast with boulders which have apparently come from the interior of the province.

Striæ in Albert county.

In a few places in Albert county, along the immediate coast of the Bay of Fundy, the striæ, as has been shown, are, in some instances, parallel thereto. At Germantown Lake and Point Wolf, on the lower evels, either small local glaciers have moved along the east and west valleys, or these may have been traversed by icebergs during the period of submergence.

General theory of glaciation.

Co-ordinating the data at hand respecting the glaciation of the region, it would seem that the theory of local glaciers upon the higher grounds, and icebergs, or floating ice upon the lower, during the post-Tertiary submergence of these, is sufficient to account for all the facts coming under observation. Some of the local glaciers have doubtless been quite large. Those occupying the interior of the western part of the area, producing the parallel striæ met with there, must have been of considerable extent; while the valley of the St. John, with the lake basins and tributary valleys connected therewith, would appear to have been filled with a confluent mass of ice moving towards the coast. On either side of the St. John River, north of the highland area, the striæ show a pretty close parallelism, with, perhaps, a slight convergence. This is probably caused by the contour of the valley slopes, and the position of the lake basins with respect to the general trend of the local glacier occupying it.

Glaciation of district east of St. John River.

The ridges east of the St. John, viz., those between Washadamoak Lake and Belleisle Bay; between the latter and the Kennebeckasis; also the one to the south-east of the Kennebeckasis, have each been gathering grounds for smaller local glaciers, nearly all of which have coalesced with, or been tributaries or branches of the main sheet of the St. John valley and have been guided by it in their movements, really flowing parallel thereto, and in some few cases even crossing valleys lying at a wide angle to that of the St. John and partly ascending the slopes on the southern sides. South of the Kennebeckasis valley, however, there are some anomalous striæ on the higher grounds, which seem explicable only on the theory of a heavy sheet grinding against the northern sides of their summits, while no land as high lies to the north or north-west nearer than the South-West Miramichi region. In a few cases here it seems doubtful whether the ice moved northward or southward. In others, the striæ seem to have been produced by a local sheet which came across a valley a short distance from an opposite summit. A remarkable circumstance in connection with the glaciation of the region east of the St. John River, but within its drainage basin, is that the tops of hills are often glaciated, while a zone along their northward facing slopes, at a lower level, is cumbered with thick masses of rotted rock and the rock surface remains unglaciated. No general glaciation of the whole northern flanks of hills or ridges has taken place, the evidence of ice action being apparently quite local.

Phenomena on water-shed between Petitcodiac and Kennebeckasis rivers.

In studying the glaciation of central Kings, Albert and Westmoreland, the conclusion reached is that the water-shed between the Salmon or Kennebeckasis River, on the one side, and Pollett River, and the waters flowing into Petitcodiac on the other, shed the ice both ways; that to the north-east of the divide mentioned consisting of local glaciers which flowed down the valleys of Pollett and Coverdale Rivers and Turtle Creek, while on the flat summitt of the plateau lying to the south the general movements were towards the coast of the Bay of Fundy. Along the north and north-west brow of this plateau, east of the divide referred to, there is no evidence whatever of ice having impinged against it from the north. South-west of the divide mentioned, however, the ice movements were influenced partly, perhaps, by the high lands of the interior, and partly, also, no doubt, by the greater masses of ice which occupied the St. John valley and its tributaries. Here the general movement of the whole was towards the Bay of Fundy, but local inequalities caused diversions from this course in many places. Considerable areas on both sides of the divide, *i. e.*, around the sources of the streams which flow in opposite directions, are unglaciated.

M 2 (a). Stratified Gravel, Sand and Clay (Fresh-Water).

Stratified Inland Gravel, Sand and Clay, and Kames of the Higher Levels.

Mode of occurrence of stratified gravels, etc.

If this is a typical region for boulders it is also such in a no less remarkable degree for coarse gravels and shingle. In the hilly, broken district bordering the Bay of Fundy, stratified gravels, with the sand beds which usually accompany them, occur in great quantities both above and below the 220 feet level. In river valleys and lake basins and along the upper limit of the marine beds, as well as below it, they are found, in certain localities, in extensive sheets in the form of terraces, and sometimes as ridges or kames. Their great development here led Mr. G. F. Matthew to regard them as a distinct member of the series of superficial deposits, and accordingly, in the report already referred to (Report of Progress Geol. Surv. Can., 1877-78, part E.E.), he describes and classifies them under the designation of *Syrtensian* deposits and assigns tnem a place immediately above the boulder-clay, and, in the coast districts, between it and the Leda clay. The stratified deposits which I propose to discuss under the above head, however, are those met with at levels above the limits of the Leda clay and Saxicava sand, that is, upon the higher grounds of the region, and are considered, provisionally, as occupying the interval between the till or boulder-clay and the recent deposits. Such gravels, sands, etc., as occur along river valleys and in lake basins above the 220 feet contour line, as well as those found below that level, will be discussed in a subsequent chapter and their relation to the deposits now under consideration shown. The stratified inland beds here described are thus classified because their character and mode of occurrence are, to some extent, different from those met with at lower levels. As recognized in New Brunswick and discussed in former reports, they comprise lenticular sheets in a partially stratified condition formed (a) from ordinary subærial influences, such as the loosening and transportation of pre-existing beds of decayed rock or till from higher to lower grounds by rains, frost, melting snow, etc., this subærial action having been pre-glacial and

Deposits above 220 foot contour.

post-glacial, and, indeed, in progress since, and (b) from glacial floods, that is, from the waters resulting from the melting of land ice during and at the close of the glacial period. The seams of clay or loam interstratified with these gravels and sands are, in this region, rather thin lenticular masses and very irregular.

The deposits under consideration seldom or never form regular, well defined terraces beyond, or outside of the valleys of rivers and lakes, and, moreover, their stratification is often irregular and sometimes obscure. They constitute, nevertheless, an important part of the superficial deposits of the region. **Uneven surface.**

These gravels and sands, so far as observations have extended, invariably overlie the till wherever the two occur together, and underlie, or merge into, the fluviatile and lacustrine beds. Peat bogs and marshes often occupy the hollows upon their surface. **Relation to other formations.**

The great development of these gravelly and sandy deposits upon the higher grounds of this region compared with other parts of the province, is largely owing to the abundance of the hard gritty debris of the older rocks, their disintegration having yielded immense quantities of coarse pebbly materials. In former reports (Annual Report, Geol. Surv. Can., 1885, page 35, G.G., and Annual Report, Geol. Surv. Can., 1886, page 20, M.) these deposits are described in some detail and their origin discussed. **Cause of abundance of gravels.**

The kames occurring in connection with these gravels, and which are supposed by some geologists to be of glacial origin, have already been treated of on page 28. **Kames.**

River Terraces and Kames of River Valleys.

Above the 220 feet contour line some remarkable terraces of fresh-water origin were met with in the river valleys of this region, notably along the Nerepis; north and east of Loch Lomond; along Ratcliffe's Brook, also on the upper part of Big Salmon River, near where the Shepody road crosses it, etc. These will be now described in some detail. Kames also occur in several of the river valleys and along streams where the drainage has apparently become lessened since the materials were originally thrown into the valleys after the glacial period, or rather, perhaps, where the rivers have cut down more deeply into them. These deposits (terraces and kames) with the overlying loamy beds often, however, extend along rivers some distance below the 220 feet contour, and are together referred to in former reports as *valley drift.* Since the last great Post-Tertiary upward movement of the land commenced, river erosion and transportation of materials occupy- **Terraces and kames of river valleys.**

ing the valleys above the 220 feet level have been going on coincidently therewith. Hence we find that along some rivers the marine deposits are overlaid, from the 220 feet contour down to their mouths, with these fluviatile gravels, sands and clay, capped sometimes with loam or recent deposits. The materials of these fluviatile terraces and kames are, of course, similar to the gravels, etc., described under the last head, being largely derived from a common source, *i.e.*, from the rotted rock and till of the drainage basin of the river along whose course they are found. There is this difference, however, that the fluviatile materials referred to are sometimes finer and more water-worn, and have fewer large boulders interspersed through them. Intercalated beds of clay are also, perhaps, less common in the river terraces here, but this is partly due to local conditions, the deposits containing less fine matter than in some other parts of the province.

Marine deposits sometimes overlain by these beds.

Soil of terraces

Unless capped with loam these terraces usually constitute a dry soil; but they are often covered with a layer of this material of variable thickness which greatly improves their fertility.

A few of the larger terraces and accumulations of river gravel may here be noted:—

Localities of river terraces.

1. Along the valley of Nerepis River, above and below Welsford station, N. B. Ry., also south of Gaspereau station, terraces extend. At Welsford they are 140 feet high, at Gaspereau 205 feet, and between Welsford and Nerepis stations 110 feet.

2.—On the Long Reach, St. John River, at the first cross road below Jones' Creek, in the second concession, there is a terrace 190 feet high.

3. Along Magaguadavic River, extensive terraces occur in places, especially north of the limits of the map. At Red Rock settlement, at the base of Red Rock Mt., in a valley there between Magaguadavic River and Lake Utopia, which is really part of the old pre-glacial course of that river, a fine terrace, 228 feet high, occurs.

4. Along the Digdeguash River valley terraces were seen in numerous places. In the lower part they are probably lacustrine, or rather have been formed in lake-like expansions of the river. They have, however, been much denuded, the remnants now forming kames.

5. In the tract around the head of Moannes Stream in western Charlotte, especially in the vicinity of Hitchings Mill, great quantities of gravel were observed, partially terraced,—height, 220 feet.

6. East of St. John River we find terraces without number. In the valley of Jones' Brook. above Tennant's Cove, there are deep banks of terraced gravels.

7. In Belleisle valley terraces occur at The Point; above Belleisle

Corner; at Northup's Brook, and, indeed, all the way up to Studholm's Millstream.

8. Great quantities of gravel constituting fluviatile terraces from 150 to 250 feet high were seen along the upper part of Millstream valley, in some places, kame-like. These are somewhat similar to the terraces, etc., presently to be referred to, occurring abont the head of Smith's Creek, also in Kennebeckasis valley, especially on the east and north sides of Sussex Vale and at South Branch. River terraces in Millstream and Kennebeckasis valleys.

9. A well developed terrace occurs at the forks north of the Kennebeckasis River, on the main road from Penobsquis to Anagance. Height 200 to 225 feet. Water-worn gravel! A red pine barren.

10. Where the Shepody road crosses Big Salmon River (height of bridge 700 feet) three terraces occur on the right bank. The first is 6 to 8 feet above the river, the second 50 feet, and the third 75 to 80 feet. The last is wide, has an uneven surface and much coarse, pebbly material and slopes upwards to a height of 90 or 100 feet.

11. Along North River and around the head of a branch of Never's Brook, between Butternut Ridge and Lewis Mt., great quantities of stratified gravel occur in terraces and mounds, some above the 220 feet contour line and some below it. These have apparently been thrown down about the margin of the Post-Tertiary sea. Hummocks and short ridges of gravel and sand are frequently indicative of shore lines as well as terraces. At North River.

12. Along the valley between Loch Lomond and Barnesville, and towards Hammond River, at Upham, etc., terraces and kames of fluviatile origin are well developed. Some of these, especially near the margin of the lakes, and for 50 feet above it, may be lacustrine; but it would seem as if the Hammond River itself flowed along this valley not only in pre-glacial times, but for a short period subsequent to the Ice Age. At Loch Lomond, etc.

13. Terraces and short kames are of frequent occurrence along Germain Brook from Hardingville down to its confluence with Hammond River.

14. A wide terrace or series of terraces occurs along Ratcliffe's Brook 390 to 400 feet high.

15. On the road from Dolin's to Mark's Lake great banks of gravel, terraced in places, were seen on the west side of Loch Lomond. These apparently hold in that body of water.

In addition to the above it may be stated that every river or stream in the region has a greater or less amount of stratified gravel, etc., terraced along its banks, the development of the terraces and their elevation corresponding always with the volume of water, the velocity of the river, etc., as well as with the quantity of material originally thrown down in the valley during the glacial period. This question, however, will be discussed in the sequel.

Kames of river valleys.

Along river valleys, hummocks and confluent ridges, called kames—residual portions of terraces—may be observed. The summits of these are often level and mark the elevation of the flood, either fluviatile or marine, when the terraces were formed. In this region, kames in river valleys appear, as stated on page 30, to be the result of denudation, *i.e.*, they are masses of gravel, sand, etc., left from the rivers wearing away the chief portion of the terraces of which they once formed a part. Below the 220 feet level nearly all these kames are the remains of marine terraces, and their origin and mode of occurrence seem to have been as follows:—During the Post-Tertiary subsidence the river valleys, up to the 220 feet level, formed estuaries, and terraces were built up in them from the materials carried down by the rivers. On the re-elevation of the land, the process of erosion began again in these, and the rivers denuded large portions of the terraces coincidently with the upward movement, leaving in some places only marginal strips along the banks, and in others mounds or ridges in the middle of the valleys. These last now constitute the kames mentioned.

How formed.

The principal river valley kames met with in the region are:—

Localities of.

1. At Flume Falls, Magaguadavic River, already referred to, and extending down river an unknown distance (see map). Not traceable owing to wooded condition of valley.

2. At Piskahegan bridge, Magaguadavic River, extending along east side of valley continuously for a mile or more below the bridge, and above it for an unknown distance. District likewise wooded.

3. Just below Watt Junction, N.B. Ry., in Digdeguash valley, a kame has been formed by the denudation of a terrace by the main river on the one hand and the N. W. Branch on the other.

4. Further down the Digdeguash valley, between Rolling Dam and Dyer's, short kames occur, first on the west side, and below the railway bridge, on the east side. Their height is about 220 feet above the sea, showing they are undoubtedly portions of denuded marine terraces. No fossils were, however, detected in them.

5. Along a stream called Meadow Brook, to the north of South Oromocto Lake, (see map) a kame was seen.

6. In Belleisle valley a kame stretches from the foot hills close to Pascabec stream nearly to the cross road below (see map). Height about 175 feet.

7. In the same valley another extends from the mouth of Northrup's Brook nearly to Belleisle Corner (see map). This kame is also below the 220 feet level, but has, nevertheless, been caused by the denuda-

tion of terraces here principally by Belleisle Creek and Northrup's Brook.

8. A kame was observed on the road from Millstream to Collina, near the branch of that stream which is crossed (see map).

9. At the mouth of South Branch, Kennebeckasis, and just north-east of Penobsquis village, a kame 150 feet high occurs. It is also a part of a denuded terrace.

10. In Hammond River valley, a kame is seen on left bank, between Fowler's Corner and the road going to Saddleback settlement. Length about a mile. Height 450 to 500 feet.

11. The whole valley between Loch Lomond and Hammond River, by way of Barnesville, contains kames and hummocks of gravel. One on the west side of the valley extends from Barnesville nearly to Hammond River (see map).

12. Where the Salt Spring's valley joins that of Hammond River, short kames and mounds of gravel are conspicuous phenomena.

Numerous short kames, ridges and hummocks were observed in other river valleys; but as they evidently all belong to the same class, and are apparently of like origin, it seems unnecssary further to enumerate them.

Lake Terraces and Kames.

The deposits found around lakes (terraces and kames) were briefly described on page 30. The materials of these sometimes resemble boulder-clay, having been packed together by the shove of the lake ice; in other places they consist of fine blown sand; but in general they are composed of gravels of different degrees of coarseness. Well-rounded boulders are frequently packed into these gravels. Around the margins of extinct Post-Tertiary lakes, and of others partially drained out these deposits are often well exhibited. **Lake terraces.**

On the margin of Grand Lake terraces and kames were observed from Sypher's Cove to the Keyhole and beyond it. These are now in process of formation and hold in lagoons or swampy or peaty tracts. At the northern end, and along the lower part of Salmon River, terraces and mounds of gravel and blown sand occur from 75 to 100 feet above the present level of the lake. The peninsula between Grand and Maquapit lakes is covered with water-worn gravel and sand to a height of 100 to 110 feet above the lake surface, and really resembles a wide flat kame at the lower end. A short distance to the north of the Jemseg River a kame 100 feet above the lake is also seen (see map). These all go to prove the former high level of Grand Lake. At Upper Gagetown, on the west side of the St. John River, terraces and kames also **Formation of at Grand Lake, etc.** **Along St. John River.**

occur at about the same elevation, and in numerous places along the river, especially at the mouths of tributaries, other terraces and fragments of terraces at about this height (100 feet) were noted. Proceeding up the St. John beyond the limits of the map we find, at the mouth of the Oromocto and above Marysville on the Nashwaak, terraces and sand banks evidencing former shore lines; while in the Keswick valley a remarkable terrace, described in Report of Progress, Geol. Surv. Can., 1882-83-84, page 37 G.G., occurs between Burnside and Lawrence stations, N. B. railway, which is from 115 to 120 feet above the tidal waters of the St. John. In the report cited it is accounted for on the theory of a dam further down the Keswick valley, but from the evidence now on hand it seems more reasonable to suppose that this valley was, in the Post-Tertiary period, occupied by an arm of a lake which stood at about that level, and into which the gravels, etc., forming the terrace were deposited. A close study of all the facts in the St. John valley, from the Keswick to its mouth, leaves little doubt that a post-glacial lake existed here for some time, previous to the wearing out of the present outlet of the St. John, as referred to on page 8, and that its elevation above the existing tidal waters was probably from 100 to 120 feet.

Terrace at Keswick.

Post-glacial lake at Keswick, and in St. John valley.

Post-glacial lake in Kennebeckasis valley.

The valley of the Kennebeckasis seems also to have been occupied by this extinct lake, or formed an arm of it for a certain period. Terraces occur at Norton station 105 feet high; along Caldwell's Brook opposite, 120 feet high; on the east side of Sussex Vale at different elevations from 80 to 125 feet, etc. Some of the latter, between Sussex Corner and Penobsquis, are banks of blown sand similar to those at the head of Grand Lake. On the north-west side of Sussex Vale, in and around the lower part of Smith's Creek valley, terraces of similar character and height were met with; and others 80 to 100 feet high skirt the valley of Studholm's Millstream at Berwick and vicinity, extending along the base of the hills between that and the confluence of Millstream with the Kennebeckasis. Correlating the facts obtained in the Kennebeckasis valley with those found along the St. John and its other tributaries, it seems tolerably certain, therefore, as stated above, that the great post-glacial lake of the St. John valley extended into this basin also, but was here a comparatively shallow body of water, and its existence probably of short duration. As the land continued to rise it shrank back towards the St. John; but the remains of a drift-dam at Apohaqui indicate that a portion of it was held in above that point for another limited period, Sussex Vale and some of the valleys connected therewith being the seat of a smaller lake until the drift-dam at Apohaqui referred to became eroded.

Reference has been made to Smith's Creek valley and its partial occupation by the lake mentioned, but there is some evidence which rather goes to show that this valley was occupied, especially in the upper part, by a lake of its own in post-glacial times, which stood at a somewhat higher level than those above described. For example, at the upper end of the valley between White's Mountain, Cornhill and Newtown there is an extensive gravel terrace 225 to 250 feet above sea level, which has a flat, even surface, with a gentle inclination down stream. This terrace is composed, in the upper part at least, of well water-worn materials, with an occasional sand bed, but no clay was seen in it. It would seem that at about the same time that Sussex Vale was occupied with a post-glacial lake, at a height of 80 to 100 feet above sea level, Smith's Creek valley also held in one at a level of about 250 feet. Several drumlins in the lower part of that valley appear to be the denuded remnants of a drift-dam which existed there. A shore line is also traceable in several places, notably opposite Newtown. Into the upper part of this body of water the gravels, etc., referred to were deposited and now form the terrace described. Lake in Smith's Creek valley.

Evidences of extinct post-glacial lakes were also seen in other parts of the region. Shallow ones occupied the valley lying to the north of Dolin's Lake, St. John county, as shown by the character of the deposits there and the configuration of the basin.

All these small post-glacial lakes seem to have been short-lived. The abundant precipitation about the head waters of the Kennebeckasis would soon cause the streams to cut through the dams holding them in and occasion their extinction. Duration of post-glacial lakes.

In regard to terraces and kames met with on the borders of existing lakes, more particularly those due to other than marine agencies, we may cursorily refer to a few of them. Terraces and a kame occur along the south and east sides of Lake Latimore, St. John county, which hold it in. The height of the lake is 302 feet, and the kame rises 10 to 25 feet above its surface. The materials are coarse, water-worn gravel and boulders, evidently having been worked over by the lake waters and lake ice. Terraces and kames in St. John county.

Another kame and terrace were seen along the south-east side of Negro Lake (366 feet high ?), which have apparently been formed by the lake ice. Otter and Negro lakes are probably on the same level.

On the east side of Second and Third lakes, above Loch Lomond, gravel terraces, mounds and short kames are numerous. They rise from 50 to 75 feet, or, perhaps more, above the level of Loch Lomond, which is 300 feet above the sea. No regularly formed kames were seen among them, but these and the terraces along the east side of the lake show that that body of water once occupied a higher level and covered a larger area than at present.

Kame at McDougall lake.

A fine kame occurs at McDougall Lake (see map), which is also of lacustrine origin, although lying probably below the 220 feet contour line.

Sand's Lake, on Shepody road, is a small body of water on the east bank of Salmon River held in by a terrace or kame. Water-worn pebbles six to twelve inches in diameter occur in the gravel. This lake is without inlet or outlet, being fed by springs. Its height above the sea is about 800 feet. I was credibly informed that it is inhabited by eels.

Theory regarding the origin of river terraces and kames.

In Report of Progress Geol. Surv. Can., 1882-83-84, page 41, G.G., and Annual Report, 1885, page 38, G.G., a theory of the origin of river terraces and kames was propounded, which it now seems desirable to consider in some detail, especially as many new facts regarding these formations have been discovered in the region in question. From the foregoing descriptions of terraces and kames it will be seen they are quite common along all our rivers and streams, and, in many places, are typically developed. They seem, therefore, to afford a sufficient basis of fact for discussion as to their origin.

Mode of occurrence of terraces.

Terraces are found at all elevations along the river valleys of New Brunswick from their mouths to their sources, and form benches or steps from a few feet in height up to one hundred feet or more above the level of the adjacent river bed. In length they are seen from a quarter of a mile or less to several miles, winding along the valley slopes. As has been shown long ago by Prof. J. D. Dana (Manual of Geology, 3rd ed., p. 551), "in the position of the upper limit of the " *river-border formations* there is no direct relation to the level of the " ocean. They were made by flooded rivers or lakes, and the height of " the flood-waters determined their level. The streams over plateaux " or slopes 2,000 feet above the ocean would have made deposits at that " height, *plus* the height of the flood above it." In dimensions and number these formations are found to have a close relation to the river along the banks of which they occur; the depth of the valley, the volume of water and extent of the drainage area, as well as the amount of loose materials occupying it ready for transportation, being all factors in the production of river terraces and kames. The largest rivers are found invariably to have the largest terraces and *vice versa*. They have always more or less slope down stream; the surface generally corresponding to that of the river. Sometimes there are terraces of the same elevation on opposite sides of the valley, but this appears to be accidental, each terrace having apparently been formed separately and independently. The materials are water-worn gravel and sand, with a few small boulders, and usually become coarser towards the summit. The lower terraces are generally capped with loam of various depths. Boulder-clay often underlies them, especially on the upper slopes of valleys.

A characteristic feature of river terraces is that they are usually better developed below the mouths of affluents, water-falls and constrictions and bends in the river valleys, where the flow has been most rapid and the amount of detrital material in the valley greater, than along the wider and more level reaches. Indeed, it is almost invariably found that their elevations, relative to the river, are greater where the valleys are narrowest and deepest, and correspondingly lower where they are widest.

Objections to generally accepted theory of their origin.

The generally accepted theory that terraces have been formed by flooded rivers at the close of the glacial period and subsequently denuded in part, as the volume of water decreased and became confined to narrower channels, thus cutting down into the original deposits, seems to be only partially correct and to require modification or extension. That the river valleys of New Brunswick have been flooded to a depth equal to the height of the upper terraces,—the St. John, for example, 150 to 200 feet,—from the melting ice of the glacial period, is a view which does not seem to be sustained from the evidence at hand.* Moreover, this theory fails, also, to take into account the fact that these valleys, in certain places, were partially or wholly filled with masses of glacial drift during the ice age, sufficient to block them up nearly to the general level of the country on both sides. This is evidenced by the accumulations still found occupying them in places, causing the diversion of the rivers from their old pre-glacial channels. A more reasonable solution of the problem seems, therefore, to be, that on the final retreat of the ice of the glacial period, the river valleys, or such portions of them as were then open between the embankments of glacial drift referred to, would be re-occupied by the precipitation of the river basin. These waters would, in portions of the river valleys, form lakes or chains of lakes all tending to overflow by the lowest passage, which, in most cases, would be along the course of the pre-glacial valley. Erosion and the filling up of these lake-like expansions with detritus

Probable mode of formation.

* What I mean is, that no such body of water as a river 150 to 200 feet deep, flowed in the St. John valley at the close of the glacial period, or at any other time. Such a river, with the velocity it would acquire in certain parts of its course, would sweep everything in the shape of loose materials occupying the valley out to sea. But, if the view that the glaciers of the ice age were produced by a slow, secular change of climate and other conditions, be correct, it seems reasonable to conclude that their retirement was brought about by a reversal of these conditions and would likewise necessarily be slow. Hence the theory of glaciers dissolving rapidly, except for a few months, perhaps, in each summer, does not seem tenable.

would then commence, every tributary, as well as the main river, carrying down its contribution, which, wherever these river expansions were of any considerable length, would be thrown down and form deltas and terraces. Gradually the smaller and narrower ones, more especially in their upper reaches, would become partially or wholly filled with detrital material except in the passage or channel of the river. As the embankments of glacial drift referred to holding in the lakes became eroded and the river's passage through them deepened coincidently with a lowering of its waters, these partially filled lake-like expansions would assume the river-like form, and eventually become a part thereof, and terraces appear along the sides. Finally, by erosion and the deepening of the river's channel, it would reach a comparatively even flood–plain, and as it became more and more confined to a narrow channel other and lower terraces would appear along its borders from time to time. In this way might the terraces have been formed without supposing the existence of enormous floods and rapidly dissolving glaciers. Indeed, the view here indicated does not require that the rivers should be very much greater in volume than they now are. On a small scale this process is, in reality, still going on in certain parts of river courses simultaneously with a general seaward movement of the materials of their valleys. In this way, also, it may be stated, have the kames of river valleys been produced, which, as already shown, are but residual portions of terraces, although it may be found that they sometimes contain till or glacial drift in the bottom. They have, however, under certain conditions of the rise and fall of the river, been enlarged or lengthened at one or both ends by periodic increments of material.

Probable origin of river valley kames.

Erosion by rivers.

None of the New Brunswick rivers have succeeded since the glacial epoch in eroding the drift materials entirely from their valleys down to the rocky floor. On the contrary, there would seem, in many parts of river courses, to be an accumulation of deposits. This, however, is owing to the varying speed of the currents and the quantities of sand, gravel, clay, etc., at hand. In some parts there is a local wear and deepening, in others a deposition, yet this is only temporary and may be the seat of erosion later on; the final destination and resting place of all the materials of a river valley being the floor of the ocean.

Formation of stratified deposits on lake borders.

The stratified deposits around lake-borders, which likewise comprise terraces, kames, hummocks, etc., have had an origin somewhat similar to river-border formations, but are by no means so regular and systematic in structure. Wherever they occur at elevations beyond a few feet above the level of the lake surface, they indicate a subsidence of its waters and a draining out, caused, generally, by the river or outlet wearing down the barrier holding in the lake. A characteristic feature of lake borders is the presence of mounds, sometimes wholly of gravel, but occasionally with boulder-clay underneath, while in other places they consist altogether of blown sand. Ridges of compacted gravel, sand and clay, with boulders, apparently unstratified, and resembling till somewhat, are also met with in the banks of the lakes. These have been produced by the shove of the ice which forms on them every winter. The highest post-glacial level of lakes is traceable in the higher terraces and mounds of gravel, sand, etc.

M2 (*b*). Marine Deposits.

Leda Clay and Saxicava Sand, and Kames Along the Coast.

Leda clay and Saxicava sand occur under somewhat different conditions here from what they do in northern New Brunswick, and are by no means so well developed. Nor are fossils found in them so abundantly either, and such as have been detected are rather poorly preserved. This may be partly due, however, to the fact that the strong currents and turbid waters of the Bay of Fundy were unfavorable to the life of marine testacea in the Post-Tertiary period, and to the presence of iron and other minerals in the clays destructive to the shells entombed in them.

Mode of occurrence of Leda clay and Saxicava sand.

Fossils.

The Leda clay and Saxicava sand series of this region is usually associated or interstratified with gravels; indeed, the Saxicava sand is, to a large extent, made up of these. The terraces and deltas occurring at different elevations near the coast, from sea level to 220 feet above it, are also composed chiefly of gravels, which, however, sometimes contain arenaceous strata, and irregular lenticular sheets of clay in the bottom. In many of the terraces, however, no clay or sand is to be seen, while, on the other hand, a few on the lower levels are composed almost wholly of sand and clay, and it is these usually which are fossiliferous. Some of the more remarkable marine terraces may here be described.

A large and remarkable terrace lies east of the Magaguadavic River, extending to the Popelogan River, and from the coast at and near Beaver Harbour back as far as Messinet Stream. Its general height is from 200 to 225 feet. Ridges or kames 250 feet high rise in it. Along the main highway from St. George to Lepreau its elevation is from 200 to 220 feet. On the eastern side of L'Etang it seems to be highest, sloping thence gradually eastward and southward. North of the main highway mentioned, especially in the vicinity of Messinet Stream, it

Localities where observed.

Pennfield.

rises to 220 to 230 feet, and several kettle holes from 10 to 20 feet deep were observed in it there. Old shore lines and beaches are distinctly seen in places, especially at Pennfield. The materials are water-worn gravel and sand with a few boulders interspersed through them, and seem to have been brought down by the Magaguadavic River and scattered about on the sea shore here during the great Post-Tertiary submergence.

New River. Another extensive terrace lies between Popelogan and New rivers, the general elevation of which is from 160 to 200 feet. It is composed of similar materials to the Pennfield terrace, being the detritus of the two rivers mentioned thrown down along the Post-Tertiary sea-border here and levelled off by the tidal currents.

Sand Cove. At Sand Cove, Lancaster, a terrace with Leda clay (containing fossils) and Saxicava sand, forms the bank. It is narrow and abuts against a ridge a few hundred yards behind. This and another terrace or kame at Manawagonish beach exhibit the structure of the fossiliferous marine terraces to good advantage.

Mispec. At the mouth of Mispec River terraces 75 and 125 feet high were met with.

On the east side of the mouth of Black River terraces were also observed at the 75 and 100 feet levels.

Gravel terraces occur along Emerson's Creek, one at a height of 75 feet and another at about 175 to 180 feet, both in a well developed condition.

Quaco. At Quaco, on the south-west side of Mosher's Brook, there is a terrace 160 feet high; and at the mouth of Vaughan's Creek similar terraces were seen facing the Bay of Fundy.

Point Wolf and Alma. Marine terraces were observed at Point Wolf and Alma from 100 to 125 feet high. A section of one at the latter place is given on page 24.

Marine fossils. No fossils were detected in any of these sea-border terraces east of the St. John ;* but they are undoubtedly marine, as they all face the Bay of Fundy and have been formed in the shallow waters during the Post-Tertiary subsidence. Marine fossils of this age have, however, been found at Fairville, near St. John, and at Lawlor's Lake, in the Kennebeckasis valley, as well as at the two localities mentioned above, viz., Sand Cove and Manawagonish beach.

Petitcodiac. Between Petitcodiac and Penobsquis a number of terraces, from 200 to 220 feet high, mark the upper limit of the marine beds, showing that

* Mr. Geoffrey Stead, of St. John, has found marine fossils at Quaco, St John county, during the past summer (1890), in Leda clays 4 to 10 feet above high tide level in the Bay of Fundy. Two species not mentioned in former New Brunswick collections were obtained, viz., a *Mactra* and a *Solen*.

the sea swept up and down this valley during the submergence referred to. Others were noted on both sides of the Kennebeckasis valley in different places farther west, and especially in the valley of Patticake Brook.

East of Petitcodiac sta. terraces, evidently marine, occur at Boundary Creek, etc.

In connection with the terraces just described a number of kames have been noted as occurring below the 220 feet level. These, as shown by Mr. Matthew, are approximately parallel in direction to the Bay of Fundy coast, their courses thus diverging at a wide angle from those of the kames on the higher levels. Marine terraces often flank them. Mr. Matthew has described thirty-seven of these in the report already cited (Report of Progress Geol. Surv. Can., 1877-78, page 13 E.E.). As, however, the elevations of many of them were omitted, I shall here refer to the principal ones, giving some additional features and characteristics to aid in elucidating their origin. **Kames, direction of.** **Where observed.**

1. South of Lake Utopia a wide flat kame stretches about a mile and a half in a north-east and south-west direction, damming up the lake; height, from 165 to 180 feet. The materials composing it are stratified gravel and sand with a few scattered boulders.

2. Pennfield Ridge, so-called, is another. It is in reality a wide raised beach of Post-Tertiary age. Length, upwards of three miles; course about S. 65° W.; height from 200 to 225 feet. Gravel and sand also, with a few boulders, all water-worn.

3. At Pisarinco there is a kame along the shore, ending at Negro Head; course, S. 60° W. This is also a flat gravel and sand ridge.

4. A kame extends from Fairville, St. John, nearly to Spruce Lake, the Manawagonish road, so-called, passing along its summit most of the distance; course, S. 50° W.; height, 180 feet. Gravel, sand and boulders, well exposed in a pit opposite Manawagonish beach.

5. A kame-like ridge on the north-west side of Germantown Lake was noted; course parallel to lake and coast; height, 150 feet. Gravel and sand, with rock probably underneath.

The courses of these kames, it will be seen, are parallel to the coast of the Bay of Fundy, and show that they must have been formed by its currents, more especially its tidal currents; but river currents may, in certain cases, notably the St. John River in that of the Fairville and Manawagonish kame, have been instrumental, in some degree, in modelling them. **How formed.**

The materials composing these kames are such as lay on the surface in great abundance when the Post-Tertiary subsidence took place, viz., decayed rock material, boulder clay, boulders, moraine stuff, etc. The rivers, also, doubtless supplied large quantities of detritus. Some of these kames were formed along moraines or banks of boulder-clay or low rocky ridges.

The relation of the stratified gravels, sands, etc., below the 220 ft. level, generally, to the glacial deposits of the region, leads unmistakably to the conclusion that the formation of marine terraces and kames took place during the Post-Tertiary submergence of the coastal district. The lower beds would seem, indeed, to have been deposited at the close of the glacial period or soon afterwards, that is, whenever the subsidence referred to had so far advanced that tidal currents could act upon glacial and other debris in the submerged areas. At this stage the conditions of the Bay of Fundy would probably be unfavourable to the existence of marine life. Local glaciers would still cling to the shores and ice-laden currents would scour the bottom. Hence, although clay is found interstratified with the lower gravels, that is, those gravels immediately overlying the boulder-clay, it has, so far, proved to be unfossiliferous. It was not, perhaps, until the subsidence had attained its maximum that molluscan life existed here, and this consisted merely of a few hardy arctic and subarctic forms. The more prolific fossil beds were laid down at a later stage, and when an upward movement of the land was taking place and had somewhat advanced.

Sequence of events during Leda clay and Saxicava sand period.

The general sequence of events during the Leda clay and Saxicava sand period seems to have been about as follows:—A subsidence of the land at the close of the glacial period, accompanied by flooded rivers from the melting ice, etc., during the summers, and consequent transportation of large quantities of detritus to the sea. This, together with the boulder-clay, and other superficial deposits lying upon the submerged area, acted upon by the powerful currents of the Bay of Fundy would, in some places, be spread over the bottom, in others thrown into banks in the lee of moraines, ridges and bosses. The temperature of the water, its turbid condition, etc., would be unfavourable to the existence of marine life. The clays, it will be seen, are, therefore, often scanty, and in many places, coarse and pebbly, and contain few, if any, molluscan remains. When, however, the subsinence had attained its maximum, which was about 220 feet below the present high tide level, or perhaps, in the early stage of the upward movement, marine invertebrata seem to have occupied the waters, the shells of which became embedded in the finer clay deposits. Emergence continuing, tidal currents would act powerfully on the shallow bottom, and the rivers, cutting more deeply into the sediments occupying their mouths, would still transport considerable quantities of detritus seaward. Ridges would be built up in some places, while elsewhere they would be levelled down. In the quieter bottoms, and in lagoons and estuaries, molluscan life would thrive more abundantly as the upward movement progressed coincidently with an amelioration of climate. While, however, Leda clay was being deposited in some parts, Saxicava sands and gravel beds would, doubtless, be laid down in others, where the sweep of the currents would not permit deposition of the former. The upward movement still advancing, erosion of pre-existing marine beds would still be continued by tidal currents in the sea bottom, and by the rivers in the estuarine portions. The Saxicava sands would partake largely of the character of the gravels from which, at this stage, they would be almost wholly derived, and the marine life would now assume the character represented by the remains found in the upper part of the Leda clay and in the Saxicava sands. The shoaling movement of the sea-border went on till the land attained a height somewhat above that which at present obtains.

Gravels and sands in Leda and Saxicava sand series.

The gravels, sands, etc., composing the marine terraces and kames of the region may, therefore, be considered as forming part of the Leda clay and Saxicava sand series, and as occupying the same geological interval. Their great development here is owing to peculiar local conditions, such as the large quantities of debris originally furnished by the hard crystalline rocks, and the erosion of these since by glaciers, by atmospheric action, by rivers, Bay of Fundy currents, etc. That the terraces and kames have been formed as described above is evidenced by the fact that they often contain, interstratified, coarse gravels, layers of pebbles, or sometimes of finer sand, and occasionally near the bottom, clay, the materials varying according to the nature of the supply and the strength of the transporting currents. As a rule, however, the coarsest materials are at the base and summit as we would naturally expect.

Strength of Bay of Fundy currents.

It has been shown by Mr. Matthew in the report cited that the tidal currents of the Bay of Fundy are sufficiently strong to transport coarse materials and form gravel and sand banks. During the Post-Tertiary subsidence they would probably be still stronger as they swept through the whole length of the bay and across the submerged isthmus of Chiegnecto.

Absence of fossils in St. John valley, and why.

The absence of marine fossils from clays in some sheltered valleys, where we might naturally expect to find them, is difficult of explanation. Probably some of these basins, although below sea level during the Post-Tertiary subsidence, were really occupied by fresh or brackish waters, similarly to the St. John valley now from its mouth to Fredericton or Keswick. Even during a part of the time of the great change of level mentioned, the St. John waters must have been fresh, or nearly so, owing to the barriers at or near its mouth. For, a subsidence of 220 feet would allow the sea to invade the region above the Long Reach on the St. John River only by its own valley, and, perhaps, one or two smaller ones. Hence the absence of marine fossils above the mouth of the Kennebeckasis, notwithstanding that the stratified gravel, sand and clay were deposited at and below sea level.

List of fossils. A list of the molluscan and other remains found in the Leda clay and Saxicava sand of the region is given in Mr. Matthew's report, already referred to. No additional species were discovered by the writer during the past three seasons.

M3(a). Fresh Water Deposits (Recent.)

River-flats (Intervales.)

Fresh water alluviums. Alluvial deposits of this kind are found along all the larger rivers of the region, but are nowhere so extensive as in the St. John valley between Oak Point, in the Long Reach, and the western border of sheet No. 1 N.E. All the islands in this part of the river's course are alluvial except portions of Foster's and Caton's islands; and a selvage of intervale land, of varying width, also skirts either bank. River-flats stretch along the Nerepis, also in the valley of the Canaan above Cole's Island, and occur at the head of Belleisle Bay extending some distance up Belleisle Creek. The Kennebeckasis valley and those connected with it are noted for their intervales and meadow lands throughout. Sussex Vale is largely an alluvial flat. Deposits of this kind are found along Petitcodiac and North rivers above tidal waters, and minor ones skirt the tributaries. The abrupt and precipitous character of the Bay of Fundy coast from Alma to St. John harbour precludes the formation of intervales in the lower reaches of the rivers there; but west of St. John, especially in Charlotte county, we find them again occurring along the chief rivers. The Magaguadavic has large flats between the lower and upper falls, and beyond that, becoming narrower, however, as we go up stream. Along the Digdeguash, Bocabec and St. Croix, similar alluvial flats of various widths may be seen extending nearly to their sources.

Flats of like character are met with on the margins of lakes, but in the area under consideration they are of very limited width, and scarcely worthy of notice.

Mode of formation. The mode of formation of these deposits has been discussed, to some extent, in previous reports (Annual Report Geol. Surv. Can., 1885, page 48 G.G., also Annual Report, 1886, page 27 M.). In Southern

New Brunswick they are of similar origin and character to those referred to, except, perhaps, in the St. John valley, where their great development is due, largely, to local conditions instead of directly to fluviatile action, such as the partially submerged state of the district and the ponding back of the waters of the St. John River by obstructions at its mouth. The formation of the extensive river-flats there may be said to have commenced during the great Post-Tertiary subsidence, coincidently with which a partial filling up of the St. John valley must have taken place. On the subsequent upward movement of the land the waters of the St. John, as stated on a previous page, were held in by barriers consisting partly of boulder-clay and partly, perhaps, of marine deposits, and ponded back, forming a large fresh water lake. In these quiet waters the finer sediments carried down by the St. John and its tributaries were, and are still being deposited, making the intervales, islands, etc., referred to. The pent-up waters after finding vent by the present outlet of the St. John would be lowered somewhat, exposing these alluvial beds as dry land. while channels alongside of or through them would be formed by the contracted currents. A section of these beds would exhibit the following series in descending order:—

In St. John valley.

1. Loam, river-silt, or fine sand.
2. Stratified gravel, sand, and, perhaps clay in the bottom.
3. Boulder-clay or rotted rock, etc.

The St. John River flats referred to are annually overflowed by spring floods, which rise from six to ten feet or more above the ordinary summer level of the river. These floods deposit a layer of loam or silt upon the flats year after year, which serves to maintain their fertility and repair the waste going on. Their agricultural character will be referred to in the sequel.

Lacustrine Deposits.

(Shell-Marl, Infusorial Earth, etc.)

A deposit of shell-marl occurring at Lawlor's Lake, St. John county, is described by Mr. Matthew in the report already several times cited, page 34, Part E.E. (Report of Progress Geol. Surv. Can., 1877-78.) This substance has been reported from other lakes in this region, but I have not had an opportunity to examine them. A considerable bed of infusorial earth occurs in the bottom of Fitzgerald Lake, St. John county. This lake basin lies six miles east of the city of St. John, near Lake Latimore, in the hill district from which the city water supply is obtained. The lake was drained off by the St. John Water Company a

Shell-marl, where found

Infusorial earth.

few years ago, its average depth having been only about five feet, and the bed of earthy tripolite referred to thus exposed. Mr. Wm. Murdoch, C.E., of St. John, has been making efforts to have it utilized. Its extent and value will be considered under the head of Economic Materials.

Other deposits of tripolite were found at Pollett River Lake, Mechanic settlement, and Pleasant Lake lying to the south of the latter, near the old Shepody road. The bed in Pollett River Lake is four feet deep, and is described on page 26, Part D, Report of Progress Geol. Surv. Can., 1878-79.

Peat Bogs.

Peat bogs abundant.

Peat bogs are numerous in southern New Brunswick, and some of them large. In no other part of the province is the surface so diversified with peaty areas as in the coastal tract between the St. Croix and Black River, St. John county. From Spruce Lake to the Magaguadavic River especially, they are a characteristic and ever-recurring feature of the scenery. Indeed, every depression that caught the drainage seems to have yielded a peat bog. The climatic conditions of the Bay of Fundy coast seem peculiarly favorable for the growth of the mosses composing them, being damp and cool in summer, and with an abundance of foggy weather. Some of the bogs attain a considerable width, although by no means as large as those of the coast district of north-eastern New Brunswick, page 22, Part N (Annual Report Geol. Surv. Can., 1887-88), the great majority not covering larger areas than from two to five acres each. Of late years many of these peat bogs have become valuable on account of the immense quantities of cranberries (*Vaccinium macrocarpon* and *V. Vitis-Idœa*) which they produce. Hundreds of bushels are collected and shipped to the principal markets every season.

Musquash bay.

One of the largest bogs on the Bay of Fundy coast occurs east of Musquash harbour, extending from there to Ludgate Lake and curving round thence to the north-west side of it, crossing the highway and the Shore Line railway. This bog covers an area of about 450 acres, and its greatest depth is about 20 feet, thinning out, of course, towards the margin. Apparently it occupies the ancient pre-glacial valley, or outlet of the drainage basin of Ludgate and Spruce Lakes, or rather, perhaps, the lower part of it. Its surface is on the same level as these lakes, that is 175 feet above the sea; but it rises in the central parts and has ponds or lakelets here and there. Bosses, or low ridges of rock, protrude through the moss in places.

A peat bog of considerable extent is also seen at Little Popelogan River, through which the Shore Line railway passes.

Another lies near Meadow station, New Brunswick railway, at the north-west branch of Digdeguash River.

A third large one occurs along the upper part of the Digdeguash River, at the border of sheet No. 1 S. W., which is also traversed by the New Brunswick railway.

These bogs are nearly destitute of trees, and contain numerous ponds in which water lies all the year round. The origin of these ponds was discussed on page 22, Part N, Annual Report Geol. Surv. Can., 1887-88.

A number of large peat bogs are reported to occur in the country lying to the north-west of Canaan River, and also between Salmon River and the South-West Miramichi beyond the limits of the map (sheet No. 1 N.E.) The hunters call them caribou plains. One of these lies about the head of Little River, near the north-west corner of the sheet mentioned. Cranberries are reported to be very abundant on all these bogs. **Bogs north of the St. John.**

Reference has been made by Messrs. Bailey and Matthew (page 230 Report of Progress Geol. Surv. Can., 1870-71), to the numerous peat bogs in the southern part of the province, and the localities of some of them noted.

The occurrence of formations of this kind along the coast of the Bay of Fundy in certain places now submerged at high tides was likewise observed, and the facts in connection therewith noted. Mr. Matthew in the report cited also refers to similar drowned peat bogs at Frye's Island, Charlotte county, on Navy Island, St. John harbour, and elsewhere. These all prove a slight subsidence of the region, not, perhaps, exceeding 10 to 20 feet, since the commencement of their growth. The peat bed on Navy Island, just mentioned, was examined by me and found to lie apparently altogether in the littoral zone; but being covered up on the lower margin its extreme depth could not be exactly ascertained. It was examined by Prof. Jas. Fowler and Mr. Matthew some years ago and described. The roots and stumps of trees *in situ* were discovered in it. The change of level indicated by the submergence of the peat bogs along the shores of southern New Brunswick referred to is about the same as that found to have taken place on the north-eastern coast, (page 25, Part N, Annual Report Geol. Surv. Can., 1887-88), being from 10 to 25 feet. **Change of level indicated by peat bogs.**

Vegetable Mould, or Decayed Vegetable Matter.

Upon the forest-clad areas of the region, and also on newly-cleared lands, a stratum of vegetable matter of variable thickness occurs, which is dark coloured and composed of rotten leaves, remains of **Vegetable mould, how occurring.**

herbacious plants and of mosses, decayed wood, etc. In swampy tracts it is usually much thicker than on drier grounds, where, in addition to the accumulations *in situ*, other materials composing it have often been transported to the lower grounds by streams, winds, etc. But it is along river valleys where the thickest deposits of this kind are met with. In the flats or intervales found in these, vegetable matter, often converted into humus, besides forming a surface layer, is also disseminated through the clay and sand constituting them, or occurs interstratified therewith in dark carbonaceous seams. Its presence in these deposits is due, first, to the superabundance of plant growth upon these flats while they were in process of formation, and, secondly, to the transportation of this matter at the same time from the tributary valleys and slopes on both sides. It is to this vegetable mould or humus that these intervales owe their greater fertility. This stratum of vegetable material is continuous with the peat bogs, as pointed out in my report on North-Eastern New Brunswick (Annual Report Geol. Surv. Can., 1887-88), these occupying the depressions and being considered merely as a thickening of the layer referred to, through the additional growth of sphagna, etc.

Absence of, in certain localities.

In the district under consideration, however, this material is scarcely anywhere to be found beyond the areas occupied by the original forest, except, in river valleys, as stated, where it forms a great part of the uppermost strata of the loamy or intervale deposits. This is owing largely to the fact that a considerable portion of the region has been cleared and overrun by fires which destroyed it. In other parts, also, there is such an abundance of coarse, stony and gravelly material in the superficial beds as to interfere with its growth, and, indeed, prevent the accumulation of vegetable matter sufficiently deep to constitute a layer. Upon the sandy and clayey tracts near the coast of St. John and Charlotte counties a matted sheet of the roots and stems of ericaceous and other plants undergoing decay is occasionally met with, which is, perhaps, analogous to that described. In the localities covered by the latter, however, the soil is invariably poor and unfit for cultivation.

Bleached sands on Carboniferous area.

Upon the Middle Carboniferous area, included in sheet No. 1 N. E. the lenticular seams of fine-grained white or grey sands, referred to on page 17, Part N, Annual Report Geol. Surv. Can., 1887-88, were met with. Usually they underlie the layer of vegetable mould above described and are especially noticeable in newly-cleared lands, or those turned up by the plough for the first time. The bleached or whitish colour of these sands is due to the deoxidation of the iron in them through the chemical action of the rain-water and the overlying stratum of decayed vegetable matter, as explained in the report cited. They are always regarded as indicating a poor soil, but cultivation by disseminating them causes them to disappear, thus reducing their impoverishing effects to a minimum.

M 3 (*b*). Marine Deposits (Recent).

Dunes or Sand Beaches.

Sand beaches, where met with.

Dunes or sand beaches were observed in a number of places, especially at Alma, at the mouths of Tynemouth and Gardiner's creeks, at Courtenay Bay, Sand Cove and Manawagonish beach, near St. John; also, near St. Andrew's, forming, at ebb tides, a roadway between the mainland and Minister's Island, at Herring Cove, Campobello Island, and in several places around the island of Grand Manan. These have all been cast up by the waves, and have derived the materials composing them either from the wear of the coast line or from the detritus carried down by the rivers, or both. None of them exceed a few rods in width. In some of the beaches enumerated the sand is coarse and mixed with shingle and pebbles; in others, as at Courtenay Bay and Sand Cove, St. John county, it is a fine blown sand. The texture of the sand in each locality depends upon the nature of the rocks from which it was derived.

Uses.

Glass works were erected at Courtenay Bay some years ago, and the coarser grades of glass-ware manufactured from the sands occurring there. The enterprise was, however, abandoned after a short time, from what cause I have not ascertained.

Salt Marshes.

Salt marshes of district.

Salt marshes are of limited extent in the region under examination compared with those occurring at the head of the Bay of Fundy, *i.e.*, in Cumberland Bay and the Basin of Minas. They were met with along the Petitcodiac River on both sides nearly as far up as Salisbury, and there form a very valuable part of the farms adjoining the river. At Germantown Lake and Little Rocher, Albert county, narrow salt marshes were also observed. Further west, at Gardiner's and Emerson's creeks, small areas of this kind skirt the lower part of the streams. East of the city of St. John a marsh of considerable extent occurs, and another lies inside of Manawagonish beach. Salt marshes cover an area of some extent along both sides of the lower part of Musquash River. Narrow ones were noted elsewhere, one of which occurs at Grand Harbour, Grand Manan.

Fertility of.

The salt marshes along Petitcodiac River, Germantown Lake, also in the vicinity of St. John and at Musquash, are dyked and yield large quantities of hay. Their fertility appears almost inexhaustible. The higher and dryer portions are cultivated with the plough and yield cereals and root crops also in abundance. Sir J. W. Dawson states (Acadian Geology, 2nd ed., p. 23), that the "soil of the salt "marshes in Nova Scotia is so valuable, though nearly destitute of "organic matter, that it is found profitable to cart it upon the upland "as a manure. Its best varieties have now been cropped for more "than two centuries without becoming unproductive, though there can "be no question that under this treatment a diminution of its fertility "is perceptible." "Draining," he says, "is well known to be essential "to the fertility of the marshes, and many valuable tracts of this land "are now in an unproductive condition from its neglect." These remarks apply with equal force to the marshes in southern New Brunswick.

Estuarine Flats.

Estuarine deposits.

Estuarine flats of greater or less area are laid bare at ebb tides in nearly every inlet, harbour and cove along the coast of the Bay of Fundy. At Quaco, also in St. John harbour, and in Passamaquoddy Bay, etc., sandy and muddy deltas or plains are exposed twice daily in the littoral zone. Their materials consist of river detritus and that worn off the coast border by the sea. Bars, so-called, of sand, gravel, etc., are common where the fresh and salt waters meet. These are, of course, modified in size and shape by the tidal currents which sweep up and down the Bay of Fundy.

In some of the estuarine deposits, especially in those occurring in quiet sheltered coves, fine examples of ripple marking and wave action were observed. Phenomena of this kind are well exhibited in the flats of Courtenay Bay, in St. John harbour.

CHANGES OF LEVEL IN THE RECENT PERIOD.

Evidence of change of level in Recent period.

On page 10 of this report evidence was adduced to show that in the Recent or Prehistoric Period the land along the north side of the Bay of Fundy was, perhaps, 40 to 80 feet higher than at present, relative to the level of that body of water, and that after the formation of the peat beds a slow subsidence set in which continued until recently. It was further stated that the position of the salt marshes, dunes, etc., along the coast with respect to sea level, rather supported the view that this coast district was now stationary or nearly so.

The extensive salt marshes at the head of Cumberland Basin contain about forty thousand acres. There are also large marshes around Shepody Bay and along the Petitcodiac estuary. These have all a nearly uniform surface, which is at or near the level of the highest tides of the Bay of Fundy, and were evidently formed by the inflowing tides by successive increments of material deposited during the slow subsidence which took place in the Recent Period or since the peat bogs grew. The relative levels of sea and land seem to have changed but little, if any, since these marshes were laid down, for the larger portion of them can be utilized for agricultural purposes by dyking, while the high tides can readily be admitted, to the extent of overflowing them, by opening the dykes. In the Basin of Minas dykes upwards of two hundred years old are said to enclose some of the marshes there, and are still effective, when kept in repair, in preventing the encroachments or overflowing of these by the sea. These facts indicate that the Bay of Fundy coast area is without perceptible change of level at present and must have been so for a considerable time.

Evidence as to stationary condition of district now.

Salt marshes.

Dunes, when examined, show that in some places they must originally have been thrown up into low parallel ridges or beaches at successive intervals of time and that the process of formation must have occupied many years. None of these ridges or beaches are above the reach of high tides at the present day. Their attitude, therefore, with respect to sea level corroborates the evidence furnished by the salt marshes regarding the stationary condition of the region.

Dunes.

Again, long ranges of cliffs border the Bay of Fundy, which are really trenches cut laterally into the solid rocks by the sea. These show that its erosive action must have been exerted in one horizontal plane for a very long time. Examples illustrating this fact are numerous. The perpendicular precipices between Quaco and Alma, 500 to 700 feet in height, are, perhaps, among the more noteworthy. On the shores of Grand Lake similar phenomena were observed, although on a smaller scale. On the west side of this lake, at Redbank, a cliff from 25 to 50 feet above the summer level of the water has been worn away in this way, the shelving ledge extending out from the base several hundred feet and sloping down gently beneath the lake waters. The erosion of this cliff must have been accomplished while the lake was at or near its present level, and have taken a very long time, as it would necessarily be much slower than along a seashore owing to the circumscribed area of that sheet of water.

Cliffs.

The basin of Grand Lake appears also to have been enlarged, laterally, to a considerable extent, from erosion of its banks by wave

Lake shores.

action, lake ice, currents, etc. At the Keyhole and Sypher's Cove, also, on the west side of Grand Lake, lagoons are held in by beaches of sand, gravel and boulders thrown up by wave and current action. Some of these beaches lie in parallel ridges, but none are beyond the reach of the tides and floods of the lake. These facts are all in favour of the foregoing view, viz., that the surface of its waters is nearly stationary, or rather that the land here has maintained its present level with reference to the sea for a considerable period.

Monuments of erosion.

The waters of Grand Lake are tidal, but the rise and fall do not exceed one to two feet.

Should the land in this region be elevated so as to raise the coast cliffs from 75 to 100 feet above their present level, laying bare the ledges and whole littoral zone and the adjacent bottom of the Bay of Fundy to that depth, such a grand and distinct shore line, or notch in the land, would be exhibited as to be unmistakable for ages, notwithstanding the great subærial denudation to which the surface of the country is now subjected. No such cliffs and shore lines were left anywhere in this district as monuments of marine erosion during the whole Post-Tertiary period.

Classification and Geological Relations of the Soils and Subsoils of the Region.

Relation between soils and rocks of the region.

The intimate relation which exists between the soils and subsoils of a district and the underlying rock-formations is a well known fact. But in some parts of the region under discussion certain causes which have been in operation for long ages have tended to modify these relations to a considerable extent. In a general way, soils and subsoils may be classified (1) according to their origin or mode of formation into (a) sedentary soils, or those formed *in situ*, or in close proximity to the rocks from which they were derived, and (b) transported soils, *i.e.*, those which have been subjected to influences that have removed them from the beds where they were originally formed and deposited them in new localities. This method of classifying the soils of southern New Brunswick was referred to in my preliminary report on the surface geology of the province (Annual Report Geol. Surv. Can., 1885, pp. 50-52, G.G.) Transported soils may generally be subdivided into drift or boulder-clay, and alluviums, the latter embracing all the soils formed by the deposition of materials from water either salt or fresh. Another method of classifying soils to which reference may be made, is (2) according to their physical and mechanical characteristics, as, *e.g.*, gravelly, sandy, clayey, or loamy soils, etc. These varieties often

Sedentary and transported soils.

shade into each other, or are interstratified in the same bed. Other distinctions are occasionally recognized; some soils rest on a hardpan which forms the subsoil, and is a stratum of compact clayey, sandy and gravelly material impervious to water.

In regard to sedentary and transported soils, it may be stated that seldom is either found wholly by itself, or unmixed with the other, and the former are usually overlain by the transported materials. Most generally there is a commingling of these nearly, if not altogether, down to the surface of the rock, or else an overlapping, or a complete masking, of the sedentary by transported soils.

In the region under consideration sedentary soils, often in a degraded and imperfect condition, may be found (1) upon the Middle and Lower Carboniferous areas (see the geologically coloured maps of the solid rocks); (2) in north-western Charlotte, upon the tract occupied by the Devonian and Cambro-Silurian rocks, and (3) upon the flat summits of the pre-Cambrian plateau in eastern Kings and Albert counties. In these areas the materials belonging to the local rocks are, however, not infrequently intermingled to a certain depth with clays, sand or gravels which have been transported greater or less distances, or otherwise are overlain by them. Boulders foreign to the particular locality are everywhere scattered over the surface and occasionally partially embedded in the deposits, except, perhaps, upon the pre-Cambrian itself. Of the three areas occupied by sedentary soils indicated, the one upon the pre-Cambrian plateau furnishes those most closely related to the underlying rocks and without transported material. Boulders are, of course, numerous here, but they are nearly all local. This is due to the fact mentioned in a previous part of this report, viz., that no ice passed over the plateau from the north or north-west carrying boulders or other materials from adjoining rock-formations; whatever ice-action there was upon it having been caused by local glaciers which accumulated upon its surface and moved off its slopes, generally speaking, in the direction of the Bay of Fundy. Where sedentary soils are found.

Upon the hills and ridges to the west of this plateau, and more especially in the valleys among them, we find transported soils in great variety. The rocks belonging to the different geological formations here extend across the district in a north-east and south-west direction, or approximately parallel to the coast of the Bay of Fundy, in narrow, irregular, but somewhat parallel belts. The ice of the glacial period crossed this district, or a considerable part of it, nearly at right angles to the course of these. The drainage has likewise been largely in the same direction, many of the rivers intersecting the ridges by deep valleys of greater or less width. Hence the soils and debris of one series of rocks Where transported soils occur.

have been moved southward upon those of others and intermingled with them to a greater or less extent. On the summits of the hills and ridges sedentary soils occur, but the slopes and valleys are occupied with heterogeneous materials of varied, and, in many cases, of uncertain origin. It was observed, also, that the deeper soils and subsoils of many of the valleys were derived from those rocks in the district which had suffered most from the denuding processes to which they were subjected in past ages. In a few cases transported soils were seen to have been formed by a northward movement of the materials. These were, of course, on northward facing slopes and would seem to have been the result mainly of atmospheric action.

Transported soils are best exhibited below the 220 feet level, where the action of the sea, and especially that of the powerful tidal currents of the Bay of Fundy, have spread out and intermingled the materials belonging to the different geological formations to such a degree that nowhere can they be said to have any direct relation to the rocks beneath. It is in this area, also, that the distinction of soils based upon their physical and mechanical character is best exemplified. Considerable tracts are covered wholly with gravel, other areas embrace sandy soils only, while in numerous localities clayey and loamy soils form the surface beds, to a greater or less extent. The marine alluviums referred to in another part of this report consist wholly of transported materials.

Agricultural Character, Forest Growth, etc.

Character of soils in region.

The agricultural character of a considerable portion of the region under consideration was incidentally described by Messrs. Bailey and Matthew in Report of Progress Geol. Surv. Can., 1870-71. Generally speaking, it exhibits soils of great variety and different degrees of mechanical consistency, and, indeed, over a large part of the area, of quite inferior agricultural capabilities. As is well known, the character of the soil in any particular district depends largely upon the nature of the rocks which form its elevated grounds; the materials of these being strewn, to a greater or less extent, over the lower grounds. From the fact that the hills in this district crumble down into coarse, gritty materials, it will easily be seen that large portions of these must have entered into the composition of the soils bordering the Bay of Fundy. Upon certain tracts of these hilly crystalline belts themselves the soil, as will readily be inferred, is mostly sedentary, and consists in a large measure of coarse, gravelly and pebbly materials, often intermingled, or at least overspread, with boulders. In other places the gravelly materials give place to a clay soil (boulder-clay), which, when cleared of boulders, is strong and fertile. These clay soils are found generally on the summits of the hills, or of the plateaux, where there is a level, or comparatively level tract, and this is one reason why, in certain localities, these lands are preferred by settlers, while the lower intervening valleys are neglected. In the valleys referred to there is either a coarse. gritty soil, composed of materials washed off the hill sides, or, if clayey, it is often too heavy and wet for profitable culture in the humid climate of this country. The boulders, which are, however, everywhere scattered about in these districts are a serious hindrance to good farming. The labour of clearing the forest off the land is trifling compared with that necessary to remove the boulders. Recently machines called "stone-lifters" have been invented, which greatly facilitate their removal, and are in use in western Charlotte. The land, when once cleared of these surface boulders, is generally fit for the plough, and in most places easy to cultivate and fertile, being especially suitable for the production of hay and for pasturage. Large areas upon the crystalline ridges, however, more especially those underlaid with granite, appear to be quite barren. Comprising tracts overrun by forest fires, as many of them do, their surfaces present little else than coarse, gritty debris, alternating with patches of bare rock. Peat bogs are common in the hollows, especially near the Bay of Fundy coast, and wherever the drainage is insufficient.

Boulders in the soil.

Upon the Cambro-Silurian and Devonian, of Charlotte county and southern Queens, which are occupied partly by sedentary soils, there are some tracts of good farming lands. The surface is often rolling, the drainage, wherever this is the case, being good; and there is also more or less calcareous matter disseminated through these soils in places, brought thither by the ice during the glacial period, and other transporting agencies, from the Lower Carboniferous belts which lie immediately to the north of them. The best soils here occur, however, upon the Cambro-Silurian belts, the rocks of this series having crumbled down into a heavy clay, which is, perhaps, the predominant kind of surface material upon these. Less coarse gravel and gritty debris are found here owing to the greater distance from their source, *i.e.*, from the pre-Cambrian. But the contiguous Devonian rocks themselves yield a gravelly and pebbly, boulder-strewn soil which has overlapped the Cambro-Silurian to some extent. Considerable tracts on these formations are, therefore, unsettled, and, indeed, practically useless for agricultural purposes. Peat barrens and swamps are numerous. A belt of good land, with a rolling surface, extends across the country from the St. Croix to the Magoguadavic, north of the coast hills, however, compris-

Soils upon the Cambro-Silurian and Devonian.

ing the so-called ridges of western Charlotte. This and the narrow belts skirting the rivers embrace the principal agricultural lands of value.

Good soils upon lower Carboniferous rocks.

The lower Carboniferous rocks occupy the chief part of eastern Kings, and also form narrow bands coming up from beneath the Middle Carboniferous overlap in its westward extension. The district occupied by these sediments having suffered a considerable amount of denudation, presents a varied and irregular surface, the prevailing features being rolling hills or ridges, with intervening valleys of erosion. Consisting, as the rocks often do, of red, marly shales, and containing greater or less quantities of lime, they decompose into a loose, friable, easily cultivable soil, which is unequalled for its strength and fertility. Gypsiferous beds also occur in the vicinity of the salt springs, along Salt Springs creek, and in the North River valley near Petitcodiac, which likewise enrich the soil in these particular localities. The only drawback to the complete utilization of the tracts covered by these sediments, agriculturally, is in their flatness in certain parts. Wherever the rocks lie in a horizontal attitude the clays resulting from their disintegration settle down into a hardpan which, from the imperfect drainage, often becomes covered with a peaty, or boggy material, and in these places, of course, the soils are always wet, cold and infertile. Where, on the contrary, the slope is sufficient, to afford a natural drainage of the surplus waters due to precipitation the land is warm and rich.

Character of soil on Middle Carboniferous area.

The Middle Carboniferous area, excepting, of course, the alluvial tracts within its limits, exhibits, perhaps, less variety in the physical character of its soils than those resting on any of the other geological formations. The uplands are either dry, gravelly or sandy, and more or less strewn with boulders, or else, in undrained places, they are clayey, heavy and cold. Almost everywhere upon the newer upland soils a layer of fine whitish or greyish sand occurs in lenticular seams underneath or associated with the thin covering of vegetable mould or decayed vegetable matter which mantles the virgin soil. This was referred to in my last report (Annual Report Geol. Surv. Can , 1887-88, part N.) and its origin and mode of occurrence described. These sands are said to derive their colour from the chemical change and deoxidation of the iron in them through the combined action of the overlying organic matter and the surface waters. Cultivation by the plough readily disseminates them through the soil and subsoil and causes their disappearance. Newly ploughed fields, *i.e.*, those ploughed for the first time, often look, at a distance, as if a coat of lime had been irregularly spread over them. But wherever these sands occur they are said by the farmers to denote a cold and unproductive soil.

The soils upon the Middle Carboniferous rocks are, perhaps, more strictly sedentary than any other in the region, and, of course, partake, in a great measure of the coarse silicious nature of the underlying strata, and are almost devoid of lime. They require, therefore, different methods of culture from the soils derived from other rock-formations. Lime and composts are the chief fertilizing requisites for them; but in the level districts a judicious system of draining is also necessary. Soils more sedentary.

A considerable portion of the surface of this millstone grit area is covered with sphagnous swamps or peaty barrens. These occupy the hollows or valleys in the upland districts wherever the drainage is insufficient, as well as much of the lower tracts. Underneath the boggy or peaty matter the hardpan referred to occurs, which is impervious to water. Hence these areas afford the most favourable conditions for the growth of sphagna and other plants peculiar to bogs. Swamps and barrens.

The best lands for general agricultural purposes upon the Middle Carboniferous rocks are those found on the slopes bordering river valleys and lake basins, where the natural drainage is good. These slopes are also overlain by a greater or less thickness of loamy material, which in some cases, was deposited when the waters were formerly at a higher level; while in other places it seems to consist of the finer materials, washed down from the higher grounds, and is therefore a subærial deposit. Best soils on Middle Carboniferous.

The alluvial soils of the region, both fresh-water and marine, are probably the best for general agricultural purposes. The fresh-water alluviums, generally called intervales or meadows, occupy considerable areas along the St. John River and also in the Kennebeckasis and Belleisle valleys. Narrower belts of these skirt the Magaguadavic and Digdeguash rivers. Indeed, they occur in greater or less breadth along every river valley in the country. The more remarkable and valuable intervales, however, are those of Kings and Queens counties, occurring in the St. John valley and along the Kennebeckasis and its tributaries. These are composed of finely divided materials derived from the rocks met with along the courses of the rivers and are wholly free from boulders. Alluvial soils of the region,

The principal distinction between the soils of these fresh-water intervales and all others in the district, lies in the fact of their containing a much larger proportion of organic matter or humus. Formed as they are by the deposition of the finer materials held in suspension by flooded rivers, they are usually composed of loam or silt intermingled with greater or less quantities of the decayed vegetable matter transported thither. The lower intervales are overflowed every spring for Distinction between fresh-water alluviums and other soils.

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a few weeks, and a thin layer of material laid down upon them which increases, or at least serves to maintain, their fertility. Their physical and mechanical character is such that they readily dry soon after the spring freshets retire, and are friable and easy of cultivation. These intervales are especially valuable for the production of hay, and for stock raising; but cereals and root crops likewise grow well upon them. Their area in Kings and Queens counties can be best seen by an inspection of the map.

Salt marshes.

The extent of the salt marshes, (marine alluviums) and the particular locality where each occurs, have been referred to on a former page of this report. The largest are those at Musquash and St. John. Smaller marshes are found at Manawagonish Cove, Little Rocher and along the Petitcodiac below Salisbury. All these are dyked and under cultivation, and are a source of considerable revenue to the owners. The marshes are formed of a fine, apparently homogeneous mud, which varies somewhat in colour in different localities according to the nature of the source whence it was derived. In some places the soil of these marshes resembles a loam. They have been cropped since the first settlement of the country—one to two hundred years—and little, if anything, done to repair their waste or maintain their original fertility. Draining and rebuilding the dykes are necessary in some cases. It is said the productive power of these marshes can be partially restored, or increased, by allowing the tides to overflow them occasionally depositing a fresh layer of matter; but they are not cultivated, or utilized to the best advantage. If properly dyked and drained, as the marsh near St. John city is, their value in an agricultural point of view could hardly be estimated. For stock raising, and for the production of hay, and other crops they possess characteristics which render them superior to all other classes of soils in New Brunswick.

Value of.

Character of Soils in the Different Counties included in the Region.

Charlotte county.

In Charlotte county good tracts of land for agricultural purposes are found in the vicinity of St. Stephen, and, indeed, all along the St. Croix River, from Oak Bay to Upper Falls, and eastward to the Digdeguash River, including all the area occupied by Pomeroy, Little, Old, Scotch and the other ridges in that section. Some of the valleys between these are, however, gravelly and stony; but the slopes and summits of these rolling boulder-clay hills afford good soil, much of which is in an excellent state of cultivation. At Bay Side and upon the Lower Carboniferous tract, near St. Andrews, there are some fine farms where large quantities of root crops are raised. To the east of the above mentioned part of Charlotte county, however, the country is certainly not well adapted for agricultural pursuits. It is hilly, broken and boulder-strewn; large tracts are covered chiefly with coarse gravel, yet there are numerous settlements, and patches of greater or less extent of good soil. on which the thrifty, hardy settlers can, by combining fishing with agriculture, subsist in comparatively comfortable circumstances. Along the Magaguadavic River, especially in the vicinity of St. George and eastward, there are a number of good farms, also around L'Etang harbour, and upon the Pennfield terraces. In these places large clearings have been made, and many of the farmers are, apparently, in moderately good circumstances. The eastern part of Charlotte county consists, however, for the most part, of poor, barren land, and but little of it is cleared and cultivated.

The West Isles and Grand Manan are, generally speaking, similar to the mainland as regards farming capabilities. Occasional patches of good soil are found upon them; but the inhabitants are largely devoted to fishing and trading, so that very little land is utilized in tillage. The same remark applies, indeed, to the immediate coast of the mainland. Campobello, evidently has some good land upon it; but the principal part of that island is owned by a company of foreign capitalists, who use it mainly as a summer resort, and the conditions for its successful settlement by farmers are, therefore, not favorable. **Grand Manan an West Isles.**

A large part of St. John county is closely similar to that of Charlotte as regards its agricultural character. This remark applies more especially to the higher grounds on the ridges and hills. But in the valleys, even among these, tracts of various extent, composed of more finely comminuted materials form rich and productive soils. The salt marshes at Courtenay Bay, Manawagonish and Musquash are highly valuable. Along the coast from the mouth of Black River to Melvin's Beach, east of Quaco, there are several good farming tracts. East of St. John towards Loch Lomond, thence to the upper branch of Hammond River, especially in the vicinity of Hardingville, and along Germain Brook, Porter's Stream, etc., there are a large number of good farms. But some of the older settlements in this part of the county have been abandoned, or at least allowed to go waste and are now being rapidly covered with a second growth of trees. Along the Intercolonial railway as far out as Torryburn, also along the old Westmoreland road to Dolin's Lake and beyond it as far as Mark's Lake, some good strips of land are found; but the hills and ridges are all gravelly and boulder-strewn. Skirting the Kennebeckasis from Torryburn to Boar's Head there are patches of arable soil here and there; the larger portion is, however, sterile and forbidding. The eastern part of St. John county **St. John county.**

is still almost entirely in a wilderness state, and is the scene of extensive lumber operations.

King's county. Kings county, taken altogether, although containing much hilly, stony land, has many fine valleys and uplands, and is the best agricultural district in southern New Brunswick. The choicest portions are in the valleys of the Kennebeckasis, Belleisle and Millstream, and along Smith's Creek, Trout Brook, etc. There are also some good farms in Westfield parish, on the west side of the St. John, especially in the vicinity of the Nerepis and along the Long Reach; while in the extreme northern part of the county the uplands of Butternut Ridge and vicinity are of high fertility, underlain as they are mainly by Lower Carboniferous limestone. The latter district has a reputation beyond the limits of the county for its great agricultural capabilities.

High grounds. Upon the higher grounds of the south-eastern part of Kings, especially along Hammond River and its affluents, there are a large number of good settlements, boulder-clays and rotted rock *in situ* forming the soil here in most places. These when cleared of stones are usually found to be heavy rich lands, well adapted for the production of hay and cereals. Other tracts are too dry and stony, while still other portions are swampy and wet. Considerable areas here, however, owing to their rocky, boulder-strewn condition, are practically valueless in an agricultural point of view.

Intervales. The best portions of Kings county, agriculturally, are, of course, its intervales and meadows; and from the great number of streams traversing it and the width of many of their valleys, especially in districts occupied by the Lower Carboniferous rocks, these cover a large area. Some of these valleys, as has been shown on a former page, held lakes in the Post-Tertiary period, and have bottoms covered with lacustrine gravels, clays, loam, etc. Many of the farms are large and in an excellent state of cultivation; their proximity to the city of St. John affords easy access to its markets, and the consequent regular intercourse of the people with the business portion of that community has rendered them intelligent, industrious and thriving.

Queens and Sunbury counties. The agricultural character of Queens county is, to a large extent, different from that of the districts already described. The larger part of the county is occupied by Middle Carboniferous rocks and consequently the general surface is in marked contrast to that of Kings, St. John and Charlotte counties, the soils and subsoils being, for the most part, sedentary. The valley of the St. John and those of Grand and Washadamook lakes contain fine settlements and many large, well cultivated farms. West of the St. John good land is found in Jerusalem and Hibernia settlements, etc., also in the vicinity of Gagetown. Near the mouth of the Otnabog there are also some excellent upland farms. Intervales skirt the St. John River here, the character of which has been already described. These fresh-water alluviums are quite extensive in Queens county (see map), forming the islands and strips of greater or less breadth on both sides of the river. They are of great value, their productiveness being almost inexhaustible. Large quantities of hay are raised from them year after year without the application of any fertilizing material. The best uplands of this county for agricultural purposes, are those along the banks of the rivers and lakes where the natural drainage is good. On the flat grounds of the interior, between the hydrographic depressions, much barren land is found. In these places, wherever the surface is not covered with peaty material, the soil is usually clayey and cold, and, from the lack of lime and organic matter in its composition, poor and unproductive. Fresh-water alluviums.

A large part of Queens county is occupied by settlers and under cultivation, but other pursuits, such as coal mining, lumbering, etc., interfere, more or less, with the successful prosecution of agriculture.

That portion of Sunbury county included in sheet No. 1, N. E., has a soil of similar character to that upon the Middle Carboniferous of Queens county just described.

In Albert county the different kinds of rocks met with have yielded soils of varied character and fertility, resembling, in most respects, those to the south-west, in St. John and Kings counties. This similarity is, however, most marked in the soils of the pre-Cambrian plateau and of the Lower Carboniferous band bordering it on the north-west; but, on the whole, the soil upon the pre-Cambrian in Albert county may be said to be of inferior agricultural value, and the surface much broken and boulder-strewn. Upon the Lower Carboniferous, at Elgin Corner, Mapleton, Coverdale, Turtle Creek, etc., there are, however, several fine tracts of land, which, although having a rugged, broken surface, comprise a large number of good farms, well drained, and many of them in a tolerably good state of cultivation. The sandy, porous nature of these rocks and the amount of lime in their composition render them easily disintegrated, and the result is a loose, permeable soil, easily cultivated and highly productive. On the Albert county slope of the Petitcodiac valley, there are some splendid farms, comprising upland as well as salt marsh. Several in the vicinity of Turtle Creek are noted for the great quantities of produce and the excellent stock raised thereon. Albert county. Good farms in Petitcodiac valley.

That part of Westmoreland county included in sheet No. 1, N.E., lying between Petitcodiac and the head waters of Canaan River, embracing Westmoreland county.

Steeves and Lutz mountain districts, etc., is somewhat varied in character as regards agricultural capabilities. But along the Petitcodiac and North rivers, as well as on the southward-facing slopes of Steeves and Lutz mountains, there are excellent farming tracts. Areas of considerable extent are, however, flat and wet. and other parts are barren; while the whole surface is more or less boulder-strewn and swampy, and peat bogs are common. Much of the soil is, therefore, unsuited for agriculture, especially in view of the humid climate of southern and eastern New Brunswick. This district, therefore, although settled for a long time, is now occupied only along the river slopes, and upon the ridges, where the natural drainage is good.

Forest Growth, etc.

The original forests of the region seem to have been dense and luxuriant, judging from the remnants of them still existing. They consisted of a great variety of trees and shrubs, chief among which

Principal trees.

were the common evergreens, pine, spruce, balsam-fir, hemlock-spruce, cedar, etc.; while the principal deciduous trees were maple, birch, elm, ash, beech, oak, poplar, hacmatac, etc., many of which were large and formed thick umbrageous forests. The commoner species of economic importance were white pine, black spruce, black and yellow birch, rock maple, hemlock-spruce, ash, hacmatac, cedar, etc. This part of the province was, therefore, at one time an important lumbering section, and on almost every river mills for the manufacture of lumber

Industries.

were to be found. The manufacture and export of spruce and pine deals and the building of wooden ships, were then important industries and gave employment to large numbers of people. The condition of things is now, however, very materially changed. So extravagantly and recklessly has the lumber business been prosecuted that a considerable portion of the country has become entirely denuded of its timber, and what the lumberman's axe failed to reach has, through carelessness

Destruction of the forests.

and want of proper regulations conserving the forests, been since largely destroyed by fires. The dry, gravelly and stony tracts in Charlotte county have suffered more from the latter cause than, perhaps, any other part of the region; nothing but a scanty growth of bushes covering them now. The districts drained by the larger rivers in this county have, indeed, nearly all their timber cut down, especially the pine and spruce; but a second growth is rapidly springing up in certain areas to supply its place, which can already be utilized for many purposes. The large hardwoods of the original forests still flourish in many localities from which the spruce and pine are gone; but they, too, are becoming depleted. In the northern and eastern parts of Charlotte county, however, *i.e.*, in the parishes of Lepreau and Clarendon, the old forest growth still exists, although largely thinned out by the lumbermen. A large part of Lancaster, in St. John county, also those parts of Kings and Queens counties lying to the south-west of the St. John River, are still likewise mostly occupied by the original forest. The chief timber obtained in these districts is spruce, with pine and hemlock in certain localities, all of which are manufactured into deals, boards, etc. Cedar is also abundant, and large quantities are now cut for railway ties, fence posts, telegraph poles, etc. Black birch is also a common tree, and the wood of this and of the rock maple are used extensively in the manufacture of furniture and woodenware, also in carriage-making, cabinet work, etc. **Uses.**

In the district lying to the east of the St. John River the sylvan growth is closely similar to that just described, except, perhaps, upon the Carboniferous area in Queens, Sunbury and Westmoreland counties, where certain trees locally predominate which are not so common on the highland tracts. Commencing in the south-eastern part of this district, we find that scarcely any of the original forest growth occurs in St. John county, except in the parish of St. Martins. The eastern part of this parish is still covered by black spruce, pine, black birch, etc., of economic importance, which afford a sufficient supply yet for several mill-owners and lumbermen to carry on a large business. The tract of country, occupied by the original forest here, extends into Albert county as far as the Shepody River, and on the higher grounds is covered by a heavy growth of spruce, birch, maple, hemlock, with more or less pine, cedar, etc. Lumbering operations are prosecuted at Point Wolf, Upper Salmon and Shepody rivers, etc. **Character of forest east of St. John.**

Upon the hilly tract in Kings county lying to the south-east of the Intercolonial railway, the forest comprises nearly the same kinds of trees as there are upon the areas last described, with, perhaps, a predominance of birch and maple groves, more especially on the ridges underlain by Lower Carboniferous rocks. In some of these groves the rock or sugar maple forms clumps to the exclusion of almost every other tree. These are called "sugaries," and formerly considerable quantities of sugar and syrup were made therefrom. The trees upon the Lower Carboniferous ridges are usually large and form a dense umbrageous forest. The original growth still obtains, except near the Intercolonial railway and around the borders of some of the older settlements. **Sugar maple.**

West of the Intercolonial railway the ridges are more denuded of their original forest covering, but the old growth still predominates in this part of Kings and Westmoreland counties wherever the country is wooded. It has here, however, been thinned out in most districts, and the trees cut down are now being replaced by younger ones, so that the forest in many cases consists of part old and part recent growth. Lumbering operations are still carried on in a number of places in Kings county, and mills for the manufacture of the various kind of lumber may be found on different streams. In addition to these a spool factory has been erected near Sussex, and a match factory at Havelock Corner.

Kinds of trees on Middle Carboniferous.

On the Middle Carboniferous area in Queens, Westmoreland and Sunbury the relative abundance of some kinds of trees is different from that in the forests upon the ridges just described. The black spruce is, on the drier grounds, replaced, to some extent, by the white species, and in swampy and peaty tracts occurs abundantly in a smaller form along with hacmatac. The hemlock-spruce is also abundant and large here, and cedar is met with in dense groves in wet places, which are known as "cedar swamps." The latter tree is here, as elsewhere, cut for various uses, chiefly for fencing, telegraph poles, etc. The butternut and oak were observed growing on the sand beaches on the west side of Grand Lake. Great quantities of the smaller kinds of black spruce, hacmatac, etc., are cut and shipped from the Grand Lake and Washadamoak districts as cordwood.

The forests in northern Kings and in Queens and Sunbury counties still consist chiefly of the original growth, except in the immediate vicinity of Grand and Washadamoak lakes and of some of the older and larger settlements. Portions of these districts having been overrun by fires many years ago, the older growth destroyed has been replaced by a recent one, which already attains a considerable size. But other areas have no forest covering except the dry, naked trunks of the trees left unburnt, and a sparse undergrowth of bushes and ericaceous plants. These are known as barrens.

Forest fire in 1889.

In the summer of 1889 an extensive forest fire swept over portions of Queens and Sunbury counties, and in the drainage basin of the Canaan River especially, destroyed large areas covered by timber trees.

Materials of Economic Importance.

Economic materials.

The materials of economic importance met with in the superficial deposits of the region are peat, infusorial earth or tripolite, shell-marl, brick-clay, fine sand, gravel for railway ballasting, road-making, etc. Brine and medicinal springs also occur here which probably appertain to the superficial strata.

The peat bogs of the area were referred to on page 70 of this report and the large one lying east of Musquash harbour described in some detail, as the peat there is now about to be utilized in the preparation of a material called "moss litter." This article is used in stables as bedding for horses, etc. Owners of studs in the principal cities of the United States, who were hitherto using the European moss litter, have been looking for a material of this kind prepared from the peat found on this side of the Atlantic. What they require is a spongy moss sufficiently light and porous to be an absorbent of the liquids and ammonia which collect in stables, and which, after being used in this way, would make a fertilizer for gardens, etc. A few capitalists from St. John, St. Stephen and other places have formed what is known as the Musquash Moss Litter Company, and having purchased the bog referred to, are now (autumn of 1889) erecting buildings and machinery there for the preparation of this article. The company claims that the peat moss found in this locality is well adapted for the purpose intended and is equally as good as the German moss litter. Hitherto a large amount of time and capital have been spent by the Musquash Company in experimenting or testing the quality and suitability of the different grades of peaty or boggy material obtained here for the object in view, and it has been found that what is about half decayed, *i.e.*, sufficiently so to be changed to a dark colour and rendered somewhat short in the fibre without being absolutely brittle, is the best. This kind of peat is not found in the upper or living part, nor yet in the deep-lying rotted material, but between the two, where the mosses and rootlets are only partially decomposed, and the fibres strong enough to prevent the moss from crumbling to pieces. The chief process in its preparation is that of depriving it of the water, of which it contains from 90 to 95 per cent. This is effected partially in the pits by a machine called a plunger; the moss is then brought by tramways into a building and subjected to great pressure by passing it between heavy rollers, and lastly the residual moisture is driven off by evaporation. It is then packed into bales and is ready for shipment. The chief market is in the large cities of the United States.

Peat bog at Musquash. **Moss litter, uses of.** **Preparation of**

The above is, as yet, the only way in which the peat bogs of this section have been utilized, unless it is in growing cranberries. For the latter purpose some of them in Charlotte county and elsewhere are considered valuable. The large yield of this fruit here, which always finds a ready market at good prices, is an important source of income.

Cranberries on bogs.

Infusorial earth (tripolite) has been mentioned as occurring at Fitzgerald Lake, St. John county, and Pollett River and Pleasant lakes, Kings county. In regard to the deposit at the former place Mr. Wm.

Tripolite.

Murdoch, C.E., of St. John, who has been interesting himself in its development and endeavoring to have it introduced into use in St. John, has sent me the following summary of facts in a letter dated April 5th, 1890:—The area of Fitzgerald Lake was seventy acres, and the depth, before the tripolite began to form, probably exceeded fifty feet. This is only a surmise, however, as the extreme depth has not been ascertained. The area of the infusorial earth, which nearly fills the lake basin, is fully sixty acres, and it probably reaches a depth of fifty feet.

Bed at Fitzgerald Lake.

Character of.

Immediately below the surface of this material there is a bed of a light grey colour, about a foot in thickness. When dry this is almost perfectly white, and weighs about fifteen pounds per cubic foot. Below this stratum, the colour, when fresh, is a reddish brown. After drying it becomes grey, and though weighing no more than that just described, the lumps become so hard and tough that a nail can be driven into the material without causing fracture. The contained cement is not impaired by drying, but will soften again in water and afterwards become hard.

Uses.

Its cohesiveness and porosity render this article useful as a non-conductor of heat, and this property has made it available at the Engine Room of the St. John Gas and Electric Lighting Company. All the steam pipes and cylinders of their four high speed engines have been covered with it, and it has given great satisfaction during the past eight months.

It also makes an excellent polishing powder for gold, silver and electro-plate, as well as an absorbent in the manufacture of dynamite and other chemical preparations, and is an important factor in the preparation of ultramarine.

Deposits in King's county.

The deposit at Pollett River Lake, Mechanics' settlement, Kings county, has been described in Report of Progress, 1878-79, page 26 D. It is reported to be about four feet deep, and makes an admirable polishing material. Mr. Hoffmann, chemist and mineralogist to the Geological Survey, has given an analysis of it also on page 4 H. of the above-mentioned report. A third bed of this material occurs in Pleasant Lake, which lies about six miles to the south-west of Pollett Lake.

Shell-marl.

Shell-marl is found at Lawlor's Lake, St. John county, and has been reported from some other places in southern New Brunswick. The deposit at Lawlor's Lake is about two feet deep, and contains several species of fresh water molluscs. Mr. Matthew has described it in the Report of Progress 1877-78, pages 34-35 E. E.

Brick-clay occurs in numerous places in the region, and often with the fine-grained sand necessary for brick-making in the vicinity. Large brick-kilns are in operation at Fairville and Courtenay Bay, St. John county, and near Sussex, Kings county, also at Lewisville, Westmoreland county. The clay used in the manufacture of brick at these places is the ordinary marine (Leda) clay of the district. Fossils occur in it at Fairville (see Mr. Matthew's Report cited above, page 23 E.E.) Brick-clay.

Gravel suitable for ballasting railways, road making, etc., of various degrees of coarseness, may be obtained in every section of this gravel-strewn country. Pits from which it has been taken for railway use, may be seen at the Digdeguash and Lepreau rivers on the Shore Line railway; at Welsford and South Bay on the New Brunswick railway, and at Rothesay, Boundary creek, etc., along the Intercolonial railway. Gravel.

Brine springs occur at Sussex and Salina, Kings county, and at Bennett's Brook, near Petitcodiac, Westmoreland county. The springs at Sussex are the only ones from which salt is now made. Five or six hundred bushels of salt per annum are manufactured here by the ordinary process of boiling the brine in pans. Work is carried on only during the summer months. The salt prepared at the Sussex Salt Works is said to be of a very superior quality for dairy use; but the sale is limited, the consumption being merely local. Several surface springs occur in the vicinity of these salt works, only a few of which have yet been utilized. Brine springs.

At Salina there are likewise a number of surface springs, but the brine in any of them does not contain more than about three per cent. of salt. The manufacture of salt was commenced here a few years ago but was discontinued. The owners of these springs are desirous of having them more fully tested by borings, and possibly this might result in improving the quality of the brine. At Bennett's Brook nothing, so far as I could ascertain, has been done to utilize the springs there.

The brine at all these places contains a greater or less percentage of sulphate of lime or gypsum.

Medicinal springs occur at Apohaqui and Havelock Corner, Kings county. There are two springs at the former place, one being a little more than a mile from the railway station, and the second and larger one nearly four miles. These waters have been analyzed and found to be alkaline. They have attained a reputation for their curative properties, and are used with beneficial results in cases of indigestion and general debility. With cod liver oil they make a natural emulsion. Medicinal springs.

The springs at Havelock have been known locally for a great number of years, and many persons in the vicinity state they have been benefitted by the use of the waters. Derangements of the digestive system, and various skin diseases have, it is stated, been treated with success by their aid.

GEOLOGICAL AND NATURAL HISTORY 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. D. ADAMS, M.Ap.Sc.
R. A. A. JOHNSTON.

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

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present, herewith, my report upon the work carried out in the Laboratory of this Survey during the interval comprised between the date of my last and December 31st, 1889. During that period, twelve hundred and thirty-seven specimens were received—brought or sent—either for identification, for information in regard to their economic value, or for analysis or assay. The results obtained were, in very many instances, of no special interest save to those immediately concerned, and have, in consequence, been excluded from the present report, in favor of such work as was deemed most likely to prove of general interest.

Of the work herein recorded—the analyses of the Natural Waters were conducted by Mr. Frank D. Adams, whilst the analyses of the Limestones and Dolomites, as likewise the Gold and Silver assays, were carried out by Mr. R. A. A. Johnston. These, as likewise some other 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 honor to be,

Sir,

Your obedient servant,

G. CHRISTIAN HOFFMANN.

OTTAWA, September 30, 1890.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

FROM THE

LABORATORY OF THE SURVEY.

COALS AND LIGNITES.

[*In continuation of previous reports on this subject—Report of Progress,* 1882-83-84, *Part M.: Annual Report,* 1885, *Part M. and Annual Report,* 1887-88, *Part T.*]

72.—PEAT.—From St. Hubert, Chambly county, Province of Quebec. Structure, somewhat dense; contained a rather large proportion of intermixed rootlets; color, clove-brown; dull; fracture, uneven; powder, brown; it communicates a deep brownish-red color to a boiling solution of caustic potash. This peat had been pulped, sticks and roots separated, and dried by exposure to the air. It had not been compressed. This specimen had been kept in the show-cases of the Museum for years, and may fairly be regarded as having been in a thoroughly air-dried condition. **Peat from St. Hubert, Chambly county, P.Q.**

Specific gravity, 0·7484 (temp. 15·5° C.)—weight of one solid cubic foot, calculated from the specific gravity, 46·77 pounds. Analysis by fast coking gave:

Hygroscopic water	10·28
Volatile combustible matter	61·48
Fixed carbon	25·23
Ash	3·01
	100.00

Coke, per cent .... 28·24
Ratio of volatile combustible matter to fixed carbon 1 : 0·41

It yields a loosely fritted coke: the gases evolved during coking burnt with a pale yellow, slightly luminous, smokeless flame. The ash has a pale brownish-yellow color,—it does not become agglutinated at a bright red heat, at a most intense red heat it forms a slaggy mass.

Lignitified wood from Swan River, Manitoba.

73.—LIGNITIFIED WOOD.—From Swan River, Manitoba, township 37, range 26, west of the principal meridian. Geological position—Cretaceous (Lower portion of Neobrara-Benton shales). Collected by Mr. J. B. Tyrrell.

Has a dense and wood-like structure; color 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 color to a boiling solution of caustic potash; by exposure to the air becomes fissured.

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 loosely fritted coke: the gases evolved during coking burnt with a yellowish, somewhat luminous, slightly smoky flame. The ash has a pale brownish-yellow color,—it is readily fusible at a bright red heat, running into a fluid slag.

Coal from head waters of Mill and Pincher Creeks, N.W.T.

74.—COAL.—From a seam near the head waters of Mill and Pincher Creeks, section 10, township 5, range 1, west of the fifth initial meridian, District of Alberta, North-west Territory. The seam—which was discovered by Andrew Christie in December 1887—has a thickness of about eight feet. Geological position,—Cretaceous. Received from Mr. N. F. M. Scobie.

Structure somewhat coarse lamellar—made up of layers of a greyish-black, somewhat dull, and jet black coal of brilliant lustre, with an occasional layer of mineral charcoal; shows slickensides; fracture irregular, that of the brighter layers not unfrequently conchoidal; hard and firm; powder brownish-black, almost black; it communicates a very pale brownish-yellow color to a boiling solution of caustic potash.

Analysis by fast coking gave:

Coal from head waters of Mill and Pincher Creeks, N.W.T., cont.

Hygroscopic water	1·99
Volatile combustible matter	20·88
Fixed carbon	61·87
Ash	15·26
	100·00
Coke, per cent	77·13
Ratio of volatile combustible matter to fixed carbon	1 : 2·96

It yields a non-coherent coke: the gases evolved during coking burnt with a yellow, luminous, somewhat smoky flame. The ash, which is white, is infusible even at a most intense red heat.

75.—COAL.—From second crossing, Marten Creek, Crow Nest Pass, Rocky Mountains, British Columbia. There are said to be four seams of this particular material at this locality, having a thickness of respectively three, four, five and six feet. Geological position—Cretaceous, Kootanie series.

Coal from Marten Creek, Rocky Mountains, B.C.

Structure compact—made up of more or less spherical or lenticular shaped nodular grains of pitch-black color and brilliant lustre, thickly disseminated through a matrix of dull, greyish-black, coaly matter. Does not soil the fingers; tough; sonorous; fracture, somewhat irregular, with a tendency to large conchoidal; powder brownish-black; it communicates a reddish-brown color to a boiling solution of caustic potash. Takes fire in a lamp flame, burning with a yellow, luminous flame which, however, dies out almost immediately after withdrawal from the source of heat. Resists exposure to the air. From a microscopic examination of thin slices of this coal it is inferred that the aforementioned nodular grains consist of an altered resinous matter.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	2·10	2·10
Volatile combustible matter	44·41	57·71
Fixed carbon	43·63	30·33
Ash	9·86	9·86
	100·00	100·00
Coke, per cent	53·49	40·19
Ratio of volatile combustible matter to fixed carbon	1 : 0·98	1 : 0·52

Coal from Marten Creek, Rocky Mountains, B.C., cont.

It yields—by slow coking, a bulky, coherent, highly vesicular coke—by fast coking, a firm and lustrous coke in concentric layers, in which the form of the particles of coal from which it has been derived is entirely obliterated, and of about the same, or if anything less, bulk than the original coal. When heated in a covered crucible it produces a very large amount of gases which burn with a yellow, luminous, very smoky flame. Color of the ash, pale reddish-white—when exposed to a bright red heat it remains unaffected, at a most intense red heat it becomes slightly sintered.

This material constitutes an excellent gas-coal, not only by reason of the large amount of volatile combustible matter it is capable of affording—in which respect it is superior to a very large number of cannel coals which are employed for gas-making—but also from the fact that this would appear to be of superior quality for illuminating purposes.

Anthracite from Graham Island, Queen Charlotte Islands, B.C.

76.—ANTHRACITE.—From Hooper Creek or Nicholson's Tunnel, Cowgitz, on Skidegate Channel, southern end of Graham Island, Queen Charlotte Islands, British Columbia. Main seam. Geological position—Cretaceous.

Structure, compact; it is, here and there, intersected by films of calcite; color, velvet-black; lustre, bright; brittle; fracture, sub-conchoidal; does not soil the fingers; powder greyish-black, almost black; it communicates only a just perceptible yellowish tinge to a boiling solution of caustic potash; when suddenly heated, decrepitates slightly.

Specific gravity, 1·5027 (temp. 15·5° C.)—Weight of one solid cubic foot, calculated from the specific gravity, 93·92 pounds.

Analysis by fast coking gave :

Hygroscopic water	1·99
Volatile combustible matter	7·65
Fixed carbon	80·62
Ash	9·74
	100·00
Coke, per cent	90·36
Ratio of volatile combustible matter to fixed carbon	1 : 10·54

It yields a non-coherent coke. When heated in a covered crucible it evolves but a small amount of gases which burn with a slightly yellowish, smokeless flame of feeble luminosity. The ash, which has a reddish-white color, does not agglutinate even at a most intense red heat.

On the Hygroscopicity of Certain Canadian Fossil Fuels.

Hygroscopicity of certain Canadian fossil fuels.

Introductory.—My paper on this subject, as published in the Transactions of the Royal Society of Canada—Vol. vii, (1889), *sec.* iii, *p.* 41,—*is accompanied by an extended table giving locality of occurrence, a mineralogical description and results of proximate analyses of the various fuels experimented on. As this table is here unavoidably omitted, another has been substituted for it which, however, is limited to showing the percentage of water contained in the fuels at the time of experiment, their hygroscopicity and behaviour with potash solution.*

Ultimate analyses of some of the lignites, lignitic coals and coals as also the calorific power—as determined by Thompson's calorimiter—of very many of them, together with generalizations on the physical and chemical characters and applications of the fuels in question, will be found in my report on the Coals and Lignites of the North-West Territory, which constitutes Part M. of Report of Progress of the Geological and Natural History Survey of Canada, 1882-83-84.

The experiments, in this connection, here recorded, and which were conducted upon material in all stages of alteration, ranging from surface peat to anthracite, were all carried out under precisely similar conditions.

The various fuels were all reduced to as near as possible the same state of mechanical division, having been ground just sufficiently fine to allow of their passing a sieve of ninety holes to the linear inch. The material—of which, in each case, one gram and a-half was employed—was placed in low, broad, flat-bottomed, straight-sided, very light glass bottles, provided with accurately ground glass stoppers. In the drying experiments, the specially constructed staging—which carried thirty of these bottles—supported by glass legs, stood over a glass dish (almost equal in area to the mouth of the bell jar) containing strong sulphuric acid; the whole being covered by a bell jar with ground rim resting upon an accurately ground plate. In the absorption experiments the glass dish containing the sulphuric acid, was replaced by one containing a shallow stratum of water, over which were heaped shreds of filtering paper, and the bell jar enclosing the experiments was in turn covered by another of much larger dimensions—an arrangement which effectually prevented the deposition of dew. The temperature of the room (which was artificially heated—the work having been carried out during the winter months) in which the experiments were conducted, ranged from 65° to 70° F. The experiments were all made in duplicate—the two experiments with the same fuel being carried out, as affording a better check, on separate occasions.

Hygroscopicity of certain Canadian fossil fuels, cont.

In some preliminary experiments, fifteen of the lignites, in duplicate, were exposed to an absolutely dry atmosphere for 48 hours, at the expiration of which time they were found to have parted with the greater part of their moisture. They were then further exposed for consecutive periods of 36, 44, 68, 68, 48, and 42 hours, during which periods they incurred an additional loss (in each case the mean of the thirty experiments) of respectively 1·25, 0·84, 0·73, 0·59, 0·29, and 0·15 per cent. of water (the loss—taking the mean of the two experiments with each of the fifteen fuels—ranging from 0·92 to 1·66, 0·71 to 0·97, 0·51 to 0·80, 0·36 to 0·75, and 0·19 to 0·37 per cent.) or a total loss of 3·85 per cent. for the additional 306 hours. A still further exposure for consecutive periods of 93, 120, 70, and 90 hours, was attended by a further loss (in each case the mean of the thirty experiments) of respectively 0·48, 0·45, 0·15, and 0·19 per cent., or an aggregate loss of 1·27 per cent. for the 373 hours (additional to the previous 354 hours) exposure. The peat, which had already been submitted to an exposure of 354 hours, was further exposed for consecutive periods of 93, 120, 70, 90, and 48 hours, which resulted in an additional loss of respectively 0·53, 0·53, 0·16, 0·16, and 0·05 per cent., or for the total period of 421 hours (additional to the preceding 354 hours) a combined loss of 1·43 per cent. In like manner a lignitic coal which had previously been submitted to an exposure of 354 hours, was also further exposed for consecutive periods of 93, 120, and 70 hours, and with the result that it incurred an additional loss of respectively 0·34, 0·32, and 0·08 per cent., or for the total period of 283 hours (additional to the former 354 hours) an aggregate loss of 0·74 per cent.

The period of exposure—both in a dry and moist atmosphere—finally adopted, in all cases, was 354 hours, weighing at intervals of 190, 94, and 70 hours; and it was found that, during the last 70 hours of this exposure—

In a dry atmosphere, the loss incurred by the—

Lignites	ranged from	0·33 to 0·58 p.c.,	the average loss being 0·42 p.c.
Lignitic coals....	" "	0·13 to 0·26 "	" " " 0·20 "
Coals	" "	0·02 to 0·10 "	" " " 0·05 "
Semi-anthracites.	" "	0·01 to 0·02 "	
Anthracite......	amounted to 0·05 p.c.		

In a moist atmosphere, the amount of water re-absorbed by the—

Lignites	ranged from	0·26 to 0·85 p.c.,	the average gain being 0·55 p.c.
Lignitic coals....	" "	0·07 to 0·26 "	" " " 0·19 "
Coals	" "	0·02 to 0·12 "	" " " 0·07 "
Semi-anthracites..	" "	0·02 to 0·04 "	" " " 0·03 "
Anthracite......	amounted to 0·06 per cent.		

The peat and anthracitic coal comported themselves, in both above regards, in much the same manner as a lignite and coal respectively. Hygroscopicity of certain Canadian fossil fuels, cont.

It will be observed that there is a remarkably close agreement in the amounts of water lost and re-absorbed by each of the respective varieties of fuel during the last 70 of the 354 hours exposure, and that the amount of this loss and re-absorption is (apart from the anthracite) proportionate to the degree of alteration of the fuel—it being greatest in the lignites, and least in the semi-anthracites.

From the above results, coupled with those obtained in the preliminary experiments, it is evident, that beyond a certain point, the lignites and lignitic coals part with their water but very slowly, so that even after an exposure of 354 hours to an absolutely dry atmosphere, these yet retain a certain amount of water removable by a yet more protracted exposure. The coals and semi-anthracites, on the other hand, may fairly be regarded as dry after such period of exposure—indeed, it was found that, in many instances, the semi-anthracites and more altered coals had, during the last 70 hours, suffered no alteration in weight.

In the accompanying table the various fuels have been arranged in the order of their diminishing hygroscopicity. On referring to the same, it will be seen that the capacity for retaining, and with it that for re-absorbing, water varies with the degree of alteration which the fuel has undergone—it being most pronounced in the lignites, less so in the lignitic coals, and least in the coals. Thus, we find that the amount of water retained by the lignites[1] (and peat—which, in this regard, comports itself like a lignite) ranges from 2·50 to 5·00 (2·43 to 5·12) per cent., whilst that retained by the lignitic coals[2] ranges from 1·00 to 2·00 (1·10 to 2·09) per cent., and that retained by the coals[3] (together with the anthracitic coal, semi-anthracites, and anthracite, which, in this particular, behave like coals) from 0·10 to 1·00 (0·03 to 1·11) per cent., also—that the amount of water re-absorbed by the dry fuel, ranges, in the case of the lignites[4] (and peat, whose behaviour, in this regard, is precisely similar to that of a lignite,) from 10·00 to 14·50 (10·06 to 14·45) per cent., in that of the lignitic coals[5] from 6·50 to 9·00 (6·62 to 8·80) per cent., and in that of the coals (together with the

[1] Excluding No. 3, which stands out conspicuously from all the rest, in that it retained an exceptionally large amount of water.

[2] Omitting No. 33, which forms the connecting link between the lignites and lignitic coals, and retained a much larger percentage of water than any of the other fuels of the latter class.

[3] Disregarding No. 44, which forms a connecting link between the lignitic coals and coals, and retained a larger percentage of water than any of the other coals.

[4] Passing over No. 37, in which it was found to be exceptionally low.

[5] Omitting No. 42, which forms the connecting link between the lignitic coals and coals, and re-absorbed a somewhat smaller amount of water than any of the other lignitic coals.

Hygroscopicity of certain Canadian fossil fuels, cont.

anthracitic coal, semi-anthracites, and anthracite[1]) from 1·50 to 6·00 (1·66 to 6·19) per cent.; or briefly:—

Lignites	retain from	2·50 to 5·00,	and re-absorb from	10·00 to 14·50	p.c.	water
Lignitic coals.	" "	1·00 to 2·00,	" "	6·50 to 9·00	"	"
Coals........	" "	0·10 to 1·00,	" "	1·50 to 6·00	"	"

Comparing the results given in column 5, with those recorded in column 4, we find that the degree of alteration of the fuel as indicated by the potash reaction, is further evidenced by its relative hygroscopicity. Thus, we see that whereas—

The coloration imparted to a solution of caustic potash, by	The percentage of water re-absorbed ranges, in the case of
LIGNITES—is dark to intense brownish-red, and that by	LIGNITES .... from 10·00 to 14·50
LIGNITIC COALS — most frequently brownish-yellow, but occasionally brownish-red, the	LIGNITIC COALS ...... " 6·50 to 9·00
COALS—in many instances give no coloration, at other times a faint yellowish one, or one ranging between that and pale brownish-yellow.	COALS .... " 1·50 to 6·00

The considerations which led to the arrangement of the fuels, here treated of, under the headings mentioned, were alluded to in a previous paper (Report of Progress of the Geological and Natural History Survey of Canada, 1882-83-84, Part M, p. 5, et séq.). It was there shown that:—

1. Whereas the Lignites all have a greater or less tendency to disintegrate on exposure to the air; contain a large amount of water; communicate an intense coloration to a solution of caustic potash; yield (by fast coking) a non-coherent coke, and have a chemical composition very similar to that of many foreign lignites.

2. The Lignitic Coals show a greater disposition to resist[2] exposure to the air—being, on the whole, tolerably firm; contain much less water; do not impart so deep a coloration to a solution of caustic potash; show (by fast coking) a slight caking tendency, and in regard to chemical composition, occupy a position between true lignites and true bituminous coals.

[1]The anthracite, it will be observed, contrary to what might have been expected, re-absorbed far more water (the experiments were repeated, and with the same results) than any of the semi-anthracites or more altered coals, and in this regard, takes rank with some of the least altered of the latter; its capacity for retaining water is, however, as may be seen, very slight.

[2] Employed, throughout this paper, in the sense of "not breaking down."

TABLE SHOWING HYGROSCOPICITY OF CERTAIN CANADIAN FOSSIL FUELS.

1.	2.	3.	4.				5.										6.
			Hygroscopicity.				Potash Reaction (2).										
			a. Per cent. water—	b.	c.	d.											
Number of Specimen.	Variety of Fuel.	Per cent. water—at 115°C.—in fuel at time of experiment.	in dry coal. (1)	in saturated coal	lost in dry atmosphere.	re-absorbed in moist atmosphere.	Intense brownish-red.	Deep brownish-red.	Dark brownish-red.	Brownish-red.	Brownish-yellow.	Pale brownish-yellow.	Very pale brownish-yellow.	Faint brownish-yellow.	All but colorless.	Colorless.	Number of Specimen.
1.	Lignite.	13·63	4·53	18·98	9·10	14·45			*								1.
2.	do.	12·89	3·92	17·40	8·97	13·48		*									2.
3.	do.	16·37	6·65	19·83	9·72	13·18	*										3.
4.	do.	14·78	2·73	15·64	12·05	12·91			*								4.
5.	do.	21·84	4·76	17·66	17·08	12·90		*									5.
6.	do.	14·20	2·96	15·85	11·24	12·89			*								6.
7.	do.	13·73	4·77	17·63	8·96	12·86		*									7.
8.	do.	20·54	3·76	16·33	16·78	12·75			*								8.
9.	do.	12·62	3·67	16·36	8·95	12·69			*								9.
10.	Peat (3)	10·28	4·20	16·86	6·08	12·66	*										10.
11.	Lignite.	19·90	4·07	16·54	15·83	12·47			*								11.
12.	do.	13·06	3·83	16·18	9·23	12·35			*								12.
13.	do.	11·91	5·12	17·39	6·79	12·27		*									13.
14.	do.	13·08	3·49	15·73	9·59	12·24		*									14.
15.	do.	12·31	3·89	16·04	8·42	12·15			*								15.
16.	do.	11·68	4·19	16·28	7·49	12·09		*									16.
17.	do.	11·90	3·38	15·47	8·52	12·09			*								17.
18.	do.	11·47	3·70	15·70	7·77	12·00			*								18.
19.	do.	16·82	3·68	15·64	13·14	11·96			*								19.
20.	do.	8·92	2·71	14·52	6·21	11·81			*								20.
21.	do.	11·13	4·03	15·80	7·10	11·77	*										21.
22.	Lignitified wood.	9·66	4·12	15·83	5·54	11·71			*								22.
23.	Lignite.	11·91	3·70	15·39	8·21	11·69			*								23.
24.	do.	11·25	3·19	14·84	8·06	11·65			*								24.
25.	do.	10·02	3·38	14·32	6·64	10·94			*								25.
26.	do.	11·47	2·86	13·73	8·61	10·87			*								26.
27.	do.	10·58	2·40	13·19	8·18	10·79			*								27.
28.	do.	10·72	2·86	13·64	7·86	10·78			*								28.
29.	do.	9·86	2·95	13·28	6·91	10·33			*								29.
30.	do.	11·52	3·37	13·66	8·15	10·29			*								30.
31.	do.	9·18	2·64	12·88	6·54	10·24			*								31.
32.	do.	10·35	2·60	12·66	7·75	10·06			*								32.
33.	Lignitic coal.	6·03	2·81	11·61	3·22	8·80				*							33.
34.	do.	5·58	1·67	10·43	3·91	8·76					*						34.
35.	do.	7·02	1·52	10·27	5·50	8·75					*						35.
36.	do.	7·01	2·09	9·75	4·92	7·66					*						36.
37.	Lignite.	7·66	2·67	10·22	4·99	7·55			*								37.
38.	Lignitic coal.	6·50	1·42	8·72	5·08	7·30					*						38.
39.	do.	7·83	1·86	9·08	5·97	7·22		*									39.
40.	do.	5·38	1·15	8·24	4·23	7·09					*						40.
41.	do.	4·97	1·10	7·72	3·87	6·62					*						41.
42.	do.	6·12	1·37	7·57	4·75	6·20					*						42.
43.	Coal.	4·41	0·82	7·01	3·59	6·19							*				43.
44.	do.	5·03	1·40	7·58	3·63	6·18						*					44.
45.	do.	3·68	0·90	7·07	2·78	6·17						*					45.
46.	do.	4·93	1·07	6·69	3·86	5·62							*				46.
47.	do.	3·65	1·11	6·64	2·54	5·53					*						47.
48.	do.	3·91	0·83	6·06	3·08	5·23							*				48.
49.	Anthracite.	1·99	0·19	5·26	1·80	5·07									*		49.
50.	Coal.	4·03	0·80	5·78	3·23	4·98								*			50.
51.	do.	3·27	0·73	5·10	2·54	4·37								*			51.
52.	do.	2·36	0·60	3·90	1·76	3·30									*		52.
53.	do.	2·75	0·69	3·89	2·06	3·20								*			53.
54.	Anthracitic coal.	2·07	0·50	3·59	1·57	3·09							*				54.
55.	Coal.	2·65	0·23	3·29	2·42	3·06										*	55.
56.	do.	2·90	0·60	3·66	2·30	3·06							*				56.
57.	do.	1·99	0·46	3·38	1·53	2·92										*	57.
58.	do.	2·45	0·64	3·47	1·81	2·83								*			58.
59.	Semi-anthracite.	1·60	0·23	2·94	1·37	2·71										*	59.
60.	Coal.	2·12	0·35	2·95	1·77	2·60									*		60.
61.	do.	1·89	0·11	2·62	1·78	2·51										*	61.
62.	do.	1·63	0·38	2·83	1·25	2·45										*	62.
63.	do.	2·10	0·64	3·06	1·46	2·42				*							63.
64.	do.	1·79	0·03	2·44	1·76	2·41										*	64.
65.	do.	1·93	0·43	2·73	1·50	2·30							*				65.
66.	Semi-anthracite.	1·04	0·12	2·27	0·92	2·15										*	66.
67.	Coal.	1·75	0·39	2·53	1·36	2·14						*					67.
68.	do.	1·05	0·09	2·21	0·96	2·12										*	68.
69.	Semi-anthracite.	0·71	0·20	2·24	0·51	2·04										*	69.
70.	Coal.	1·24	0·22	2·26	1·02	2·04								*			70.
71.	do.	1·82	0·39	2·35	1·43	1·96							*				71.
72.	Semi-anthracite.	0·70	0·12	1·78	0·58	1·66										*	72.

(1.) That is to say the amount of water retained by the same after exposure to a perfectly dry atmosphere for 354 hours.

(2.) The treatment with solution of caustic potash was conducted at the ordinary temperature. This offers some advantages over that by digestion at a boiling heat—the action not being so energetic (although sufficiently so, as the results show, to obtain the desired result), a greater number of shades of color are obtained, thus admitting of a more accurate estimate of the nature of the fuel. The experiments were all carried out simultaneously, and under precisely similar conditions; the results admit, therefore, of a fair comparison. The fuels were all reduced to a very fine powder; specific gravity of the potash solution, 1·16 time of contact, shaking at intervals, two hours; after which filtration was proceeded with, the filtrates being collected in flat, broad-faced, narrow-sided white glass bottles of uniform dimensions. The amount of alkaline solution, and weight of fuel employed, was in all instances the same.

(3.) This specimen had been kept in the show-cases of the Museum for years, and may fairly be regarded as having been in a thoroughly air-dried condition

3. Whilst the Coals resist exposure to the air; are hard and firm; contain but a small proportion of water; communicate but a very slight, if any, coloration to a solution of caustic potash; yield (by fast coking), in the majority of instances, a good firm coke, and in respect to general appearance and chemical composition closely resemble some varieties of coal of the Carboniferous system.

NATURAL WATERS.

Natural waters.

Water from 'potash' spring, Harrison Hot Springs, B.C.

1.—Water from the so-called "potash" spring, Harrison Hot Springs, south end of Harrison Lake, British Columbia. Collected at the instance of Dr. A. R. C. Selwyn.

Temperature of the water at the spring, 120° F. An analysis of the same, by Mr. Frank D. Adams, afforded the undermentioned results:

At the time of examination it contained a small amount of suspended matter—this was removed by filtration; it consisted of a little organic and argillaceous matter, together with a little ferric hydrate and a trifling amount of very fine sand. The filtered water was perfectly colorless, even when viewed in a column two feet in length, and inodorous; taste, slightly saline: it exhibited a distinct alkaline reaction with reddened litmus paper, but did not affect the color of turmeric paper. The specific gravity of the water, at 15·5° C., was found to be 1001·00. 1000 parts, by weight, of the filtered water, at 15·5° C., contained:

Potassa	·0128
Soda	·3945
Lithia	undet.
Strontia	undet.
Lime	·1134
Magnesia	·0008
Alumina	trace
Ferrous oxide (very small amount)	undet.
Sulphuric acid	·3657
Carbonic acid	undet.
Silica	·0586
Chlorine	·2558
Organic matter	trace
	1·2016
Less oxygen equivalent to chlorine	·0577
	1·1439

The lithia and strontia were detected by means of the spectroscope—strong and persistent lines being obtained in both instances. Iodine and bromine were also sought for, but not detected.

Water from 'potash' spring, Harrison Hot Springs, B.C., cont.

The foregoing acids and bases may reasonably be assumed to exist in the water in the following state of combination :

(The carbonate being calculated as mono-carbonate, and all the salts estimated as anhydrous.)

Chloride of potassium	·0202
" sodium	·4059
" lithium	undet.
Sulphate of soda	·4107
" magnesia	·0024
" lime	·2256
" strontia	undet.
Carbonate of lime	·0366
" iron (very small amount)	undet.
Alumina	trace
Silica	·0586
Organic matter	trace
	1·1600

Total dissolved solid matter, by direct experiment, dried at 180° C. 1·1669

There was not enough of the water at the disposal of the operator to admit of the estimation of the lithia, strontia, iron and carbonic acid. The determination of these constituents would necessarily involve a trifling alteration in some of the above figures.

An imperial gallon of the water—at the aforementioned temperature—would contain :

(The carbonate being calculated as anhydrous bi-carbonate, and the salts without their water of crystallisation.)

	Grains.
Chloride of potassium	1·414
" sodium	28·413
" lithium	undet.
Sulphate of soda	28·749
" magnesia	·168
" lime	15·792
" strontia	undet.
Bi-carbonate of lime	3·689
" iron (very small amount)	undet.
Alumina	trace
Silica	4·102
Organic matter	trace
	82·327

Water from 'sulphur' spring, Harrison Hot Springs, B.C.

2.—Water from the so-called "sulphur" spring, Harrison Hot Springs, south end of Harrison Lake, British Columbia. Collected at the instance of Dr. A. R. C. Selwyn.

Temperature of the water at the spring, 150° F. Mr. Frank D. Adams has made an analysis of this water, and with the following results:

Water from 'sulphur' spring, Harrison Hot Springs, B.C., cont.

At the time of examination it contained a small amount of suspended matter, consisting of argillaceous matter, very fine sand, flocculent organic matter—apparently vegetable matter—and a little ferric hydrate: this was removed by filtration. The filtered water was colorless, even when viewed in a column two feet in length: taste faintly saline, somewhat flat: it reacted distinctly alkaline with red litmus paper, but did not affect the color of turmeric paper.

The specific gravity, at 15·5° C., was found to be 1001·13. 1000 parts, by weight, of the filtered water, at 15·5° C., contained:

Potassa	·0155
Soda	·4433
Lithia	undet.
Strontia	undet.
Lime	·1221
Magnesia	·0007
Alumina	trace
Sulphuric acid	·3922
Carbonic acid	undet.
Silica	·0662
Chlorine	·2829
	1·3229
Less oxygen equivalent to chlorine	·0638
	1·2591

The lithia and strontia were detected by means of the spectroscope—the lines being, in both instances, very distinct. Iodine and bromine were also sought for, but not detected.

It may be reasonably assumed that the foregoing acids and bases exist in the water in the following state of combination:

(The carbonate being calculated as mono-carbonate, and all the salts estimated as anhydrous.)

Chloride of potassium	·0246
" sodium	·4471
" lithium	undet.
Sulphate of soda	·4723
" magnesia	·0021
" lime	·2120
" strontia	undet.
Carbonate of lime	·0621
Alumina	trace
Silica	·0662
	1·2864
Total dissolved solid matter, by direct experiment, dried at 180° C	1·3000

Water from 'sulphur' spring, Harrison Hot Springs, B.C., cont.

The quantity of the water at the disposal of the operator was too limited to allow of his estimating the amounts of lithia, strontia and carbonic acid. The knowledge of their respective amounts would call for a slight alteration in some of the above figures.

An imperial gallon of the water, at 15·5° C., would contain:

(The carbonate being calculated as anhydrous bi-carbonate, and the salts without their water of crystallisation.)

	Grains.
Chloride of potassium	1·722
" sodium	31·297
" lithium	undet.
Sulphate of soda	33·061
" magnesia.	·147
" lime	14·840
" strontia	undet.
Bi-carbonate of lime	6·259
Alumina	trace
Silica	4·634
	91·960

Water from a boring in the township of Otonabee, P.O

3.—Water from a boring on the west half of lot twenty-six, in the fourth range of Otonabee, Peterborough county, Ontario. It rises from the Trenton limestone.

The examination and analysis were conducted by Mr. Frank D. Adams.

On opening the bottles a slight, but decided, odor of petroleum was noticeable. The water contained a considerable amount of suspended matter. This was filtered off and examined—it consisted of argillaceous matter, very fine sand, partially decomposed fragments of wood, fragments of seed-cases and other vegetable matter, together with some carbonate of lime, small amounts of carbonates of magnesia and iron and a very small amount of sulphate of lime. The filtered water, when viewed in a column two feet in length, was found to have a faint brownish tinge. Taste, mildly saline. Lithia and strontia were detected by means of the spectroscope. Baryta was not sought for. The presence of iodine and bromine requires confirmation. The specific gravity of the water, at 15·5° C., was found to be 1003·91.

Its analysis gave as follows, for 1000 parts by weight:

Water from a boring in the township of Otonabee, P.O., cont.

Potassa	·0487
Soda	2·0364
Lime	·3492
Magnesia	·2022
Alumina	·0008
Ferrous oxide	·0031
Sulphuric acid	·0011
Carbonic acid (fixed)	·0931
" (half-combined and free)	(*)
Silica	·0153
Chlorine	2·9858
Organic matter	trace
	5·7357
Less oxygen equivalent to chlorine	.6736
	5·0621

The foregoing acids and bases are most probably combined in the water as follows:

(Carbonates calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of potassium	·0770
" sodium	3·8403
" calcium	·4088
" magnesium	·4797
Sulphate of lime	·0019
Carbonate of lime	·2536
" iron	·0050
Alumina	·0008
Silica	·0153
Organic matter	trace
	5·0824
Total dissolved solid matter, by direct experiment, dried at 180° C.	5·0213

* The amount of total carbonic acid varied in different bottles—most probably due to faulty corking. In some bottles the amount found proved to be just about that required for the conversion of the mono-carbonates into bi-carbonates, whilst in others the amount found was appreciably in excess of that required for the formation of bi-carbonates.

Water from a boring in the township of Otonabee, P.O., cont.

An imperial gallon of the water would contain:

(Carbonates calculated as anhydrous bi-carbonates, and the salts without their water of crystallisation.)

	Grains.
Chloride of potassium	5·390
" sodium	268·821
" calcium	28·616
" magnesium	33·579
Sulphate of lime	·133
Bi-carbonate of lime	25·564
" iron	·483
Alumina	·056
Silica	1·071
Organic matter	trace
	363·713

Water from a boring at Maisonneuve, P.Q.

4.—Water from a boring on the property of Messrs. Viau & Frère at Maisonneuve, Hochelaga county, province of Quebec. The boring, which is in Cambro-Silurian strata, had, at the time of collection of the water, been carried to a depth of 1500 feet.

The examination and analysis were conducted by Mr. Frank D. Adams.

The sample of water sent for examination had, when received, a faint yet decided odor of sulphuretted hydrogen; it contained but a very trifling amount of sediment; color of the clear water, when viewed in a column two feet in length, light yellow; taste, mildly saline; reaction, faintly alkaline. The specific gravity, at 15·5° C., was found to be 1006·31. Total dissolved solid matter, by direct experiment, dried at 180° C., in 1000 parts, by weight, of the water—7·4129.

Its analysis gave as follows, for 1000 parts by weight:

Potassa	·0190
Soda	3·3899
Lithia	undet.
Lime	·0836
Strontia	undet.
Magnesia	·1165
Ferrous oxide	undet.
Alumina	trace
Sulphuric acid	1·6636
Boric acid	undet.
Carbonic acid	·3819
Phosphoric acid	undet.
Chlorine	2·4623

Water from a boring at Maisonneuve, P.Q., cont.

Iodine	(*)
Bromine	undet.
Silica	·0135
Organic matter	undet.
	8·1303
Less oxygen equivalent to chlorine†	·5555
	7·5748
Sulphuretted hydrogen	·0098

In the absence of a knowledge of the respective amounts of the undetermined constituents, the remaining ones may be represented as being present in the following state of combination:

(Carbonates being calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of potassium	·0301
" sodium	4·0358
Sulphate of soda	2·8624
" lime	·0867
Carbonate of lime	·0855
" magnesia	·2447
Alumina	trace
Silica	·0135
	7·3587
Carbonic acid, half-combined	·1658
" free	·0503
	7·5748

An imperial gallon of the water would contain:

(Carbonates calculated as anhydrous bi-carbonates, and all the salts without their water of crystallisation.)

	Grains.
Chloride of potassium	2·107
" sodium	282·506
Sulphate of soda	200·368
" lime	6·069
Bi-carbonate of lime	8·617
" magnesia	26·103
Alumina	trace
Silica	·945
	526·715
Carbonic acid, free	3·521
	530·236

* The iodine was subsequently estimated and found to equal 0·000027 parts per 1000.
† That equivalent to bromine and iodine, not ascertained.

Water from a pond in the parish of Pennfield, N.B.

5.—This, and the following water—the one from a pond, the other from a spring—are from the parish of Pennfield, Charlotte county, New Brunswick. They were examined for Mr. W. F. Todd.

Water from the pond. The sample received was clear and colorless. A qualitative analysis of the same afforded Mr. R. A. A. Johnston the following results:

Soda	very small quantity.
Lime	very small quantity.
Magnesia	very small quantity.
Ferrous oxide	trace.
Sulphuric acid	very small quantity.
Chlorine	small quantity.

The water was accompanied by a sample of material which is said to form a sediment, of from one to three feet and a-half in thickness, at the bottom of the pond. This on examination was found to consist of infusorial earth.

Water from a spring in the parish of Pennfield, N.B.

6.—Water from the spring on hill side. The water had a pale brownish yellow color. A qualitative analysis, by Mr. R. A. A. Johnston, showed it to contain:

Soda	trace.
Lime	trace.
Ferrous oxide	small quantity.
Sulphuric acid	trace.
Chlorine	trace.
Silica	small quantity.
Organic matter	small quantity.

The iron exists in this water in combination with an organic acid. The clear water by exposure to the air soon becomes turbid, and deposits a reddish-brown precipitate of ochre, and if the exposure is sufficiently protracted the iron separates so completely that no trace of the same can be detected in the water.

This water was accompanied by a sample of reddish-brown slime, which was stated to be deposited by the water in considerable quantity. This slime consisted of hydrated peroxide of iron, with a trace of manganese, a small amount of alumina, a very appreciable amount of organic matter and a trace of phosphoric acid.

IRON ORES.

Iron ores.

1.—RED HEMATITE, from the property of Mr. Joseph L. McNeely, lot fourteen, range eleven, of the township of Beckwith, Lanark county, province of Ontario. Geological position—Calciferous.

Hematite from the township of Beckwith, P.O.

Color, dark-greyish reddish-brown: in parts coated with a purplish to brownish-red unctuous powder: streak, cherry red: fracture, uneven and minutely crystalline: contains a little calcite and other minerals disseminated through it.

Its analysis afforded me the following results:

Ferric oxide	81·671
Manganous oxide	·081
Potassa	·020
Soda	·069
Lime	1·487
Magnesia	·046
Alumina	·913
Silica	13·853
Carbonic acid	·651
Phosphoric acid	·245
Sulphuric acid	·028
Titanic acid	none
Water, hygroscopic	·333
" combined	·665
	100·062
Metallic iron	57·170
Phosphorus	·107
Sulphur	·011

The sulphuric acid is, apparently, present as sulphate of lime.

2.—RED HEMATITE, from lot twenty-four, range eleven, of the township of Darling, Lanark county, province of Ontario. Examined for Mr. W. J. Morris.

Hematite from the township of Darling, P.O.

A partial analysis, by Mr. Frank D. Adams, gave:

Ferric oxide	92·602	per cent.
Phosphoric acid	·538	"
Sulphuric acid	·010	"
Metallic iron	64·821	"
Phosphorus	·235	"
Sulphur	·004	"

3.—RED HEMATITE. A compact red hematite from location 280 R., about three-quarters of a mile west of Loon Lake, district of Algoma, province of Ontario. Collected by Dr. A. C. Lawson.

Hematite from near Loon Lake, P.O.

Iron Ores, cont.

Hematite from near Loon Lake, P.O., cont.

Agreeably with the results of determinations made by Mr. R. A. A. Johnston, it contained:

Metallic iron	57·25 per cent.
Insoluble matter	16·41 "
Titanic acid	none

Magnetite from the township of North Crosby, P.O.

4.—MAGNETITE, from the property of Mr. E. Quinn, lot twelve, range two, of the township of North Crosby, Leeds county, province of Ontario. Examined for Mr. J. H. Whelan.

Determinations by Mr. R. A. A. Johnston gave:

Metallic iron	58·77 per cent.
Insoluble matter	7·28 "
Titanic acid	none

Magnetite from vicinity of Kaministiquia station, P.O.

5.—MAGNETITE. A very fine crystalline magnetite from the vicinity of Kaministiquia station, on the line of the Canadian Pacific Railway, district of Thunder Bay, province of Ontario. Collected by Dr. A. R. C. Selwyn.

Mr. R. A. A. Johnston found it to contain:

Metallic iron	31·46 per cent.
Insoluble matter	45·42 "
Titanic acid	none

Magnetite from Gunflint Lake, P.O.

6.—MAGNETITE. A fine-grained, compact magnetite from McKinley's location, north shore of Gunflint Lake, about seventy miles southwest of Port Arthur, district of Algoma, province of Ontario. Collected by Dr. A. C. Lawson.

Determinations by Mr. R. A. A. Johnston gave:

Metallic iron	61·08 per cent.
Insoluble matter	19·65 "
Titanic acid	none.

Magnetite from 'Milner' mine, Clementsport, N.S.

7.—MAGNETITE. This, and the following specimen are from Clementsport, Annapolis county, province of Nova Scotia. The analyses were conducted by Mr. Frank D. Adams.

Sample of ore from the "Milner" mine. It consisted of an association of fine crystalline magnetite and a dark-grey shale. Analysis gave:

Metallic iron	32·189 per cent.
Phosphorus	·220 "
Sulphur	·168 "
Insoluble matter	33·300 "
Titanic acid	none.

8.—Sample of ore from the "Potter" mine. Consisted of an association of a fine crystalline magnetite and a dark-grey shale. It was found to contain: Magnetite from 'Potter' mine, Clementsport, N.S.

Metallic iron	42·102	per cent.
Phosphorus	·716	"
Sulphur	·180	"
Insoluble matter	23·073	"
Titanic acid	none.	

Alluding to the above deposits, Mr. Edward Gilpin, the Inspector of Mines for the province, says (The Mines and Mineral Lands of Nova Scotia): "There are at Clementsport two beds of ore running nearly east and west. The highest of these, the 'Milner' bed, varies in thickness from two to four feet: it yields about thirty-three per cent. of metallic iron. The 'Potter' bed presents the following section where worked—ore, three feet; slate, two feet six inches; ore, three feet six inches. It is stated to yield fifteen per cent. more iron than the ore from the Milner bed." The statement in regard to percentage of iron is pretty well borne out by above analyses.

9.—SIDERITE. The deposit from which this sample was taken extends over mining locations Nos. 22, 23, 24, 25 and 26 of the township of McIntyre, district of Thunder Bay, province of Ontario. Siderite from the township of McIntyre, P.O.

The material composing the sample consisted of a fine-grained greyish siderite, often distinctly banded, the bands varying somewhat in color. Some of the fragments were highly quartzose.

A partial analysis, by Mr. Frank D. Adams, gave as follows:

Ferrous oxide	36·145	per cent.
Manganous oxide	·710	"
Lime	5·279	"
Magnesia	3·619	"
Phosphoric acid	·100	"
Sulphuric acid	·313	"
Insoluble matter	23·787	"
Metallic iron	28·113	"
Phosphorus	·044	"
Sulphur	·125	"

A previous sample of ore from this deposit was found by Mr. R. A. A. Johnston to contain 32·86 per cent. of metallic iron.

Limestones and dolomites.

LIMESTONES AND DOLOMITES.

The following analyses of limestones and dolomites are the first of a series, which it is proposed to carry out in connection with an enquiry 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. The analyses will, later on, be supplemented by determinations of their density, absorbtive power, crushing strength and elasticity, etc.

Limestone from Mallette's quarry, Pointe Claire, P.Q.

1.—LIMESTONE. From Mallette's quarry, Pointe Claire, Jacques Cartier county, province of Quebec. The beds of limestone quarried are from ten inches to four feet thick. Geological position—Birdseye and Black River formation, Cambro-Silurian.

Structure, compact; contains, in parts, a few inclusions of crystalline calcite; color, very dark brownish-grey.

An analysis, by Mr. R. A. A. Johnston, showed it to contain:

(After drying at 100° C.—Hygroscopic water=0·14 per cent.)

Carbonate of lime		95·89
" magnesia		0·68
" iron		0·26
Alumina	0·02	
Silica, soluble	0·04	2·83
Insoluble matter	2·77	
Organic matter		0·16
		99·82

This stone was used in the construction of the piers of the western half of the Victoria Bridge at Montreal, the blocks obtained for this purpose weighing from four to seven tons each.

Limestone from the township of Ramsay, P.O.

2.—LIMESTONE. From lot twenty-four, range nine, of the township of Ramsay, Lanark county, province of Ontario. The quarry from which this stone was taken is situated close to the Indian River, where a great thickness of this limestone occurs. Geological position—Laurentian.

Structure, somewhat coarsely crystalline: color, faintly bluish-greyish-white. It contains, here and there, a minute grain of pale yellow chondrodite, and numerous small scales of graphite.

It was found—by Mr. R. A. A. Johnston—to have the following composition:

Limestones and dolomites, cont.

Limestone from the township of Ramsay, P.O., cont.

(After drying at 100° C.—Hygroscopic water=0·07 per cent.)

Carbonate of lime		91·63
" magnesia		6·61
" iron		0·41
Alumina	0·14	
Silica, soluble	0·05	1·32
Insoluble matter	1·13	
		99·97

This stone has been extensively quarried for the manufacture of lime, and small quanties have been employed in Pakenham and Almonte for foundations and facings of buildings.

3.—LIMESTONE. Occurs on lots nine and ten of the sixth range of the township of Ramsay, Lanark county, province of Ontario. The same stone also occurs on lots nine and ten of the fourth and fifth ranges, and on lot sixteen of the second range, and many other places in this township. Geological position—Laurentian.

Limestone from the township of Ramsay, P.O.

Structure, coarsely crystalline: color, white but not pure white. It contains an occasional grain of pale yellow chondrodite, and, here and there, a scale of graphite.

Agreeably with the results of an analysis—conducted by Mr. R. A. A. Johnston—it contained:

(After drying at 100° C.—Hygroscopic water=0·09 per cent.)

Carbonate of lime		90·05
" magnesia		6·51
" iron		0·42
Alumina	—	
Silica, soluble	0·06	3·32
Insoluble matter	3·26	
		100·30

This stone has been extensively used for the manufacture of lime.

4.—LIMESTONE. From the Bath Road quarry, Bath road, Kingston, Frontenac county, province of Ontario. Geological position—Birdseye and Black River formation, Cambro-Silurian.

Limestone from the Bath Road quarry, Kingston, P.O.

Structure, compact—containing, in parts, some small inclusions of crystalline calcite: color, somewhat dark bluish-grey.

Mr. R. A. A. Johnston has made an analysis of this stone, and with the following results:

Limestones and dolomites, cont.

Limestone from the Bath Road quarry, Kingston, P.O., cont.

(After drying at 100° C.—Hygroscopic water=0·16 per cent.)

Carbonate of lime		90·07
" magnesia		2·52
" iron		0·26
Alumina	0·14	7·72
Silica, soluble	0·12	
Insoluble matter	7·46	
Organic matter		0·27
		100·84

This stone is largely used in the city of Kingston for building purposes.

Limestone from the Wolfe Island quarry, Wolfe Island, P.O.

5.—LIMESTONE. From the Wolfe Island quarry, Wolfe Island, opposite Kingston Harbor, Frontenac county, province of Ontario. From the three-foot bed. Geological position—Birdseye and Black River formation, Cambro-Silurian.

Structure, compact—traversed by an occasional very thin seam of crystalline calcite: color, dark brownish-grey.

An analysis—conducted by Mr. R. A. A. Johnston—gave as follows:

(After drying at 100° C.—Hygroscopic water=0·12 per cent.)

Carbonate of lime		94·81
" magnesia		2·33
" iron		0·29
Alumina	—	3·02
Silica, soluble	0·12	
Insoluble matter	2·90	
Organic matter		0·28
		100·73

This stone has been used in several public works—viz., Fern's Point lock; piers and abutments of Kingston Mills; Grand Trunk Railway bridges, and for heavy base courses in several public buildings—and these, after a lapse of some forty years, are said to be in as good a state of preservation as when first built.

Dolomite from the township of Aldfield, P.Q.

6.—DOLOMITE. From lot ten, range four, of the township of Aldfield, Pontiac county, province of Quebec. Geological position—Laurentian.

Structure, coarsely crystalline: color, white. It contains, here and there, a few grains of honey-yellow chondrodite.

An analysis—by Mr. R. A. A. Johnston—showed it to have the following composition:

(After drying at 100° C.—Hygroscopic water=0·05 per cent.)

Dolomite from the township of Aldfield, P.Q., cont.

Carbonate of lime		53·60
" magnesia		46·01
" iron		0·17
" manganese		0·14
Alumina	0·11	0·32
Silica, soluble	—	
Insoluble matter	0·21	
		100·24

7.—Dolomite. From lot twenty-seven, range nine, of the township of Barrie, Addington county, province of Ontario. Geological position—Laurentian.

Dolomite from the township of Barrie, P.O.

Structure, very fine crystalline: color, pure white.

An analysis—by Mr. R. A. A. Johnston—gave the following results:

(After drying at 100° C.—Hygroscopic water=0·07 per cent.)

Carbonate of lime		54·02
" magnesia		42·63
" iron		0·64
Alumina	—	2·52
Silica, soluble	—	
Insoluble matter	2·52	
		99·81

MISCELLANEOUS MINERALS.

Miscellaneous minerals.

1.—Bournonite. Was identified by Mr. R. A. A. Johnston in samples of ore—sent to the Survey for assay—from the following localities in the province of Ontario, viz., lot 18, range 8, of the township of Marmora (Hastings Co.), the material consisting of bournonite, in association with small quantities of chalcopyrite and pyrite in a gangue of quartz,—from the east-half of lot 22, range 3, and west-half of lot 22, range 4, of the township of Darling (Lanark Co.), the material from the first of these two localities consisting of bournonite disseminated through a somewhat fine crystalline dolomite, while that from the last mentioned consisted of bournonite with some chalcopyrite in a gangue of white sub translucent quartz,—and from the "Moore" mine, lot 17, range 5, of the township of Madoc (Hastings Co.), the material consisting of bournonite in a gangue of somewhat coarse crystalline dolomite.

Bournonite.

2.—Cyanite. This mineral—the occurrence of which, in Canada, was first noticed by Dr. A. R. C. Selwyn, it having been found by him

Cyanite.

Miscellaneous minerals, cont.

on the North Thompson River, British Columbia (Anal., G. C. Hoffmann, Rep. Geol. Can., 1878-79, p. 1 H.)—has quite recently (August, 1890) been met with by Mr. A. E. Barlow, in a pegmatite vein cutting Laurentian gneiss, on lot 9, range 3, of the township of Dryden, district of Nipissing, province of Ontario.

Hyalite.

3.—HYALITE. Good specimens of this mineral were obtained by Mr. J. McEvoy, from cavities in a dark grey foliated basalt occurring near Hīh-hūm Lake, south of Loon Lake, British Columbia.

Lepidomelane.

4.—LEPIDOMELANE. Was recognized by Mr. R. A. A. Johnston in a sample of ore from the township of Marmora, Hastings county, province of Ontario. The material consisted of a fine granular arsenopyrite, through which was disseminated a somewhat large amount of lepidomelane and a little white sub-translucent quartz.

Prase.

5.—PRASE. A breccia, consisting of angular fragments of prase, cemented together with white chalcedony, was found by Dr. G. M. Dawson, filling cavities in Tertiary basaltic rocks in mountains at head of Nicoamen River, British Columbia.

Gold and Silver assays.

GOLD AND SILVER ASSAYS.

These were, without exception, all conducted by Mr. R. A. A. Johnston.

Province of Nova Scotia.

PROVINCE OF NOVA SCOTIA.

1.—From Musquodoboit River, near Musquodoboit Harbor, Halifax county. Examined for Dr. W. H. Weeks.

Galena, together with a very trifling amount of copper pyrites in a gangue of white sub-translucent quartz. The gangue constituted but a very small proportion of the whole. Weight of sample, two ounces. Assays gave:

Gold..................	trace.
Silver................	5·833 ounces to the ton of 2,000 lbs.

Province of New Brunswick.

PROVINCE OF NEW BRUNSWICK.

2.—From Fenton's Lake, six miles east of Mineral Vale, parish of Alma, Albert county. White sub-translucent quartz, carrying very appreciable quantities of galena and a small amount of copper pyrites. Weight of samples, twelve ounces. It contained:

Gold..................	none.
Silver................	6·197 ounces to the ton of 2,000 lbs.

3.—From the parish of Waterford, Kings county. Examined for Mr. E. A. Charters. Gold and Silver assays, cont.

An association of quartz and a steatitic mineral with, here and there, a little specular iron and a few grains of iron pyrites. Weight of sample, fourteen ounces. Province of New Brunswick, cont.

It contained neither gold nor silver.

4.—From a vein between Mill Stream and Nigadoo River, parish of Beresford, Gloucester county. Sent by Mr. W. R. Payne.

A siliceous schistose rock carrying considerable quantities of iron pyrites and copper pyrites. Weight of sample, four ounces and a-half. It was found to contain:

Gold................	trace.
Silver...............	0·466 of an ounce to the ton of 2,000 lbs.

Province of Quebec.

Province of Quebec.

5.—This, and the following specimen are from the township of Courcelles, Berthier county. Examined for Mr. G. Beaucage.

Material from shaft, at a depth of four feet. A garnetiferous gneiss, through which was disseminated a few grains of iron pyrites. The sample, which consisted of twenty-five fragments, weighed twelve pounds thirteen ounces.

It contained neither gold nor silver.

6.—Material from shaft, at a depth of twenty-five feet. An association of gneiss, quartzite, calcite and a little barite—the first mentioned was traversed by bands of serpentine. This sample contained an appreciable amount of iron pyrites. The sample, which consisted of twenty-nine fragments, weighed sixteen pounds nine ounces.

It contained neither gold nor silver.

7.—From lot nineteen, range five, of the township of Buckingham, Ottawa county. Examined for Mr. L. P. Labouglie.

Consisted of iron pyrites, thickly coated with hydrated peroxide of iron. Weight of sample, one pound ten ounces. Assays gave:

Gold	trace.
Silver	none.

For results of assay of a previous sample of material from this locality, see Annual Report Geol. Can., vol. iii, p. 29 T, 1887.

Gold and Silver assays, cont.

Province of Quebec, cont.

8.—From lot ten, range four, of the township of Calumet, Pontiac county. Examined for Mr. W. A. Allan.

It consisted of a somewhat fine crystalline galena disseminated through a gangue of quartz and calcite. Weight of sample, three ounces and a-half. It was found to contain:

Gold............ ... trace.
Silver.............. 16·406 ounces to the ton of 2,000 lbs.

9.—From Wright's mine, block A and B of range one of the township of Duhamel (east shore of Lake Temiscamingue, nine miles and a-half north of Fort Temiscamingue), Pontiac county. Taken from a depth of about thirty feet.

A somewhat coarse crystalline galena, together with small quantities of iron pyrites, in a gangue which was for the most part felspathic, but also included a little dolomite. The sample, which consisted of several fragments, weighed ten ounces and a-half. Assays showed it to contain:

Gold............. none.
Silver........... 0·862 of an ounce to the ton of 2,000 lbs.

10.—From Little River, one mile up from Lake Temiscamingue, or three miles in a straight line south-east of Hudson Bay Company's Post, Pontiac county. Received from Dr. R. Bell.

A light to dark greyish, opaque quartz, carrying small quantities of iron pyrites. Weight of sample, two pounds ten ounces.

It contained neither gold nor silver.

Province of Ontario.

Province of Ontario.

Of the specimens from this province Nos. 13-42 *inc., were collected by Mr. E. Coste: Nos.* 46-51 *inc., and* 56-74 *inc., were received from Dr. R. Bell: Nos.* 52-55 *inc. and* 76-81 *inc., were collected by Mr. A. E. Barlow, and* 93-100 *inc., were collected by Dr. A. C. Lawson.*

11.—From lot two, range fifteen, of the township of Monteagle, Hastings county. This, and the following specimen were examined for Mr. W. A. Allan.

Consisted of magnetic pyrites in association with a little hornblende. Weight of sample, five ounces.

It contained neither gold nor silver.

12.—From lot thirty-two, range two, of the township of Marmora, Hastings county.

Gold and Silver assays, cont.

Province of Ontario, cont.

It consisted of arsenical pyrites in a gangue of quartz. Weight of sample, five ounces. Assays gave:

Gold.. trace.
Silver .... none.

13.—From lot six, range nine, of the township of Marmora, Hastings county. Vein east of creek.

A white sub-translucent quartz, carrying a somewhat large amount of iron pyrites. Weight of sample, one pound thirteen ounces.

It contained neither gold nor silver.

14.—From vein on Capt. O'Neill's property, lot seven, range eight, of the township of Marmora, Hastings county.

Arsenical pyrites in a gangue of greyish-white to white sub-translucent quartz. Weight of sample, two pounds seven ounces. Assays gave:

Gold............ 0·467 of an ounce to the ton of 2,000 lbs.
Silver .... none.

15.—From the Severn mine, lot eight, range eight, of the township of Marmora, Hastings county.

Arsenical pyrites in a gangue of calcite and hornblende. Weight of sample, one pound eight ounces. It was found to contain:

Gold............ 0·175 of an ounce to the ton of 2,000 lbs.
Silver .... none.

16.—From the middle vein, O'Neill shaft, lot nine, range eight, of the township of Marmora, Hastings county.

Arsenical pyrites, together with a little iron pyrites, through which was disseminated a small quantity of a faintly greenish-white chloritic mineral, a little quartz and mica. It was, in parts, coated with hydrated peroxide of iron. Weight of sample, one pound eight ounces. Assays showed it to contain:

Gold................ 2·392 ounces to the ton of 2,000 lbs.
Silver................ none.

17.—From the middle vein, shaft No. 2, lot nine, range eight, of the township of Marmora, Hastings county.

A slightly weathered fragment of arsenical pyrites. Weight of sample, six ounces. It was found to contain:

Gold................. 1·400 ounce to the ton of 2,000 lbs.
Silver................ none.

Gold and Silver assays, cont.

Province of Ontario, cont.

18.—From the middle vein, shaft No. 3, lot nine, range eight, of the township of Marmora, Hastings county.

A coarse crystalline arsenical pyrites. Weight of sample, fourteen ounces. It contained:

Gold.................. 1·633 ounce to the ton of 2,000 lbs.
Silver................ none.

19.—From the middle vein, shaft No. 4, lot nine, range eight, of the township of Marmora, Hastings county.

An association of arsenical pyrites with a small amount of iron pyrites. The whole was more or less coated with hydrated peroxide of iron. Weight of sample, one pound seven ounces. It was found on assay to contain:

Gold................ 2·858 ounces to the ton of 2,000 lbs.
Silver................ none.

20.—Slag from final treatment in extraction of gold, collected by Mr. E. Coste from in front of the Canada Consolidated Gold Mining Company's works at Deloro, township of Marmora, Hastings county.

The material consisted of a brownish-black scoriaceous slag, holding, here and there, more or less minute globules of metallic gold. Weight of sample, 93·35 grams. The whole of this material was employed for the estimation of the gold.

It was found to contain 0·5477 gram gold, which would be equivalent to 0·5867 per cent. Consequently the slag contained at the rate of 171·121 ounces to the ton of 2,000 lbs.—representing a money value of not less than $3,535·36.

21.—From vein near creek, Canada Company's lot, lot five, range nine of the township of Marmora, Hastings county.

Arsenical pyrites in a gangue of greyish-white sub-translucent quartz. Weight of specimen, two pounds thirteen ounces. Assays gave:

Gold............ 0·058 of an ounce to the ton of 2,000 lbs.
Silver........... none.

22.—From the Bob Neill mine, lot fourteen, range ten, of the township of Marmora, Hastings county.

Fine granular arsenical pyrites, through which was disseminated a somewhat large amount of lepidomelane and a little white subtranslucent quartz. Weight of sample, five pounds three ounces. It contained:

Gold............ 0·117 of an ounce to the ton of 2,000 lbs.
Silver........... none.

23.—From the Toronto Company's mine, lot six, range ten, of the township of Marmora, Hastings county. Gold and Silver assays, cont.

Fine granular arsenical pyrites, through which was disseminated a little calcite. Weight of sample, two pounds three ounces. It was found to contain: Province of Ontario, cont.

Gold............	0·117 of an ounce to the ton of 2,000 lbs.
Silver..........	none.

24.—From the big hill, lot fourteen, range ten, of the township of Marmora, Hastings county.

A white sub-translucent quartz. Weight of sample, eleven ounces.

It contained neither gold nor silver.

25.—From Jones' property, lot six, range seven, of the township of Marmora, Hastings county.

The sample consisted of two fragments—the one a greyish-white opaque quartz, carrying a somewhat large amount of arsenical pyrites; the other, which was highly weathered, contained, here and there, a little undecomposed mispickel. Weight of sample, three pounds five ounces. Assays gave:

Gold	distinct trace.
Silver	none.

26.—From an opening on lot eighteen, range eight, of the township of Marmora, Hastings county.

Consisted of bournonite in association with small quantities of copper pyrites and iron pyrites, in a gangue of white sub-translucent quartz; the latter, in parts, stained with hydrated peroxide of iron. Weight of sample, two pounds. It was found on assay to contain:

Gold..................	1·458 ounce to the ton of 2,000 lbs.
Silver................	4·375 ounces " "

27.—From an opening on the north-west quarter of lot sixteen, range nine, of the township of Marmora, Hastings county.

A white opaque to sub-translucent quartz, in parts stained and coated with hydrated peroxide of iron, carrying an appreciable amount of iron pyrites. Weight of sample, two pounds thirteen ounces.

It contained neither gold nor silver.

Gold and Silver assays, cont.

Province of Ontario, cont.

28.—From the property of Pat Malone, lot eighteen, range one, of the township of Marmora, Hastings county.

White sub-translucent quartz associated with a little hornblende. Weight of sample, two pounds one ounce.

It contained neither gold nor silver.

29.—From the Farrell mine, lot nine, range seven, of the township of Madoc, Hastings county.

Iron pyrites in a gangue of white, fine crystalline-granular quartz. Weight of sample, one pound. It contained:

Gold	trace.
Silver	none.

30.—From the Moore mine, lot seventeen, range five, of the township of Madoc, Hastings county.

Bournonite in a gangue of somewhat coarse crystalline dolomite. Weight of sample, three ounces. It contained:

Gold	trace.
Silver	2·917 ounces to the ton of 2,000 lbs.

31.—From a vein a little east of Bannockburn, lot twenty-seven, range five, of the township of Madoc, Hastings county.

White sub-translucent quartz, in parts, stained with hydrated peroxide of iron, holding a few grains of iron pyrites. Weight of sample, one pound ten ounces. Assays showed it to contain:

Gold	trace.
Silver	none.

32.—From the Richardson mine (north vein, vertical shaft), lot eighteen, range five, of the township of Madoc, Hastings county.

An association of a greyish-white to white sub-translucent quartz and brownish-yellow and reddish ankerite, together with a little mica, carrying a somewhat large amount of iron pyrites. Weight of sample, four pounds three ounces. It was found to contain:

Gold	0·408 of an ounce to the ton of 2,000 lbs.
Silver	none.

33.—From the Seymour mine, lot eleven, range five, of the township of Madoc, Hastings county.

Iron pyrites, through which was disseminated a trifling amount of dolomite. Weight of sample, twelve ounces. Assays showed it to contain:

Gold	trace.
Silver	none.

34.—From an opening on lot seven, range five, of the township of Madoc, Hastings county. Gold and Silver assays, cont.

Consisted of more or less weathered iron pyrites. Weight of sample, one pound six ounces. It contained: Province of Ontario, cont.

Gold	trace.
Silver	none.

35.—From an opening on lot one, range five, of the township of Madoc, Hastings county.

Consisted of a partially weathered iron pyrites. Weight of sample, one pound four ounces.

It contained neither gold nor silver.

36.—From an opening on the north half of lot two, range five, of the township of Madoc, Hastings county.

A very much weathered specimen, containing, however, in parts, an appreciable amount of iron pyrites. Weight of sample, two pounds nine ounces.

It contained neither gold nor silver.

37.—From Liberty's property, near Presbyterian church, village of Madoc, township of Madoc, Hastings county.

Quartz carrying a little iron pyrites. The specimen was thickly coated with hydrated peroxide of iron. Weight of sample, thirteen ounces. Assays showed it to contain:

Gold	trace.
Silver	none.

38.—From vein in Bridgewater village, township of Elzevir, Hastings county.

An association of fine granular arsenical pyrites and white translucent quartz. Weight of sample, two pounds five ounces. It was found to contain:

Gold	0·058 of an ounce to the ton of 2,000 lbs.
Silver	none.

39.—From the west shore of Deer Lake, township of Belmont, Peterborough county.

White sub-translucent quartz, slightly stained with hydrated peroxide of iron. Weight of sample, eight ounces and a-half.

It contained neither gold nor silver.

Gold and Silver assays, cont.

Province of Ontario, cont.

40.—From Big Island, Belmont Lake, township of Belmont, Peterborough county.

White translucent quartz, in parts, slightly stained with hydrated peroxide of iron. Weight of sample, one pound seven ounces.

It contained neither gold nor silver.

41.—From Anderson's property, lot fourteen, range fourteen, of the township of Huntingdon, Hastings county.

Consisted of white sub-translucent quartz. Weight of sample, thirteen ounces.

It contained neither gold nor silver.

42.—From the Kaladar mine, lots twenty-four and twenty-five, range six, of the township of Kaladar, Addington county.

White sub-translucent quartz, more or less stained and coated with hydrated peroxide of iron, carrying a small quantity of iron pyrites. Weight of sample, one pound twelve ounces. It was found to contain:

Gold............	0·700 of an ounce to the ton of 2,000 lbs.
Silver...........	none.

43.—From lot twenty-four, range two, of Stafford, Renfrew county. This, and the following specimen were examined for the Rev. Father Marion.

The material, which was labelled "Company's collection," consisted, apart from some rock matter, of weathered iron pyrites. Weight of sample, two pounds fourteen ounces and a-half. Assays showed it to contain:

Gold..	trace.
Silver..	none.

44.—From the same locality as the last.

The material, which was labelled "Private collection," consisted of more or less weathered iron pyrites in the form of small lumps and coarse to fine powder. Weight of sample, nine ounces. It was found to contain:

Gold...........	0·729 of an ounce to the ton of 2,000 lbs.
Silver...........	9·567 ounces " "

45.—From lot five, range four, of the township of Darling, Lanark county.

Consisted of massive iron pyrites, apparently free from gangue. Weight of sample, one pound five ounces.

It contained neither gold nor silver.

46.—From Sheppard's mine, vein No. 1, Lake Wahnapitae—district of Nipissing.

Gold and Silver assays, cont.

Province of Ontario, cont.

White sub-translucent quartz carrying a small amount of arsenical pyrites and a few grains of iron pyrites. Weight of sample, one pound seven ounces. Assays gave:

Gold	5·425 ounces to the ton of 2,000 lbs.
Silver	0·233 of an ounce " "

47.—From Sheppard's mine, vein No. 2, Lake Wahnapitae—district of Nipissing.

White sub-translucent quartz. Weight of sample, one pound one ounce.

It contained neither gold nor silver.

48.—From Sheppard's mine, vein No. 3, Lake Wahnapitae—district of Nipissing.

White sub-translucent quartz, in parts stained and coated with hydrated peroxide of iron, carrying a small quantity of copper pyrites. Weight of sample, one pound eight ounces. It contained:

Gold.............	0·058 of an ounce to the ton of 2,000 lbs.
Silver...........	none.

49.—From a seven-foot vein on portage at outlet of Lower Lake, Maskinongé-wagaming—district of Nipissing.

A greyish-white sub-translucent quartz, in parts stained and coated with hydrated peroxide of iron, carrying a little iron pyrites. Weight of sample, one pound five ounces.

It contained neither gold nor silver.

50.—From a two-foot vein on portage at outlet of Lake Maskinongé-wagaming—district of Nipissing.

White sub-translucent quartz, in parts stained with hydrated peroxide of iron and in some places flecked with green carbonate of copper, carrying a trifling amount of iron pyrites. Weight of sample, one pound.

It contained neither gold nor silver.

51.—From vein on west side of South Bay, Lake Wahnapitae—district of Nipissing.

White sub-translucent quartz carrying a small amount of copper pyrites. Weight of sample, twelve ounces. It was found to contain:

Gold	0·058 of an ounce to the ton of 2,000 lbs.
Silver	0·175 " " "

Gold and Silver assays, cont.

Province of Ontario, cont.

52.—From Stephen Lafricain's claim, Vermillion Lake, north of east arm of Lake Temagami—district of Nipissing.

An association of a dark green chloritic schist and fine-grained quartzite, through which was disseminated a somewhat large amount of fine crystalline iron pyrites. Weight of sample, thirteen ounces.

It contained neither gold nor silver.

53.—From a ten-foot vein on Matthias Island, two miles north-east of Temagami Post—district of Nipissing.

An association of white sub-translucent quartz with a small amount of greyish-green serpentine. Some of the fragments were much honeycombed, the cavities holding hydrated peroxide of iron. Weight of sample, one pound seven ounces.

It contained neither gold nor silver.

54.—From a five-foot vein on Walter Cockburn's claim on island in Cross Lake, near its outlet—district of Nipissing.

An association of white sub-translucent quartz with a little dark greenish-grey chloritic schist, carrying small quantities of galena and copper pyrites. Weight of sample, one pound ten ounces. It was found to contain:

Gold............	trace.
Silver...........	0·175 of an ounce to the ton of 2,000 lbs.

55.—From a one-foot vein on shore of Lake Panache, one mile and a-half south-west of La Vase River—district of Nipissing.

A greyish-white sub-translucent quartz, more or less stained with hydrated peroxide of iron, carrying a very appreciable amount of iron pyrites. Weight of sample, nine ounces.

It contained neither gold nor silver.

56.—From Big Trout Lake, between Lake Abitibi and Blanche River—district of Nipissing.

Grey quartzite stained aud coated with hydrated peroxide of iron and, in parts, with green carbonate of copper, carrying a trifling amount of iron pyrites and copper pyrites. Weight of sample, two pounds one ounce.

It contained neither gold nor silver.

57.—From Cross Lake on Temagami River—district of Nipissing.

Copper pyrites in a gangue of white sub-translucent quartz. Weight of sample, nine ounces. Assays showed it to contain:

Gold............	0·058 of an ounce to the ton of 2,000 lbs.			
Silver...........	0·058	"	"	"

58.—From the same locality as the last. Gold and Silver assays, cont.

Galena in a gangue of white sub-translucent quartz. Weight of sample, three-quarters of an ounce. It was found to contain: Province of Ontario, cont.

Gold............... trace.
Silver............... 23·333 ounces to the ton of 2,000 lbs.

59.—From a vein cutting diabase on the west side of outlet of Lady Evelyn Lake, near Montreal River—district of Nipissing.

A greyish sub-translucent quartz, with which was associated small quantities of a chloritic rock and a little calcite. It contained a little copper pyrites and was, in parts, stained and coated with hydrated peroxide of iron and green carbonate of copper. Weight of sample, one pound five ounces. Assays gave:

Gold............... trace.
Silver............... 2·040 ounces to the ton of 2,000 lbs.

60.—Mic-Mac lead vein on Haycock's location, east side of Lady Evelyn Lake, one mile and a-quarter south of outlet—district of Nipissing.

A coarse crystalline galena in association with a trifling amount of translucent quartz and calcite. It was, in parts, slightly coated with carbonate of lead. Weight of sample, six pounds twelve ounces. It contained:

Gold............... trace.
Silver............... 8·750 ounces to the ton of 2,000 lbs.

61.—North vein on Haycock's location, west side of Lady Evelyn Lake, one mile and a-half from the outlet—district of Nipissing.

A white sub-translucent quartz carrying small quantities of copper pyrites, galena and zinc blende. It was more or less stained with hydrated peroxide of iron and, in parts, with green carbonate of copper. The sample, which consisted of numerous fragments, weighed two pounds. Assays gave:

Gold............ none.
Silver........... 0·117 of an ounce to the ton of 2,000 lbs.

62.—South vein on Haycock's location, west side of Lady Evelyn Lake, one mile and a-half, southward, from outlet—district of Nipissing.

White sub-translucent quartz carrying a very appreciable amount of copper pyrites. The whole was more or less stained with hydrated peroxide of iron and, in parts, coated with blue and green carbonate of copper. Weight of sample, two pounds.

It contained neither gold nor silver.

Gold and Silver assays, cont.

Province of Ontario, cont.

63.—West vein on western side of outlet of Lady Evelyn Lake—district of Nipissing.

An association of white sub-translucent quartz, calcite, dolomite and fibrous serpentine, carrying small quantities of copper pyrites. It was, in parts, stained with hydrated peroxide of iron and blue and green carbonate of copper. Weight of sample, one pound twelve ounces.

It contained neither gold nor silver.

64.—From island at south end of narrows in Lady Evelyn Lake, about three miles southward of outlet—district of Nipissing.

A slightly greyish-white sub-translucent quartz, with which was associated small quantities of a dark green chloritic mineral. Weight of sample, thirteen ounces.

It contained neither gold nor silver.

65.—From islet opposite to, and three-quarters of a mile from, Hudson Bay Company's Post, Lake Temagami—district of Nipissing.

A milky-white quartz in association with small quantities of a dark green chloritic mineral and a trifling amount of dolomite. Weight of sample, one pound six ounces.

It contained neither gold nor silver.

66.—From vein on an island one mile and a-quarter north-east of Hudson Bay Company's Post, Lake Temagami—district of Nipissing.

A milky-white quartz, for the most part stained and, in parts, coated with hydrated peroxide of iron, holding small quantities of titanic iron ore. Weight of sample, one pound seven ounces. It was found to contain:

Gold	trace.
Silver	none.

67.—From a vein two miles north-west of Temagami Post, Lake Temagami—district of Nipissing.

Greyish-white to white sub-translucent quartz, in association with small quantities of a dark green chloritic mineral, with, here and there, a trifling amount of iron pyrites. Weight of sample, eight ounces and a-half.

It contained neither gold nor silver.

68.—From a vein on the western of the group of three islands in the south-west bay of Lake Temagami, being three miles north-east of the extreme south end of the lake—district of Nipissing.

An association of grey and white, opaque quartz, more or less stained and coated with hydrated peroxide of iron, carrying small quantities of ron pyrites. Weight of sample, one pound.

Gold and Silver assays, cont.

Province of Ontario, cont.

It contained neither gold nor silver.

69.—From Ferguson's location A, Sandy Bay, northern end of Lake Temagami—district of Nipissing.

An association of greyish-white to white translucent to subtranslucent quartz with a grey-green chloritic rock, crystalline limestone and a little felspar, carrying small quantities of copper pyrites and iron pyrites. It was, in parts, stained with hydrated peroxide of iron and, here and there, with a little green carbonate of copper. Weight of sample, eleven pounds. It was found to contain :

Gold .... trace.
Silver .... trace.

70.—From Ferguson's location B, near the eastern extremity of East Bay, Lake Temagami—district of Nipissing.

Finely disseminated iron pyrites in a gangue of quartz. Weight of sample, five pounds. Assays gave :

Gold............ none.
Silver........... 0·233 of an ounce to the ton of 2,000 lbs.

71.—From Ferguson's location C, on an island in East Bay, Lake Temagami—district of Nipissing.

A light grey schistose rock, for the most part stained and coated with hydrated peroxide of iron, carrying iron pyrites. Weight of sample, fifteen ounces. It was shown to contain :

Gold............ trace.
Silver........... 0·116 of an ounce to the ton of 2,000 lbs.

72.—From Lafricain and McKenzie's mine, north side of East Bay (about midway up bay), Lake Temagami—district of Nipissing.

A white translucent quartz in association with small quantities of a chloritic mineral, holding, in parts, a little copper pyrites. Weight of sample, one pound fourteen ounces. It contained :

Gold............ trace.
Silver........... 0·290 of an ounce to the ton of 2,000 lbs.

73.—From a vein on the north shore of East Bay, three-quarters of a mile west of portage at its eastern extremity, Lake Temagami—district of Nipissing.

Gold and Silver assays, cont.

Province of Ontario, cont.

White sub-translucent quartz, with here and there a cavity lined with hydrated peroxide of iron and, in parts, slightly stained with green carbonate of copper. Weight of sample, one pound three ounces.

It contained neither gold nor silver.

74.—From Montreal River, near Fort Metatchewan—district of Nipissing.

An association of greyish sub-translucent quartz with small quantities of calcite, containing, in parts, a little specular iron. Weight of sample, one pound thirteen ounces.

It contained neither gold nor silver.

75.—From about six miles from the mouth of the Montreal River—district of Nipissing. Examined for Mr. P. T. Lawlor.

An association of red and white quartz and a dark green chloritic mineral, carrying small quantities of copper pyrites. Weight of sample, fourteen ounces. Assays showed it to contain:

Gold	distinct trace.
Silver	none.

76.—From a vein occurring at the northern end of Lake Temagami, about two miles south of Ferguson's location—district of Nipissing.

White crystalline limestone in association with small quantities of chlorite. It contained, in parts, a trifling amount of copper pyrites, and was, here and there, stained with green carbonate of copper. Weight of sample, one pound eleven ounces.

It contained neither gold nor silver.

77.—From a vein discovered by Malcolm McLean, sixteen miles north of Temagami Post, Bear Island, Lake Temagami—district of Nipissing.

An association of white sub-transparent quartz more or less stained with hydrated peroxide of iron, and a greyish-green rock, carrying iron pyrites. Weight of sample, four pounds three ounces. It contained:

Gold	trace.
Silver	trace.

78.—From the property of Mr. E. Haycock, Temagami Island, Lake Temagami—district of Nipissing.

Gold and Silver assays. cont. Province of Ontario, cont.

An association of iron pyrites, copper pyrites and magnetite in a gangue of chlorite. Weight of sample, four pounds two ounces.

It contained neither gold nor silver.

79.—From Holditch's location, East Island, Lake Temagami—district of Nipissing.

White sub-translucent quartz in association with small quantities of chlorite and a little dolomite. Weight of sample, two pounds five ounces.

It contained neither gold nor silver.

80.—From a vein on Holditch's location on West Island, Lake Temagami—district of Nipissing.

An association of white translucent quartz with small quantities of a dark green chlorite, in parts stained with hydrated peroxide of iron, carrying a little copper pyrites and iron pyrites. Weight of sample, three pounds six ounces. Assays showed it to contain:

Gold	trace.
Silver	trace.

81.—From a vein at the south end of Portage Bay, Lake Temagami—district of Nipissing.

An association of white sub-translucent quartz with small quantities of a dark green chloritic schist and a little dolomite. Weight of sample, two pounds eleven ounces.

It contained neither gold nor silver.

82.—From a vein on a small island in Lake Nipissing—district of Nipissing. Examined for Mr, W. T. Newman.

An association of chloritic schist, mica schist, gneiss and calcite, carrying small quantities of magnetic and iron pyrites. Weight of sample, two ounces. Assays gave:

Gold	trace.
Silver	0·116 of an ounce to the ton of 2,000 lbs.

83.—From a vein crossing the river flowing into the west end of Lake Nipissing—district of Nipissing. Examined for Mr. W. T. Newman.

The sample consisted of two fragments, the one a highly rust stained rock holding a few scales of mica, the other white sub-translucent quartz stained and coated with hydrated peroxide of iron. Weight of sample, eight ounces.

It contained neither gold nor silver.

Gold and Silver assays, cont.

Province of Ontario, cont.

84.—From Great Manitou Island, Lake Nipissing—district of Nipissing. Examined for Mr. W. T. Newman.

It consisted of molybdenite, together with a few specks of iron pyrites in a gangue composed of a reddish colored felspar and a little quartz. The metallic sulphides formed but a small proportion of the whole. Weight of sample, one quarter of an ounce.

It contained neither gold nor silver.

85.—From the vicinity of Sudbury—district of Nipissing.

A greyish-white to white translucent to sub-transparent quartz. One fragment was slightly stained with hydrated peroxide of iron and contained a few specks of iron pyrites. The sample, which consisted of five fragments, weighed one pound nine ounces.

It contained neither gold nor silver.

86.—From two miles west-north-west of North Bay, Lake Nipissing—district of Nipissing. Examined for Mr. G. R. Lyon.

A reddish sub-translucent quartz, more or less coated with hydrated peroxide of iron, carrying, in parts, a very appreciable amount of iron pyrites. The sample, which consisted of numerous fragments, weighed four pounds and a quarter.

It contained neither gold nor silver.

87.—From the immediate neighbourhood of Mountain Lake (Round Lake), Montreal River—district of Nipissing. Examined for Mr. C. C. Farr.

The sample consisted of fragments of diorite, a reddish quartzite, white sub-translucent quartz and a dark green chloritic mineral. The greater number of the fragments were stained with hydrated peroxide of iron: some of them carried small quantities of iron pyrites, others, in addition, a trifling amount of copper pyrites. Weight of sample, one pound half an ounce. Assays showed it to contain:

Gold	trace.
Silver	trace.

88.—From Perley and Klock's limits, Serpent River—district of Algoma. Examined for Mr. D. A. Chisholm.

An association of white sub-translucent quartz and greyish-green chloritic schist; the whole coated with hydrated peroxide of iron. Weight of sample, two pounds eight ounces.

It contained neither gold nor silver.

89.—From the vicinity of Sable Landing, township of Salter—district of Algoma. Examined for Mr. A. Spittal. Gold and Silver assays, cont.

Copper pyrites, together with a small quantity of bornite, in a gangue consisting of white translucent quartz and greenish-grey chloritic schist. Weight of sample, one pound seven ounces. It contained: Province of Ontario, cont.

Gold............ 0·029 of an ounce to the ton of 2,000 lbs.
Silver........... none.

90.—From the south half of lot nine, range four, of the township of Graham--district of Algoma. This, and the following specimen were examined for Mr. W. A. Allan.

Dolomite in association with small quantities of a ferruginous schistose rock. Weight of sample, two ounces.

It contained neither gold nor silver.

91.—From the south half of lot eight, range four, of the township of Graham—district of Algoma.

A micaceous schist and ferruginous schistose rock in association with quartz, carrying small quantities of copper pyrites and, in parts, stained and coated with blue and green carbonate of copper. Weight of sample, two ounces and a-half. It contained:

Gold .... trace.
Silver .... none.

92.—From St. Joseph Island, Lake Huron—district of Algoma.

Sandstone, made up of rounded grains of translucent quartz, through which was disseminated a small quantity of iron pyrites. Weight of sample, one ounce and a-half. Assays gave:

Gold .... trace.
Silver .... none.

93.—From Pither's location, eastern end of Rainy Lake—district of Algoma.

A greyish-white sub-translucent quartz with which was associated a little reddish calcite and a dark green chloritic mineral. It carried a small quantity of iron pyrites. Weight of sample, nine ounces and a-half. Assays showed it to contain:

Gold........... 0·175 of an ounce to tho ton of 2,000 lbs.
Silver.......... none.

94.—From Moore's location (two miles and a-half south of Straight Lake Station, on the line of the Canadian Pacific Railway), shaft No. 1,

Gold and Silver assays, cont.

Province of Ontario, cont.

top of shaft. This, and the following six specimens are from mining locations in the vicinity of Straight Lake—district of Algoma.

Consisted of magnetic pyrites disseminated through a gangue of dark grey quartz. Weight of sample, one pound three ounces.

It contained neither gold nor silver.

95.—From Moore's location, shaft No. 1, bottom of shaft.

Dolomitic limestone impregnated with magnetic pyrites. On the exterior part of a portion of the specimen there occurred a thin band of white limestone, between which and the mass there was a slight layer of zinc blende. Weight of sample, three pounds eleven ounces.

It contained neither gold nor silver.

96.—From Moore's location, shaft No. 2. Vein fourteen feet wide.

A greenish-grey, in parts greyish and occasionally white, subtranslucent quartz, through which was disseminated a trifling amount of magnetic pyrites and zinc blende. Weight of sample, one pound eight ounces.

It contained neither gold nor silver.

97.—From Moore's location, No. 2 opening, a-quarter of a mile from the west end of the location.

Consisted of iron pyrites and magnetic pyrites in a gangue of quartz. Weight of sample, two pounds five ounces.

It contained neither gold nor silver.

98.—From Moore's location, opening No. 3.

Consisted of iron pyrites in a gangue of dark grey quartz. Weight of sample, three pounds thirteen ounces.

It contained neither gold nor silver.

99.—From Moore's location, extreme west end, near Spanish River.

A dark greyish colored quartz carrying iron pyrites. Weight of sample, one pound ten ounces.

It contained neither gold nor silver.

100.—From Moore's location G, about one mile and a-quarter east of Straight Lake Station on the line of the Canadian Pacific Railway—north side of the track.

A dark greenish-grey schistose rock carrying appreciable quantities of iron pyrites and magnetic pyrites. Weight of sample, thirteen ounces. Gold and Silver assays, cont. Province of Ontario, cont.

It contained neither gold nor silver.

101.—From lot seven, range five, of the township of Lybster—district of Thunder Bay. This, and the following specimen, were examined for Mr. J. C. Green.

White and grey quartz with cavities filled with hydrated peroxide of iron, and containing, here and there, a few specks of iron pyrites and galena. Weight of sample, one pound eight ounces.

It contained neither gold nor silver.

102.—From unsurveyed land south of the township of Lybster—district of Thunder Bay.

An association of white and amethystine quartz and a dark grey trap rock. The former held a few specks of iron pyrites. Weight of sample, one pound.

It contained neither gold nor silver.

103.—From the vicinity of Schreiber, on the line of the Canadian Pacific Railway—district of Thunder Bay, Lake Superior. Examined for Mr. T. Hay.

An association of dark grey quartz and iron pyrites. The sample weighed three pounds two ounces. It contained:

Gold	trace.
Silver	none.

104.—From Lake of the Woods, about thirty miles from Rat Portage—district of Rainy River. Examined for Mr. J. Anderson.

A greyish-white translucent quartz, more or less stained and, in parts, coated with hydrated peroxide of iron. Weight of sample, one pound eight ounces. It was found to contain:

Gold	trace.
Silver	1·050 ounce to the ton of 2,000 lbs.

105.—From an island in the Lake of the Woods—about six miles out from Rat Portage—district of Rainy River. Examined for Mr. M. W. Rublee.

An association of dark grey sub-translucent quartz with a small amount of grey chloritic schist. It contained, in parts, a small

Gold and Silver assays, cont.

Province of Ontario, cont.

quantity of iron pyrites. Weight of sample, two ounces and three-quarters.

It contained neither gold nor silver.

106.—This, and the following specimen are from Rat Portage, Lake of the Woods—district of Rainy River.

A white sub-translucent quartz, stained with hydrated peroxide of iron, carrying small quantities of iron pyrites and specular iron. Weight of sample, seven ounces. Assays gave:

Gold............	0·467 of an ounce to the ton of 2,000 lbs.
Silver...........	0·408 " " "

107.—Consisted of magnetic pyrites, together with a little iron pyrites, disseminated through a dark grey quartzite. The gangue constituted but a small proportion of the whole. Weight of sample, six ounces. It was found to contain:

Gold............	distinct trace.
Silver...........	0·340 of an ounce to the ton of 2,000 lbs.

North-West Territory.

North-West Territory.

108.—From small veins on creek near outflow of Quiet Lake, at head of Big Salmon River, a tributary of the Lewes River—Yukon district. Received from Dr. G. M. Dawson.

A white sub-translucent quartz, seamed and, in parts, stained with hydrated peroxide of iron, carrying small quantities of iron pyrites. Weight of sample, half an ounce. It contained:

Gold	distinct trace.
Silver..................................	trace.

109.—From an exposure on Forty Mile River, about three-quarters of a mile above its mouth—Yukon district. This, and the three following specimens were collected by Mr. W. Ogilvie.

An association of greyish-white calcite and greyish-green chloritic schist, carrying appreciable quantities of galena. Weight of sample, one pound fourteen ounces.

It contained neither gold nor silver.

110.—From Forty Mile River, about two miles and a-half above its mouth—Yukon district.

A somewhat fine crystalline galena, with some zinc blende and a little iron pyrites, in a dolomitic gangue. The latter constituted but a small proportion, by weight, of the whole. Weight of sample, three pounds. Assays showed it to contain: Gold and Silver assays, cont. North-West Territory, cont.

Gold............... distinct trace.
Silver............. 38·646 ounces to the ton of 2,000 lbs.

111.—From the north bank of the Yukon River, opposite to the mouth of Tatonduc River (Deer River of Schwatka), about five miles above Fort Reliance—Yukon district.

Weathered rock carrying small quanties of copper pyrites, bornite and galena. Weight of sample, fourteen ounces. It was found on assay to contain:

Gold................ trace.
Silver.............. 3·646 ounces to the ton of 2,000 lbs.

112.—From a point eight miles below Fort Reliance—Yukon district.

White sub-translucent quartz traversed by veins of a dark grey chloritic mineral. Weight of sample, eight ounces. Assays gave:

Gold............ trace.
Silver........... 0·117 of an ounce to the ton of 2,000 lbs.

Province of British Columbia.

Province of British Columbia.

Of the following—

Specimens Nos. 113-139 *are from the East Kootanie district.*
" *Nos.* 140-152 " " *West Kootanie district.*
" *Nos.* 153-184 " " *Interior plateau region.*
" *Nos.* 185-197 " " *Coast Ranges and coast region*
" *Nos.* 198-199 " " *Cassiar district.*

(*Specimens Nos.* 168-184 *were collected by Dr. G. M. Dawson.*)

113.—From about three miles and a-half south-east of Windermere, Upper Columbia Lake—East Kootanie district. Examined for Mr. John McRae.

An association of copper glance with a somewhat large proportion of hematite, an appreciable amount of dolomite and a little quartz. It was, in parts, coated with green and blue carbonate of copper. Weight of sample, six ounces. It contained:

Gold............ none.
Silver........... 0·233 of an ounce to the ton of 2,000 lbs.

114.—From Windermere. Upper Columbia Lake—East Kootanie district. This, and the two following specimens were examined for Mr. W. A. Baillie Grohman.

4

Gold and Silver assays, cont.

Province of British Columbia, cont.

Consisted of copper glance in association with appreciable quantities of hematite and quartz. Weight of sample, three ounces and a-half. Assays gave:

Gold................ none.
Silver................ 2·917 ounces to the ton of 2,000 lbs.

115.—From a lead near Windermere, Upper Columbia Lake—East Kootanie district.

Consisted of copper glance with which was associated a small amount of white opaque quartz. It was, in parts, coated with green carbonate of copper. Weight of sample, three ounces and a half.

It contained neither gold nor silver.

116.—From Bull River trail claim, six miles south of Bull River Bridge—East Kootanie district.

A greyish-white sub-translucent quartz, in parts coated with hydrated peroxide of iron and containing, here and there, a few specks of iron pyrites. Weight of sample, one ounce and a-quarter. It was found to contain:

Gold.. trace.
Silver.. none.

117.—From the "Great Western" claim, south fork of Horse Thief Creek about twenty miles from the Columbia River, into which the creek empties ninety miles south of Golden—East Kootanie district. Examined for Mr. G. A. Starke.

An association of quartz and dolomite, through which was disseminated a somewhat large amount of iron pyrites and a small amount of galena. Weight of sample, four ounces and a-half. Assays showed it to contain:

Gold................ none.
Silver................ 1·925 of an ounce to the ton of 2,000 lbs.

118.—From the "Uncle Sam" claim, right bank of Horse Thief Creek, about twenty miles from the Columbia River, into which the creek empties ninety miles south of Golden—East Kootanie district. Examined for Mr. E. T. Johnston.

White sub-translucent quartz carrying an appreciable amount of galena and a little iron pyrites. Weight of sample, three ounces. It was found, on assay, to contain:

Gold................ none.
Silver................ 3·646 ounces to the ton of 2,000 lbs.

119.—From the North Fork of Toby Creek, near Lower Columbia Lake, Columbia River—East Kootanie district. Examined for Mr. W. Rosamond. Gold and Silver assays, cont. Province of British Columbia, cont.

Coarse crystalline galena in association with a small amount of white sub-translucent quartz. It was, in parts, coated with carbonate of lead. Weight of sample, two ounces and a-half. It contained:

Gold.............. distinct trace.
Silver............. 66·354 ounces to the ton of 2,000 lbs.

120.—From a lead on Toby Creek, near Lower Columbia Lake, Columbia River—East Kootanie district.

Consisted of galena in association with a somewhat large amount of white sub-translucent quartz. Weight of sample, ten ounces. Assays gave:

Gold................ none.
Silver.............. 38·646 ounces to the ton of 2,000 lbs.

121.—From a point about twelve miles up Toby Creek, near Lower Columbia Lake, Columbia River—East Kootanie district. Examined for Mr. H. McKinnon.

Copper pyrites in a gangue of white sub-translucent quartz. The latter constituted but a very small proportion, by weight, of the whole. Weight of sample, four ounces. It was found to contain:

Gold .... trace.
Silver .... none.

122.—From No. 2 Creek, between Upper and Lower Columbia Lakes, and about eight miles from the Columbia River—East Kootanie district. Examined for Mr. G. McMillan.

Tetrahedrite together with a small quantity of iron pyrites in a gangue of white sub-translucent quartz. Weight of sample, three ounces and a-half. Assays showed it to contain:

Gold.............. distinct trace.
Silver............. 10·208 ounces to the ton of 2,000 lbs.

123.—From about one mile from Palliser Station on the line of the Canadian Pacific Railway, north side of the river, about a quarter of a mile from Kicking Horse (Hector) Pass—East Kootanie district. Examined for Mr. J. Barr.

An association of limonite and iron pyrites. Weight of sample, thirteen ounces. It contained:

Gold.. trace.
Silver .... none.

Gold and Silver assays, cont.

Province of British Columbia, cont.

124.—From the "Golden Gate" claim on Carbonate Creek, about five miles south-east of McMurdo's claims—East Kootanie district. This, and the following specimen were examined for Mr. N. Morrison.

Consisted of tetrahedrite with some galena and a little iron pyrites, disseminated through a gangue of quartz. Weight of sample, four ounces. Assays gave:

Gold.............. distinct trace.
Silver............. 13·887 ounces to the ton of 2,000 lbs.

125.—From the "Lost Chieftain" claim, Copper Creek, a tributary of the Middle Fork of the Spilimichine River, about seven miles south-east of McMurdo's claims—East Kootanie district.

A fine to somewhat coarse crystalline galena together with some copper pyrites, in a gangue of white opaque to sub-translucent quartz with which was associated a small quantity of a greenish-grey chloritic schist. The whole was more or less stained and coated with hydrated peroxide of iron. Weight of sample, fourteen ounces and a-half. It was found to contain:

Gold..... .... none.
Silver............. 37·917 ounces to the ton of 2,000 lbs.

126.—From the "Monitor" claim, Middle Fork, Spilimichine River—East Kootanie district.

A somewhat coarse crystalline galena, through which was disseminated a small quantity of calcite. The specimen was, in parts, coated with hydrated peroxide of iron and, here and there, with carbonate of lead. Weight of sample, two ounces. It was found to contain:

Gold.............. distinct trace.
Silver............. 37·537 ounces to the ton of 2,000 lbs.

127.—From about two miles from Field Station, on the line of the Canadian Pacific Railway—East Kootanie district. Examined for Mr. W. A. Baillie Grohman.

A white sub-translucent quartz in parts stained and coated with hydrated peroxide of iron, in association with a little chloritic schist. Weight of sample, eight ounces.

It contained neither gold nor silver.

128.—From the "Victory" claim, vicinity of Field Station on the line of the Canadian Pacific Railway—East Kootanie district. This, and the following specimen were examined for Mr. J. Barr.

A highly weathered rock, stained and, in parts, thickly coated with hydrated peroxide of iron, carrying some iron-pyrites. Weight of sample, three pounds ten ounces. Assays gave:

Gold and Silver assays, cont.

Province of British Columbia, cont.

Gold .... trace.
Silver .... none.

129.—From the "Rose" claim, vicinity of Field Station on the line of the Canadian Pacific Railway—East Kootanie district.

A greyish-white rock, through which was disseminated a somewhat large amount of iron pyrites. Weight of sample, three pounds. It contained:

Gold .... trace.
Silver .... none.

130.—From about thirty-five miles south-east of Golden, and about three miles from the Columbia River—East Kootanie district. Examined for Mr. P. Lambrich.

An association of quartz and dolomite, through which was disseminated a few specks of iron pyrites. It was, in parts, coated with hydrated peroxide of iron and, here and there, with blue and green carbonate of copper. Weight of sample, seven ounces and a-half.

It contained neither gold nor silver.

131.—From Cathedral Mountain—East Kootanie district. Examined for Mr. P. McCarthy.

A very fine crystalline galena disseminated through a quartzose gangue. The galena constituted, approximately, forty-one per cent., by weight, of the whole. Weight of sample, three ounces and a-half. It was found to contain:

Gold .... none.
Silver .... 0·729 of an ounce to the ton of 2,000 lbs.

132.—From the "White" mine, one mile east of Grohman—East Kootanie district. Examined for Mr. W. A. Baillie Grohman.

An association of white sub-translucent to opaque quartz with a small amount of chloritic schist, carrying a very appreciable amount of galena. It was, in parts, coated with carbonate of lead. Weight of sample, eleven ounces. Assays showed it to contain:

Gold .... distinct trace.
Silver .... 13·125 ounces to the ton of 2,000 lbs.

133.—This, and the following six specimens are from claims on Jubilee Mountain, situated on the west side of the Upper Columbia River,

Gold and Silver assays, cont.

Province of British Columbia, cont.

about thirty miles south of Golden Station on the line of the Canadian Pacific Railway—East Kootanie district. They were examined for Mr. W. A. Baillie Grohman.

From "Grangers" claim, south end of Jubilee Mountain.

An association of dolomite with some calcite and small amounts of blue and green carbonate of copper. It was, in parts, coated with hydrated peroxide of iron. Weight of sample, three ounces and a-half. It contained:

Gold............ trace.
Silver........... 0·408 of an ounce to the ton of 2,000 lbs.

134.—From "Grangers" new location, Jubilee Mountain.

An association of copper glance and blue and green carbonate of copper in a gangue of quartz and dolomite. The gangue constituted but a small proportion, by weight, of the whole. Weight of sample, four ounces. Assays gave:

Gold............... none.
Silver.............. 39·375 ounces to the ton of 2,000 lbs.

135.—From "Wells" old location, Jubilee Mountain.

An association of copper glance, blue and green carbonate of copper and brown hematite. It did not contain any readily discernible gangue. Weight of sample, four ounces. It was found to contain:

Gold............... none.
Silver.............. 22·571 ounces to the ton of 2,000 lbs.

136.—From "Wells" claim, Jubilee Mountain.

Consisted of a compact brown hematite. Weight of samples, six ounces.

It contained neither gold nor silver.

137.—From "Wells" claim—but from a different lead to that from which the immediately preceding specimen was taken—Jubilee Mountain.

A very fine crystalline galena together with a considerable amount of iron pyrites, in a gangue of quartz. Weight of sample, four ounces and a-half. It was found, on assay, to contain:

Gold................ none.
Silver............... 5·104 ounces to the ton of 2,000 lbs.

138.—From Jubilee Mountain. Name of claim not stated.

An association of blue and green carbonate of copper and hydrated peroxide of iron, enclosing a trifling amount of unaltered copper glance. Weight of sample, six ounces and a-half. It was found to contain:

Gold and Silver assays, cont.

Province of British Columbia, cont.

Gold...............	none.
Silver...............	2·187 ounces to the ton of 2,000 lbs.

139.—From Jubilee Mountain. Name of claim not stated.

An association of copper glance, blue and green carbonate of copper and dolomite. The latter constituted but a comparatively small proportion, by weight, of the whole. Weight of sample, seven ounces. Assays gave:

Gold...............	none.
Silver..............	11·667 ounces to the ton of 2,000 lbs.

140.—From the "International" claim, Selkirk Range, about fifty miles from Golden—West Kootanie district. Examined for Mr. A. McMurdo.

It consisted of galena in association with a somewhat large proportion of tetrahedrite and a little quartz. The whole was more or less coated with hydrated peroxide of iron and, in parts, with carbonate of lead. Weight of sample, four ounces. It contained:

Gold...............	2·187 ounces to the ton of 2,000 lbs.
Silver..............	60·871 " " "

141.—From Toad Mountain Camp, twenty miles west of Kootanie Lake—West Kootanie district.

An association of a highly manganiferous limonite with some calcite and a little white translucent quartz, carrying a somewhat large amount of copper pyrites, a lesser amount of tetrahedrite, and small quantities of iron pyrites. It was, in parts, coated with hydrated peroxide of iron and, here and there, with blue and green carbonate of copper. Weight of sample, one pound twelve ounces. Assays showed it to contain:

Gold...............	none.
Silver..............	89·687 ounces to the ton of 2,000 lbs.

142.—From the McKinnon claim, about three miles up, and on the east side of, the North Fork of the Illecillewaet River—West Kootanie district. Examined for Dr. G. T. Orton.

A coarse crystalline galena with, here and there, a trifling amount of calcite and white translucent quartz. It was, in parts

Gold and Silver assays, cont.

Province of British Columbia, cont.

coated with hydrated peroxide of iron. Weight of sample, one pound six ounces. It was found to contain:

Gold............... none.
Silver.............. 80·937 ounces to the ton of 2,000 lbs.

143.—From about six miles up, and on the west side of, the North Fork of the Illecillewaet River—West Kootanie district.

A somewhat coarse crystalline galena together with a little copper pyrites, in a gangue of greyish-white translucent quartz. It was more or less coated with hydrated peroxide of iron as also with a little carbonate of lead. Weight of sample, five ounces and a-half. Assays gave:

Gold............... trace.
Silver.............. 30·988 ounces to the ton of 2,000 lbs.

144.—From the "Minnie F" claim, six miles up, and on the east side of, the North Fork of the Illecillewaet River—West Kootanie district.

An association of a somewhat fine crystalline galena with some tetrahedrite and small amounts of iron pyrites and copper pyrites, in a gangue of white sub-translucent quartz. It was, in parts, thickly coated with hydrated peroxide of iron and blue and green carbonate of copper, as also with some carbonate of lead. The gangue constituted but a very small proportion, by weight, of the whole. Weight of sample, eleven pounds six ounces. It was found, on assay, to contain:

Gold.............. none.
Silver............. 139·427 ounces to the ton of 2,000 lbs.

145—From the "Edmond's" claim, two miles from the Illecillewaet Station, north side of the line of the Canadian Pacific Railway—West Kootanie district.

A somewhat fine to coarse crystalline galena in association with a little iron pyrites, in a gangue of white sub-translucent to translucent quartz. It was, in parts, stained and coated with hydrated peroxide of iron, as likewise with a little carbonate of lead and a trifling amount of green carbonate of copper. The gangue constituted but a comparatively small proportion, by weight, of the whole. Weight of sample, seven pounds seven ounces. Assays showed it to contain:

Gold.............. none.
Silver............. 116·302 ounces to the ton of 2,000 lbs.

146.—This, and the four following specimens are from the "Maple Leaf" claim, Illecillewaet River, about thirty-three miles east of Revelstoke, and within a mile of the line of the Canadian Pacific Railway—West Kootanie district. Gold and Silver assays, cont. Province of British Columbia, cont.

Highly weathered material containing a small quantity of galena. Weight of sample, seven ounces. It contained:

Gold	trace.
Silver	41·555 ounces to the ton of 2,000 lbs.

147—Highly weathered ferruginous rock matter. Weight of sample, three ounces. Assays gave:

Gold	distinct trace.
Silver	3·645 ounces to the ton of 2,000 lbs.

148.—Highly weathered ferruginous rock matter containing very small quantities of galena. Weight of sample, three ounces. It was found to contain:

Gold	distinct trace.
Silver	8·750 ounces to the ton of 2,000 lbs.

149.—Decomposed mineral matter, consisting for the most part of carbonate of lead with a little hydrated peroxide of iron and a few specks of galena. Weight of sample, eight ounces. Assays showed it to contain:

Gold	distinct trace.
Silver	35·729 ounces to the ton of 2,000 lbs.

150.—Consisted of a coarse crystalline galena. Weight of sample, one pound. It contained:

Gold	none.
Silver	98·437 ounces to the ton of 2,000 lbs.

151.—From "No. 1" claim, Hot Springs Camp, Kootanie Lake—West Kootanie district. Examined for Mr. G. B. Wright.

Decomposed vein-stuff, consisting largely of hydrated peroxide of iron with a little dolomite, carrying some galena. Weight of sample, fourteen ounces. It was found, on assay, to contain:

Gold	trace.
Silver	214·637 ounces to the ton of 2,000 lbs.

152.—From the north bank of Fish River, about fifteen miles from its entry into Arrow Lake, Columbia River—West Kootanie district. Examined for Mr. T. W. Bayne.

Gold and Silver assays, cont.

Province of British Columbia, cont.

A coarsely crystalline galena through which was disseminated a little iron pyrites and a few grains of white sub-translucent quartz. It was, in parts, coated with hydrated peroxide of iron. Weight of sample, one pound three ounces. Assays gave:

Gold.............. none.
Silver............. 108·646 ounces to the ton of 2,000 lbs.

153.—From the "Old England" claim, Rock Creek—Interior plateau region. Examined for Mr. J. Crawford.

The material consisted of:

a., from the hanging wall—iron pyrites and decomposition product of the same together with some quartz.

b., from foot wall—material very similar in character to that from the hanging wall.

c., from lower ledge—dark grey dolomite carrying small quantities of iron pyrites.

d., wall rock from between upper and lower ledges—dark grey quartzite associated with a little dolomite, carrying a trifling amount of magnetic pyrites.

A carefully prepared average sample of the whole was found, on assay, to contain:

Gold.. trace.
Silver .... none.

154.—From the "Bonanza" location, right bank of Cayoosh Creek, Lillooet, Fraser River—Interior plateau region.

Milky-white quartz, in association with a dark grey chloritic schist, more or less stained and coated with hydrated peroxide of iron. It contained, here and there, a few specks of iron pyrites. Weight of sample, seven pounds and a-half. Assays gave:

Gold............ 0·991 of an ounce to the ton of 2,000 lbs.
Silver........... 0·058 " " "

155.—From the "Crown Point" ledge, left bank of Cayoosh Creek, Lillooet, Fraser River—Interior plateau region.

A white opaque quartz, with which was associated a little dark grey chloritic schist. This specimen, which was for the most part stained with hydrated peroxide of iron, contained readily discernible specks of native gold. Weight of sample, eight ounces. It contained:

Gold............ 0·992 of an ounce to the ton of 2,000 lbs.
Silver...... .... none.

156.—Also from the "Crown Point" ledge, but from a depth of twenty-five feet from the surface. Gold and Silver assays, cont.

A white opaque quartz in association with a somewhat bluish-grey shale, carrying small quantities of iron pyrites and containing, in parts, specks of native gold. Weight of sample, three pounds thirteen ounces. Assays showed it to contain: Province of British Columbia, cont.

Gold .... 0·722 of an ounce to the ton of 2,000 lbs.
Silver .... none.

157.—From near Foster's Bar, about twenty-three miles from Lytton, Fraser River—Interior plateau region.

Consisted of tetrahedrite in association with small quantities of ankerite. The tetrahedrite, freed from all gangue, was found to contain:

Gold .... trace.
Silver .... 5·833 ounces to the ton of 2,000 lbs.

158.—From the same locality as the preceding specimen.

Consisted of stibnite almost free from gangue. It contained:

Gold .... trace.
Silver .... 2·187 ounces to the ton of 2,000 lbs.

159.—From a ledge at Anderson Lake, west of Lillooet—Interior plateau region. This, and the following specimen were examined for Mr. C. Phair.

An association of milky-white quartz with small quantities of a dark grey chloritic mineral and carbonaceous shale, carrying small quantities of iron pyrites. Weight of sample, nine ounces. Assays gave:

Gold .... trace.
Silver .... none.

160.—From a ledge on the South Fork or tributary of Bridge River, west side of Fraser River, above Lillooet—Interior plateau region.

White sub-translucent quartz, in parts coated with hydrated peroxide of iron and a little blue and green carbonate of copper, carrying small quantities of a mineral composed of lead, copper, silver and sulphur (cuproplumbite?). Weight of sample, one pound four ounces. It was found to contain:

Gold .... distinct trace.
Silver .... 20·883 ounces to the ton of 2,000 lbs.

161.—From a ledge near North Bend, on the line of the Canadian Pacific Railway, Fraser River—Interior plateau region. Examined for Mr. J. A. Walker

Gold and Silver assays, cont.

Province of British Columbia, cont.

Consisted of milky-white and dark grey quartz, carrying a small amount of iron pyrites. Weight of sample, twelve ounces. It contained :

Gold	traces.
Silver	none.

162.—This, and the three following specimens are from claims on Jamieson Creek, which runs into the North Thompson River from the west, eight miles above the mouth of Clearwater River—Interior plateau region. They were examined for Mr. D. H. McKenzie.

From the "Home Stake."

White sub-translucent quartz carrying small quantities of galena. The specimen was stained and, in parts, coated with hydrated peroxide of iron and a little carbonate of lead. Weight of sample, nine ounces. Assays gave :

Gold	1·108 ounce to the ton of 2,000 lbs.
Silver	34·242 ounces " "

163.—From the "Silver King"—For locality see No. 162.

White sub-translucent quartz, stained and coated with hydrated peroxide of iron, carrying small quantities of galena and tetrahedrite. Weight of sample, seven ounces. It was found to contain :

Gold	0·583 of an ounce to the ton of 2,000 lbs.
Silver	2·525 ounces " " "

164—From the "Silver Queen"—for locality see No. 162.

White sub-translucent quartz, more or less stained and coated with hydrated peroxide of iron, carrying small quantities of galena. Weight of sample, ten ounces. It contained :

Gold	0·758 of an ounce to the ton of 2,000 lbs.
Silver	28·992 ounces " " "

165.—From the "Kamloops"—for locality see No. 162.

White sub-translucent quartz, in parts stained and coated with hydrated peroxide of iron, carrying small quantities of galena and iron pyrites. It was found on assay, to contain :

Gold	0·700 of an ounce to the ton of 2,000 lbs.
Silver	25·200 ounces " " "

166.—From "Carbonate" lode, Rock Creek, Kettle River, Okanagan district—Interior plateau region.

A somewhat coarse crystalline galena through which was disseminated a little calcite. It was thickly coated with a yellowish-white incrustation, which consisted almost exclusively of carbonate of lead. Weight of sample, five ounces. Assays gave:

Gold and Silver assays, cont.

Province of British Columbia, cont.

Gold................	distinct trace.
Silver...............	64·166 ounces to the ton of 2,000 lbs.

167.—From Scotch Creek, Shuswap Lake—Interior plateau region.

Decomposed vein-stuff. Weight of sample, five ounces. Assays showed it to contain:

Gold................	4·317 ounces to the ton of 2,000 lbs.
Silver...............	21·350 " " "

168.—From Saw Mill Creek, three-quarters of a mile below Nicoamen, Thompson River—Interior plateau region.

Iron pyrites through which was disseminated small quantities of a dark green chloritic mineral and a little calcite. Weight of sample, one pound nine ounces.

It contained neither gold nor silver.

169.—This, and the following specimen are from Big Rock slide, opposite 89-mile stable, Thompson River, east side, eight miles above Spence's Bridge—Interior plateau region.

A highly weathered rock of a brownish-yellow to brownish-red color. Weight of sample, one pound twelve ounces. It contained:

Gold............	trace.
Silver..........	0·175 of an ounce to the ton of 2,000 lbs.

170.—Quartz, stained and coated with hydrated peroxide of iron and some blue and green carbonate of copper. Weight of sample, one pound five ounces.

It contained neither gold nor silver.

171.—From the west side of the South Thompson River—Interior plateau region.

White sub-translucent quartz, thickly coated with hydrated peroxide of iron. Weight of sample, one pound. Assays gave:

Gold................	none.
Silver...............	7·758 ounces to the ton of 2,000 lbs.

172.—From the north bank of the Thompson River, valley near Kamloops, about half way from North Thompson to Tranquille—Interior plateau region.

Gold and Silver assays, cont.

Province of British Columbia, cont.

An association of quartz and dolomite, stained and, in parts, coated with hydrated peroxide of iron. Weight of sample, two pounds. It was found to contain:

Gold	trace.
Silver	none.

173.—From the north bank of Tulameen River, two miles east of Granite Creek—Interior plateau region.

A tertiary conglomerate, the cementing medium of which consisted very largely of hydrated peroxide of iron. Weight of sample, eight ounces and a-half.

It contained neither gold nor silver.

174.—From the "Stirling" claim, Tulameen River, near Rabbit's, seven miles above Granite Creek—Interior plateau region.

A greyish opaque quartz in association with a small amount of a light greenish-grey chloritic mineral, through which was disseminated a little fine crystalline iron pyrites. It was, in parts, coated with hydrated peroxide of iron. Weight of sample, thirteen ounces. Assays showed it to contain:

Gold	trace.
Silver	trace.

175.—From the "Bonanza Queen" claim, Tulameen River, north bank, about nine miles above Granite Creek—Interior plateau region.

A white opaque to sub-translucent quartz more or less stained and coated with hydrated peroxide of iron and green carbonate of copper, carrying small quantities of copper pyrites with, here and there, a little melaconite. Weight of sample, four pounds ten ounces. It was found, on assay, to contain:

Gold	1·342 ounces to the ton of 2,000 lbs.
Silver	5·133 " " "

176.—From Loadstone Mountain, nine miles south-westward, on old Brigade trail, from Forks of Otter and Tulameen Rivers—Interior plateau region.

A pale brownish-yellow, in parts greenish-grey and pinkish colored dolomitic rock. Weight of sample, twelve onnces and a-half.

It contained neither gold nor silver.

177.—From mouth of Boulder Creek, lower end of Otter Lake, near Tulameen valley—Interior plateau region.

Gold and Silver assays, cont.

Province of British Columbia, cont.

A partially weathered, fine grained, granite containing, here and there, a few specks of iron pyrites. Weight of sample, ten ounces.

It contained neither gold nor silver.

178.—From Barrière River, twelve miles up from North Thompson River—Interior plateau region.

White opaque to sub-translucent quartz in parts coated with hydrated peroxide of iron, in association with a little reddish-brown dolomite. Weight of sample, two pounds six ounces. Assays gave:

Gold............ trace.
Silver........... 0·175 of an ounce to the ton of 2,000 lbs.

179.—From a small creek running into Barrière River—Interior plateau region.

The sample consisted of two specimens—the one a greyish-white sub-translucent quartz in association with a greyish-green chloritic mineral, carrying a little iron pyrites—the other a white sub-translucent quartz, in parts honeycombed, the cavities being lined with hydrated peroxide of iron. Weight of sample, one pound two ounces.

It contained neither gold nor silver.

180.—From Copper Creek, north side of Kamloops Lake—Interior plateau region.

A more or less weathered rock coated with blue and green carbonate of copper, carrying a little bornite. Weight of sample, one pound four ounces. It contained:

Gold................ none.
Silver............... 1·458 ounce to the ton of 2,000 lbs.

181.—From about seven miles east of Louis Creek, Cin-max Valley—Interior plateau region.

White sub-translucent quartz, with which was associated small quantities of a pearl-grey colored chloritic mineral. It was, in parts, stained and coated with hydrated peroxide of iron. Weight of sample, one pound two ounces.

It contained neither gold nor silver.

182.—From Peterson's Creek, Kamloops—Interior plateau region.

A weathered rock of a brownish-yellow color. Weight of sample, one pound fifteen ounces.

It contained neither gold nor silver.

Gold and Silver assays, cont.

Province of British Columbia, cont.

183.—From east side of Nicola Lake, half a mile from head of lake—Interior plateau region.

A highly weathered rock of a white, yellowish-white, greenish-white and brownish-red color. Weight of sample, one pound seven ounces. It was found to contain:

Gold .... trace.
Silver .... trace.

184.—From Spioos Creek, fifteen miles south of Nicola River—Interior plateau region.

A weathered rock of a light reddish-brown color, through which was disseminated a few specks of iron pyrites, Weight of sample, one pound seven ounces.

It contained neither gold nor silver.

185.—From mountain at Hope, Fraser River—Coast Ranges and coast region. Examined for Mr: J. Wardle.

The specimen, which was made up of material taken from different parts of the ledge, consisted of a somewhat greyish-white opaque quartz seamed and, in parts, stained with hydrated peroxide of iron. Weight of sample, three pounds seven ounces.

It contained neither gold nor silver.

186.—From the "Argyle" mine, Howe Sound—Coast Ranges and coast region. Examined for Mr. M. A. MacLean.

Consisted of serpentine in association with a little calcite, carrying a trifling amount of iron pyrites. Weight of sample, twelve ounces and a-half.

It contained neither gold nor silver.

187.—From mountains north of Burrard Inlet—Coast Ranges and coast region. Examined for Mr. A. K. Howse.

Magnetite disseminated through a gangue of greyish-green serpentine. The latter constituted but a small proportion, by weight, of the whole. 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.

188.—From the "McBain" claim, south-west shore of Texada Island (about two miles north of the iron mine)—Coast Ranges and coast region.

An association of greyish-white to white sub-translucent quartz with small quantities of green chloritic schist and calcite, carrying somewhat appreciable quantities of iron pyrites. Weight of sample, two pounds eleven ounces. It contained:

Gold and Silver assays, cont.

Province of British Columbia, cont.

Gold	0·175 of an ounce to the ton of 2,000 lbs.
Silver	none.

189.—From Texada Island; precise locality not stated—Coast Ranges and coast region. Examined for Mr. G. C. Chambers.

White sub-translucent quartz carrying a somewhat large amount of copper pyrites and galena. Weight of sample, two ounces and three-quarters. Assays gave:

Gold	trace.
Silver	1·633 of an ounce to the ton of 2,000 lbs.

190.—This, and the following specimen are from the "Surprise" claim, about six or seven miles north of Gillis Bay, Texada Island—Coast Ranges and coast region. They were examined for Mr. A. Raper.

From the centre vein.

White sub-translucent quartz carrying some zinc blende and a little iron pyrites and copper pyrites. Weight of sample, eleven ounces and a-half. It contained:

Gold	trace.
Silver	0·350 of an ounce to the ton of 2,000 lbs.

191.—From the outer vein.

White sub-translucent quartz, in parts stained with hydrated peroxide of iron and green carbonate of copper, carrying small quantities of copper pyrites. Weight of sample, one pound four ounces. Assays showed it to contain:

Gold	none.
Silver	0·467 of an ounce to the ton of 2,000 lbs.

192.—From the "Little Gem" claim, about five miles north of Gillis Bay, Texada Island—Coast Ranges and coast region. Examined for Mr. A. Raper.

An association of hornblende, magnetite and copper pyrites. Weight of sample, four ounces and a-half. It was found to contain:

Gold	distinct trace.
Silver	2·100 ounces to the ton of 2,000 lbs.

Gold and Silver assays, cont.

Province of British Columbia, cont.

193.—This, and the two following specimens are from Bowen Island, Howe Sound—Coast Ranges and coast region.

Wall rock.

Grey syenitic gneiss, through which was disseminated small quantities of iron pyrites. Weight of sample, one ounce. Assays showed it to contain:

Gold .... trace.
Silver .... 2·100 ounces to the ton of 2,000 lbs.

194.—Ore from lode.

Banded quartzite, containing a few specks of iron pyrites. It was, more or less, stained and coated with hydrated peroxide of iron. Weight of sample, three ounces. Assays gave:

Gold .... none.
Silver .... 0·233 of an ounce to the ton of 2,000 lbs.

195.—Ore from spur.

Banded grey quartzite containing, in parts, a few specks of iron pyrites. It was for the most part stained and coated with hydrated peroxide of iron. Weight of sample, four ounces. It was found to contain:

Gold .... none.
Silver .... 0·117 of an ounce to the ton of 2,000 lbs.

196.—From Lillooet Lake—Coast Ranges and coast region. This, and and the following specimen were examined for Mr. T. Armstrong.

A rust stained gneiss carrying small quantities of iron pyrites and copper pyrites. Weight of sample, two pounds one ounce.

It contained neither gold nor silver.

197.—From above Port Haney, Lower Fraser River—Coast Ranges and coast region.

Bluish-grey quartz carrying small quantities of copper pyrites and iron pyrites. Weight of sample, fourteen ounces.

It contained neither gold nor silver.

198.—From the "Acadia" claim, South Fork of McDames Creek—Cassiar district. This, and the following specimen were received from Mr. J. McKay.

Galena in association with small quantities of iron pyrites, magnetic pyrites, copper pyrites, bornite and calcite. Weight of sample, four ounces. It was found, on assay, to contain:

Gold .... none.
Silver .... 74·772 ounces to the ton of 2,000 lbs.

199.—From the "Pioneer" claim, McDames Creek—Cassiar district. White translucent quartz, carrying a considerable quantity of iron pyrites. Weight of sample, fourteen ounces. Gold and Silver assays, cont. Province of British Columbia, cont.

It contained neither gold nor silver.

MISCELLANEOUS EXAMINATIONS.

Miscellaneous examinations.

1.—CLAY. The deposit from which this material was taken is a very large one, extending in a straight line from Sault Ste. Marie to Gros Cap, district of Algoma, province of Ontario. Collected by Dr. A. R. C. Selwyn. Clay from vicinity of Sault Ste. Marie, P.O.

It has a banded structure, the bands varying in color from pale reddish-white to light brownish-red: is plastic: has a fine and close texture: contains no admixture of gritty matter: when burnt it assumes a pale reddish dull yellow color: if well burnt becomes strong, hard and sonorous: at a high temperature is somewhat readily fusible. Agreeably with results of experiments on a small scale, it is well suited for the manufacture of bricks and coarse pottery ware.

2.—COAL. From three miles north of Lytton, Fraser River, British Columbia. Examined for Mr. J. W. Mackay. Coal from vicinity of Lytton, B.C.

A very impure coal, containing not less than 36·80 per cent. of a reddish-brown colored ash. Notwithstanding the large amount of the latter, it yielded a slightly coherent coke.

3.—LIGNITIC COAL. From a seam on Hat Creek, about sixteen miles north of Ashcroft Station, on the line of the Canadian Pacific Railway, British Columbia. Taken from a depth of about sixty feet. Examined for Mr. H. Abbott. Lignitic coal from Hat Creek, B.C.

It gave, both by slow and fast coking a non-coherent coke. On incineration, it left 10·75 per cent. of a pale yellowish-white colored ash.

4.—COAL. From the rear of Big Pond, East Bay, Cape Breton county, province of Nova Scotia. Examined for Mr. M. A. McPherson, P.P. Coal from Big Pond, East Bay, N.S.

A proximate analysis, by fast coking, gave:

Volatile matter	41·79
Fixed carbon	44·98
Ash	13·23
	100·00
Coke, per cent	58·21

Miscellaneous examinations, cont.

It yields a firm coherent coke. The gases evolved during coking burnt with a yellow, luminous, smoky flame. Color of ash, purplish-brown.

Manganese ore from near Edgett's Landing, Hillsborough, N.B.

5.—MANGANESE ORE. From near Edgett's Landing, Hillsborough, Albert county, province of New Brunswick.

The material consisted of manganite and ferric hydrate disseminated through a siliceous gangue. A partial analysis gave:

Sesquioxide of manganese	18·37	per cent.
Sesquioxide of iron	1·31	"
Insoluble siliceous residue	71.85	"

equivalent to:

Manganese, metallic	12·79	"
Iron ......, "	·92	"

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

MINING & MINERAL STATISTICS

OF CANADA

FOR THE YEAR 1888;

BY

H. P. BRUMELL.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
WILLIAM FOSTER BROWN & CO.
1888.

OTTAWA, 7th June, 1889.

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

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to submit herewith a statistical report on the mineral production of Canada in 1888.

I wish to acknowledge the kindness of the Inspector of Mines for Nova Scotia and the Minister of Mines of British Columbia in supplying me with necessary information in regard to the mineral production of these two provinces.

Thanks are also due to the producers throughout the Dominion who so kindly forwarded the necessary information as to their production etc.

I am, Sir,

Your obedient servant,

H. P. BRUMELL.

NOTE.—The year used throughout this report is the calendar year, and the ton that of 2,000 pounds, unless otherwise stated.

The fiscal year begins the 1st of July.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1888.

Product.	Quantity.	Value.	Compared with 1887 (a).
Antimony ore ....tons.	345	$ 3,696	Decrease.
Arsenic.......... ...... "	30	1,200	
Asbestus .... "	4,404	255,007	Increase.
Baryta .... "	1,100	3,850	do
*Bricks..................thousands.	165,818	1,036,746	do
*Building stone............cub. yds.	411,570	641,712	do
Cement..... ....bbls.	50,668	35,593	Decrease.
Charcoal....... ....bush.	1,500,000	87,000	do
Coal ....tons.	2,658,134	5,259,832	Increase.
Coke..................... "	45,373	134,181	Decrease.
Copper (fine, cont'd. in ore).lbs.	5,562,864	667,543	Increase.
Fertilizers................tons.	548	21,600	Decrease.
*Flagstones................feet.	64,800	6,580	do
*Glass and Glassware................	....	375,000	
Gold...... ....ozs.	61,310	1,098,610	Decrease.
Granite..... ....tons.	21,352	147,305	Increase.
Graphite.................. "	150	1,200	Decrease.
Grindstones............... "	5,764	51,129	do
Gypsum.................. "	175,887	179,393	Increase.
*Iron. .... "	44,949	1,592,931	do
Iron ore.................. "	78,587	152,068	do
Lead (fine, contained in ore).lbs.	674,500	27,472	do
*Lime........... ....bush.	2,216,764	339,951	Decrease.
Limestone for iron flux.....tons.	16,857	16,533	do
Manganese ore........... "	1,801	47,944	Increase.
Marble and Serpentine...... "	191	3,100	Decrease.
Mica...................... "	29,025	30,207	Increase.
Mineral Paints............ "	397	7,900	do
*Mineral Water............galls.	124,850	11,456	
*Moulding sand............tons.	169	845	Increase.
Petroleum ....bbls.	733,564	755,571	do
Phosphate ....tons.	22,485	242,285	Decrease.
Pig Iron.................. "	21,799	313,235	do
Platinum.................ozs.	1,500	6,000	do
*Pottery ware	....	27,750	
Pyrites........... ....tons.	63,479	285,656	Increase.
Salt...................... "	59,070	185,460	do
Sand and Gravel (exports).. "	260,929	38,398	do
Sewer pipes and tiles................	....	266,320	
Silver................................	....	395,377	Increase.
Slate...... ....tons.	5,314	90,689	do
Soapstone.... .... "	140	280	Decrease.
Steel..................... "	9,553	472,611	Increase.
Sulphuric acid............lbs.	8,727,220	121,515	do
*Terra cotta..........................	....	49,800	
*Tiles............ ....thousands.	7,518	114,057	Decrease.
Whiting.................tons.	30	240	do
Estimated value of mineral products not returned (principally iron and building materials)...............	....	897,172	
Total..................	....	$16,500,000	Increase.

* Incomplete.
(*a*) Comparison of values only.

EXPORTS OF MINERALS AND MINERAL PRODUCTS, MINED OR MANUFACTURED IN CANADA, DURING 1888.

PRODUCT.	VALUE.	PRODUCT.	VALUE.
Antimony.............. ..	$ 6,894	Mica......	$ 23,563
Asbestus.......	277,742	Oil, mineral, coal and kerosene.	74,542
Coal..................	1,974,731	Phosphate..............	298,609
Copper................	257,287	Plumbago (graphite).....	1,080
Glass and Glassware.....	1,739	Salt...................	3,987
Gold......	628,158	Sand and gravel	38,398
Grindstones	28,176	Silver	219,008
Gypsum (crude).........	121,389	Slate......	475
Iron and steel, about......	350,000	Stone and marble, unwrought..	56,005
Iron ore................	55,177	Stone and marble, wrought	22,114
Lead ore...............	18	Other articles...........	167,630
Lime and cement........	110,256	Total.............	$4,738,810
Manganese ore....	21,832		

EXPORTS OF PRODUCTS OF THE MINE DURING THE FISCAL YEAR 1888.

EXPORTED TO	VALUE.	EXPORTED TO	VALUE.
United States...........	$3,341,308	Sandwich Islands.......	$ 7,839
Great Britain...........	478,260	France	2,970
Newfoundland....	146,222	British Guiana..........	2,184
Germany...............	46,053	Spanish West Indies....	1,960
Japan	40,180	British do	1,897
St. Pierre..............	16,312	Belgium................	1,432
China....	12,950	Gibraltar............. ..	460
Mexico	10,570	Spain..................	340
		Total............	$4,110,937

IMPORTS OF MINERALS AND MINERAL PRODUCTS DURING 1888.

PRODUCT.	VALUE.	PRODUCT.	VALUE.
Alum and Aluminous Cakes	$ 22,596	Lead, and mfrs. of	$ 260,364
Antimony	15,502	Lime	8,355
Arsenic	821	do , Chloride of	77,968
Asbestus and mfrs. of	8,910	Litharge	31,432
Asphaltum	13,640	Lithographic stone	6,144
Baryta	1,183	Manganese oxide	2,424
Borax	17,968	Marble	105,042
Brass, and mfrs. of	528,273	Mercury	8,330
Bricks	24,194	Mineral waters	27,151
do , Bath	1,447	Ores of metals	7,785
do and Tiles, fire	90,311	Ornamental stones	58,965
Buhrstones	3,746	Paints	484,623
Building stone	103,792	Paraffine wax	5,296
Cement	18,068	Petroleum	481,770
do , Portland	160,883	Plaster of Paris	6,228
Chalk	5,936	Platinum	14,108
Clay, all sorts	74,751	Potash salts	12,343
Coal	8,975,792	Precious stones	205,834
Coke	103,600	Pumice	2,957
Copper, and mfrs. of	372,719	Salt	270,385
Copperas	2,272	Sand and Gravel	32,237
Earthenware	209,989	"Silex"	1,549
Emery	14,099	Slate	38,505
Fertilizers	44,818	Soda salts	325,168
Flagstones	16,343	Spelter	40,880
Glass and Glassware	1,219,264	Sulphur	33,479
Graphite, and mfrs. of	39,687	Sulphuric acid	4,430
do Pencils	57,885	Tiles, sewer, etc	99,233
Grindstones	23,202	Tin, and mfrs. of	1,230,437
Gypsum	2,606	Whiting	20,847
Iron and Steel, all sorts, about	12,000,000	Yellow metal	83,783
		Zinc, and mfrs. of	68,439
		Total	$28,230,788

ABRASIVE MATERIALS.

GRINDSTONES.—The total production of grindstones during the year amounted to 5,764 tons, valued at $51,129. This shows an increase in quantity over last year of 472 tons, and a decrease in value of $12,879. The value given for last year is now thought to have been too high this will account for the apparent depreciation in value.

New Brunswick.

The returns received by this office show the production of New Brunswick to have been 3,793 tons, valued at the quarries at $30,729. This is the output of seven quarries and shows an increase over the previous year of 211 tons while the value is $8,259 less than that of the same year. The returned value given for the year 1887 was about $12 per ton, whereas it is now thought $9.50 is a fair average value.

Nova Scotia.

The returns, according to the report of the Inspector of Mines of this province, show a production in Nova Scotia of 1,971 tons valued at $20,400. The production is of three quarries and shows, in the quantity quarried an increase of 261 tons, and a decrease in value of $4,620.

Other abrasive materials.

There were no returns received for other abrasive materials and it is thought that none were produced, though small quantities of tripoli and hone-stones may have been mined and used locally.

The following tables show the exports and imports of grindstones and the imports of buhrstones, emery, pumice stone and "silex":—

Exports and imports.

EXPORTS OF GRINDSTONES.

PROVINCE	1887.	1888.
Ontario	$ 500	$ 252
Quebec	12	......
Nova Scotia	10,425	11,430
New Brunswick	17,832	16,494
Totals	$28,769	$28,176

IMPORTS OF GRINDSTONES.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario	1,255	$13,718	1,390	$15,915
Quebec	442	4,576	505	6,094
Nova Scotia	....	35	....	199
New Brunswick	....	....	1	9
Manitoba	30	466	56	786
British Columbia	9	479	6	199
Totals	1,736	$19,274	1,958	$23,202

IMPORTS OF BUHRSTONES.

Province.	1886.	1887.	1888.
Ontario	$1,203	$1,184	$ 239
Quebec	696	2,325	3,507
British Columbia	....	26	....
Totals	$1,899	$3,535	$3,746

IMPORTS OF EMERY AND PUMICE STONE.

Province.	1887.	1888.	
	Emery and Pumice Stone.	Emery.	Pumice Stone.
Ontario	$10,781	$10,337	$1,629
Quebec	3,968	1,915	1,255
Nova Scotia	360	232	23
New Brunswick	1,413	1,603	26
Prince Edward Island	2	....	....
Manitoba	1	...	5
British Columbia	2	12	19
Totals	$16,527	$14,099	$2,957

The imports of Emery and Pumice Stone were not kept separate by the Customs Department until this year.

Imports of "Silex or Crystallized Quartz" for 1888 are as follows:—

Ontario	5,699	cwts.	$1,154
Quebec	263	"	237
Nova Scotia	2	"	11
New Brunswick	239	"	147
Totals	6,203	cwts.	$1,549

ANTIMONY.

The production this year is entirely that of Nova Scotia. The mines of New Brunswick were idle and prospecting was carried on in the province of Quebec to a small extent. Production.

The returns received through the Inspector of Mines for Nova Scotia show a production of 345 tons valued at $3,696, all the production of the Rawdon mines. The shipments from these mines will, in all probability, be much larger next year as they have on hand a considerable quantity of good milling ore which will be treated on completion of their mill, plans for which have been prepared.

There is a decrease in production this year of 239 tons and $7,164.

The exports this year amounted to 352½ tons valued at $6,894 all from Nova Scotia. This value is probably too high. Exports and imports.

The following table shows the imports of Antimony for the last two years.

IMPORTS OF ANTIMONY.

PROVINCE.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario	47,880	$3,551	50,481	$4,754
Quebec	23,343	2,746	96,690	10,127
Nova Scotia	112	8	552	162
New Brunswick	2,016	174	3,908	417
Manitoba	....	....	180	6
British Columbia	....	....	264	36
Totals	78,351	$6,479	152,075	$15,502

ARSENIC.

Production.

Refined arsenic (arsenious oxide) was produced at the Deloro mine, Ontario, in the same quantity as last year, namely, 30 tons valued at $1,200 or $40 per ton. The work of refining was carried on for only three months of the year.

Large quantities of arsenopyrite are to be had at this mine and it is confidently expected that there will be a much greater production during the coming year.

Imports.

The imports of arsenic are as follows :—

IMPORTS OF ARSENIC.

PROVINCE.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario....................	13,136	$456	3,944	$125
Quebec....................	26,536	937	17,244	610
Nova Scotia....................	3,837	144	2,272	82
New Brunswick....................	100	4	....	....
Manitoba....................	....	....	35	4
Totals	43,609	$1,541	23,495	$821

ASBESTUS.

Returns were received from all the producers in Quebec showing a production during the year of 4,404½ tons of all grades valued at the mines at $255,007. This shows a large increase over the previous year of 185 tons in quantity and $34,031 in value. Production.

Returns were received from eleven different mines of which only nine produced.

The above increase is in a great measure due to the Bell's Asbestus Co., which consolidated and operates the property formerly owned by the Boston Asbestus Packing Co., the Hayden property of Coleraine, and the Belmina property in Wolfe Co., Mr. Louis. Wertheim, of Frankfort-on-Main, Germany, has lately purchased and is working a property situate in Coleraine township, and the indications are that there will be a greater increase next year than that shown above. The price of first-class asbestus seems to be firm at an increase over previous years and the quality of the mineral shipped correspondingly higher.

There was no production in Ontario during the year.

The returns show a production by districts as follows :— Summary.

Thetford Mines	3,067	tons.
Coleraine and Black Lake Mines	1,337½	"

summarized as follows :—

Black Lake and Coleraine	1st class,	337 tons	$25,040
	2nd "	601 "	26,495
	3rd "	399 "	5,262
Thetford	1st "	1,786 "	157,040
	2nd "	519 "	29,740
	3rd "	762 "	11,430
Totals	1st "	2,123 "	182,080
	2nd "	1,120 "	56,235
	3rd "	1,161 "	16,692

The exports were as follows :— Exports and imports.

1st class,	3,625 tons	$262,552
2nd "	110 "	5,306
3rd "	201 "	9,884
Total..	3,936	$277,742

The greater part of the above exportation was to the United States, amounting to 3,612 tons, small quantities going to Great Britain, Germany, France, Belgium and Newfoundland.

The imports of manufactured asbestus were as follows :—

IMPORTS OF MANUFACTURED ASBESTUS.

Province.	1887.	1888.
Ontario	$3,485	$3,557
Quebec	3,848	4,302
Nova Scotia..................	312	265
New Brunswick.............	576	591
Manitoba......	32	46
British Columbia...........	236	149
Totals................	$8,489	$8,910

COAL.

The production of coal in 1888 amounted to 2,658,134 tons, valued at the pit's mouth at $5,259,832. This shows a net increase over the previous year of 239,640 tons and $681,242. Production.

There has been a very marked increase year by year for the last three years, according to returns received, the production being as follows :—

1886	2,091,976 tons.
1887	2,418,494* "
1888	2,658,134 "

The production by Provinces is as follows :—

Production of Coal in 1888 by Provinces. Summary.

Province.	Tons.	Value.	No. of men employed.	No. of Producers.
Nova Scotia	1,989,263	$3,108,224	4,651	20
British Columbia	548,017	1,957,204	2,012	4
North-West Territory	115,124	183,354	390	9
New Brunswick	5,730	11,050	38	7
Totals	2,658,134	$5,259,832	7,091	40

The following tables give the details of the production and sales of coal in Nova Scotia. Nova Scotia.

* *This quantity has been corrected since last year when it appeared incorrectly.*

PRODUCTION, SALES AND COLLIERY CONSUMPTION OF COAL IN NOVA SCOTIA DURING THE YEARS 1885, 1886, 1887 AND 1888.

TABLE A.

Period.	Production.	Sales.	Colliery Consumption
1888—First quarter. Tons..........	316,793	188,953	47,491
1888—Second " "	515,526	432,860	47,215
1888—Third " "	644,121	673,701	33,954
1888—Fourth " "	512,823	470,381	47,676
Totals............	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

DISTRIBUTION OF NOVA SCOTIA COAL SOLD DURING THE YEAR 1888.

TABLE B.

Market.	Tons.
Nova Scotia :—	
Transported by land............	314,183
" sea.............	256,910
Total...............	571,093
New Brunswick....................	240,386
Newfoundland......................	93,772
Prince Edward Island................	63,111
Quebec..............................	759,720
West Indies.........................	3,484
United States.......................	33,822
Other Countries.....................	507
Total...............	1,765,895

Coal Trade of Nova Scotia by Counties during the year 1888.

Table C.

Year 1888.	Cumberland.		Pictou.		Cape Breton.		Total.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
First quarter.	114,605	102 639	110,954	81,267	91,234	5,047	316,793	188,953
Second "	139,026	122,048	131,534	107,007	244,966	203,805	515,526	432,860
Third "	138,948	122,783	135,924	138,750	369,248	412,168	644,120	673,701
Fourth "	134,749	122,425	152,679	142,136	225,396	205,820	512,824	470,381
Totals...	527,328	469,895	531,091	469,160	930,844	826,840	1,989,263	1,765,895

Production of Coal in Nova Scotia by Collieries during 1888.

Table D.

Colliery.	Tons.	Colliery.	Tons.
Chignecto	16,584	Caledonia...............	126,318
Joggins......	54,261	Francklyn	9,230
Minudie	1,544	Glace Bay..............	89,431
Springhill.....	454,939	Gowrie.................	145,018
Acadia................	325,620	International.	114,429
Black Diamond.........	26,884	Ontario................	5,166
East River............	879	Reserve	135,650
Intercolonial...........	177,708	Sydney	170,224
Blockhouse......	7,625	Victoria................	100,619
Bridgeport............	27,134	Total	1,989,263

YEARLY PRODUCTION OF COAL IN NOVA SCOTIA SINCE 1870.

TABLE E.

Year.	Tons.	Year.	Tons.
1870	700,861	1880	1,156,635
1871	754,031	1881	1,259,182
1872	984,664	1882	1,529,708
1873	1,117,643	1883	1,593,259
1874	977,446	1884	1,556,010
1875	874,905	1885	1,514,470
1876	794,803	1886	1,682,924
1877	848,395	1887	1,871,338
1878	863,081	1888	1,989,263
1879	882,863	Total.....	23,013,481

British Columbia.

The two following tables are taken from the Annual report of the Minister of Mines of British Columbia. Their titles will sufficiently explain them.

COAL TRADE OF BRITISH COLUMBIA DURING THE YEAR 1888.

TABLE F.

Name of Colliery.	Coal raised.	Sold for home consumption.	Sold for exportation.	On hand Jan. 1st, 1888.	On hand Jan. 1st, 1889.	Number of men employed.
	Tons.	Tons.	Tons.	Tons.	Tons.	
Nanaimo....	289,875	44,49	241,082	1,443	5,736	945
Wellington..	222,199	78,446	139,607	303	4,145	695
E. Wellington	33,703	6,920	28,910	2,240	112	132
Union.......	2,240	....	....	....	2,240	240
Totals....	548,017	129,865	409,599	3,986	12,233	2,012

YEARLY PRODUCTION OF COAL IN BRITISH COLUMBIA SINCE 1874.

TABLE G.

Year.	Tons.
1874	81,547
1875	110,145
1876	139,192
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

North-West Territories.

Returns were received from nine different producers in the North-West Territories, the net production amounting to 115,124 tons valued at $183,354. This shows an increase of 41,372 tons over the previous year, and of nearly 70,000 tons over 1886. The production is chiefly that of the Anthracite and Lethbridge mines, small quantities only being mined at Calgary and Edmonton and in their vicinity.

New-Brunswick.

In the Grand Lake district returns were received from seven producing mines and many others that report no production.

The amount mined was 5,730 tons having a value of $11,050. There is a decrease here of 2,630 tons and $9,197. This is due, in a large measure, to a company having bought up a great many of the partly developed lands with the intention of working them more extensively on the completion of a short line railway from Fredericton.

A line has been surveyed through the most productive part of the coal area. On the completion of any railway through this district there would undoubtedly be a great increase in the coal production. The coal is at present shipped by schooner to Fredericton and St. John, in which latter place it readily sells at an average price of $4 per ton.

Exports.

The exports of coal produced in Canada amounted to 588,627 tons, valued at $1,974,731 as shown below.

EXPORTS OF COAL, THE PRODUCE OF CANADA, FOR THE YEARS 1887 AND 1888.

TABLE 1.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario	......	....	25	$ 107
Quebec	14,737	$ 37,772	17,506	38,281
Nova Scotia	207,941	390,738	165,863	330,115
New Brunswick	1,341	4,025	3	15
Prince Edward Island	274	636	105	214
Manitoba	15	60	54	349
British Columbia	356,657	1,262,552	405,071	1,605,650
Totals	580,965	$1,695,783	588,627	$1,974,731

The destinations were as follows :—

	Tons.
Great Britain	32,598
United States	451,660
Newfoundland	71,842
St. Pierre	8,571
France	1,402
Germany	518
Sweden and Norway	600
United States of Colombia	398
Spanish West Indies	2,753
British West Indies	1,205
Sandwich Islands	5,760
Japan	8,300
Mexico	3,020
Total	588,627

EXPORTS OF COAL, NOT THE PRODUCE OF THE DOMINION, DURING THE YEARS 1887 AND 1888.

TABLE 2.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario	67,837	$170,754	70,198	$165,816
Quebec	15,188	23,413	9,864	20,179
Nova Scotia............	3,803	9,297	4,024	11,180
New Brunswick.........	2,270	7,486	230	409
Totals............	89,098	$210,950	84,316	$197,584

Destinations.	Tons.
Great Britain....................................	9,987
United States....................................	73,248
Newfoundland....................................	213
France....................................	440
British West Indies....................................	428
Total....................................	84,316

EXPORTS OF COAL FROM NOVA SCOTIA AND BRITISH COLUMBIA FROM 1874 TO 1888 INCLUSIVE (THE PRODUCE OF CANADA.)

TABLE 3.

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
Totals..	2,815,156	$5,489,692	3,094,131	$11,863,666

IMPORTS OF ANTHRACITE DURING THE YEARS 1887 AND 1888. Imports,

TABLE 4.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario	1,042,077	$4,456,827	900,776	$3,746,081
Quebec	340,046	1,315,390	348,350	1,401,904
Nova Scotia.............	21,909	79,904	22,923	94,122
New Brunswick.........	33,333	126,449	51,074	195,287
Prince Edward Island....	2,673	9,950	2,518	9,904
Manitoba	2	26	523	3,447
British Columbia........	112	1,737	....	3
Totals	1,440,152	$5,990,283	1,326,164	$5,450,748

IMPORTS OF BITUMINOUS COAL DURING THE YEARS 1887 AND 1888.

TABLE 5.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario	1,138,279	$3,226,524	1,195,736	$3,258,113
Quebec..................	73,324	147,890	82,667	175,127
Nova Scotia.............	1,131	7,135	1,423	10,001
New Brunswick.........	3,102	7,607	4,715	13,336
Manitoba	1,832	4,345	2,293	7,620
British Columbia........	665	5,259	355	4,828
Totals............	1,218,333	$3,398,760	1,287,189	$3,469,025

IMPORTS OF COAL DUST, ALL KINDS, FOR THE YEAR 1888.

TABLE 6.

Province.	Tons.	Value.
Ontario	37,195	$41,027
Quebec	10,649	14,170
Nova Scotia................	82	375
New Brunswick.............	6	170
Manitoba..................	55	267
British Columbia...........	.....	10
Total................	47,987	$56,019

There was therefore an importation of Coal during the year as follows:—

Anthracite..................................	1,326,164	tons.
Bituminous Coal............................	1,287,189	"
Coal Dust..................................	47,987	"
Total Coal imported during year 1888...	2,661,340	"
Total Value of above................	$8,975,792	

Consumption.

The amount of coal of all kinds consumed in Canada last year was approximately 4,500,000 tons as is shown by the following figures:—

Total Imports..................................		2,661,340	tons.
" Production................................		2,658,134	"
		5,316,474	"
LESS.—Exports, Produce	588,627 tons		
" not Produce.	84,316 "	672,943	"
		4,643,531	"

Coke.

The production of oven coke during the year 1888, amounted to 45,373 tons valued at $134,181. The production is altogether that of Nova Scotia, the greater part being manufactured by the Londonderry Iron Company, Limited, of Londonderry, N.S.

The following table gives the imports of coke for the last two years :—

IMPORTS OF OVEN COKE DURING THE YEARS 1887 AND 1888.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario..................	15,981	$67,797	22,948	$80,841
Quebec...................	3,696	13,849	5,171	16,068
New Brunswick.........	......	......	198	827
Manitoba................	43	260	198	816
British Columbia........	85	429	155	939
Totals..............	19,805	$82,335	28,670	$99,491

Returns were not received from two of the most important of the Ontario producers and their production of last year has been taken as representing approximately that of 1888. Charcoal.

The amount of charcoal produced, for reduction purposes, during 1888, was about 1,500,000 bushels having an approximate value of $87,000. About half of this production is that of the province of Quebec, being produced and used at the Drummondville and Radnor furnaces, the remainder made in Ontario is exported to the United States, principally to the iron works of Michigan.

Small quantities are annually made at the various gold and silver mines in Canada, where it is used for assay and test purposes.

COPPER.

Production.

The amount of copper ore produced and marketed in Canada during the year 1888 was 63,479 tons, having an approximate copper content of 5,562,864 lbs., which, calculated at the average price of twelve cents, gives a value of $667,543. There is an increase over 1887 of 22,679 tons of ore and of copper content about 2,302,440 lbs., or about 70 per cent. The price is assumed to be higher this than last year, when the value was calculated at ten and a half cents per pound.

The production for 1888 is altogether from the mines of Capelton, sample shipments only being made from other districts where development is still going on. Through the addition of the smelter at Sudbury it may be expected that there will be a much greater production next year than there has been heretofore.

According to the report of the Inspector of Mines, Nova Scotia, there has been increased activity in the copper mining of that province. Prospecting and development was carried on in several districts. The Eastern Development Co. have done a considerable amount of underground exploration on their properties at Coxheath, near Sydney, Cape Breton; during the year 600 tons were raised, and the ore now in stock amounts to 1,500 tons. No shipments were made.

Exports and imports.

The exports for 1888 were altogether from the Province of Quebec with the exception of a sample shipment from Nova Scotia of $25, and one from New Brunswick of $2. The amount from Quebec was according to Customs Department returns, $257,260. The exports, however, show a very marked increase over the two preceding years as is shown below:—

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

Imports are as follows:—

IMPORTS OF COPPER, INCLUDING PIGS, BARS, RODS, INGOTS, SHEATHING, SHEETS, OLD AND SCRAP, ETC., FOR THE YEARS 1887 AND 1888.

TABLE 1.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario...............	1,121,400	$120,204	761,600	$130,730
Quebec.................	794,600	67,855	944,800	88,438
Nova Scotia............	37,500	3,054	45,200	6,276
New Brunswick.........	54,200	5,153	5,100	1,291
Prince Edward Island....	1,000	119	400	63
Manitoba..............	2,100	242	......	......
British Columbia..	16,200	1,900	10,700	2,007
Totals.............	2,027,000	$198,527	1,767,800	$228,805

IMPORTS OF COPPER, INCLUDING ALL MANUFACTURES NOT INCLUDED IN ABOVE, FOR YEARS 1887 AND 1888.

TABLE 2.

Province.	1887.	1888.
Ontario................	$35,768	$41,748
Quebec................	56,700	79,763
Nova Scotia............	11,231	4,710
New Brunswick..........	6,644	10,371
Prince Edward Island.....	82	76
Manitoba..............	2,642	2,592
British Columbia.........	4,365	4,654
Totals................	$117,432	$143,914

GOLD.

Production.

The total production of gold in 1888 was 61.310 ozs., valued at $1,098,610, showing a slight decrease since last year. This decrease is, in a great measure, due to the Yukon district where the season was a very bad and wet one, the estimated production for the year being only $40,000. The total production for Canada for the year was $140,027, less than that of the year previous.

The production is divided by provinces as follows:—

Province.	Ozs.	Value.	Number of men employed.
British Columbia........	36,278	$616,731	2,007
Nova Scotia..............	22,407	436,939	528
Quebec.	197	3,740	13
North-West Territory.... (including Yukon)	2,428	41,200	about 257
Totals................	61,310	$1,098,610	2,805

British Columbia.

The statistics for British Columbia, as shown in the following tables, are taken from the report of the Minister of Mines of that province:—

Value of Gold Exported by the Banks at Victoria during the year 1888.

Table A.

Bank of British Columbia..............................	$286,923
" " British North America.....................	57,186
Garesche, Green & Co..................................	169,834
Total............................	$513,943

PRODUCTION OF GOLD BY DISTRICTS AS ESTIMATED BY THE GOLD COMMISSIONERS OF BRITISH COLUMBIA DURING 1888.

TABLE B.

Districts.	Divisions.	Whites.	Chinese.	Yield of Gold by divisions.	Total yield by Districts.
Cariboo	Barkerville...........	88	173	$75,294	
	Lightning Creek......	29	159	36,536	
	Quesnellemouth	....	97	56,547	
	Keithley Creek.......	34	228	64,550	$232,927
		151	657		
Cassiar.......	....	23	85	43,325	43,325
Kootenay	Eastern..	100	20	10,000	
	Western.............	52	67	37,612	47,612
		152	87		
Lillooet......	....	60	400	90,160	90,160
Yale........	Osoyoos.....	103	54	9,000	
	Similkameen.	65	170	96,000	105,000
		168	224		$519,024
	Total Whites......	554	....		
	" Chinese.	....	1453		
	Total employed....	2,007			

The following table, taken from the "Mineral Wealth of British Columbia" by Dr. G. M. Dawson, part R Annual Report of the Geological Survey for 1887, shows the amount of gold annually produced by British Columbia since the year 1858:—

ANNUAL PRODUCTION OF GOLD IN BRITISH COLUMBIA SINCE 1858.

TABLE C.

Year.	Amount actually known to have been exported by banks, &c.	Amount added to represent gold carried away in private hands.	Total.	Number of miners employed.	Average yearly earnings per man.
1858 (partial return.)	$543,000	....	$ 705,000*	3,000	$ 235
1859	1,211,304	1-3rd $403,768	1,615,072	4,000	403
1860	1,671,410	" 557,133	2,228,543	4,400	506
1861	1,999,589	" 666,529	2,666,118	4,200	634
1862	1,992,677	" 664,226	2,656,903	4,100	648
1863	2,935,172	" 978,391	3,913,563	4,400	889
1864	2,801,888	" 933,962	3,735,850	4,400	849
1865	2,618,404	" 872,801	3,491,205	4,294	813
1866	1,996,580	" 665,526	2,662,106	2,982	893
1867	1,860,651	" 620,217	2,480.868	3,044	814
1868	1,779,729	" 593,243	2,372,972	2,390	992
1869	1,331,234	" 443,744	1,774,978	2,369	749
1870	1,002,717	" 334,239	1,336,956	2,348	569
1871	1,349,580	" 449,860	1,799,440	2,450	734
1872	1,208,229	" 402,743	1,610,972	2,400	671
1873	979,312	" 326,437	1,305,749	2,300	567
1874	1,383,464	" 461,154	1,844,618	2,868	643
1875	1,856,178	" 618,726	2,474,904	2,024	1,222
1876	1,339,986	" 446,662	1,786,648	2,282	783
1877	1,206,136	" 402,045	1,608,182	1,960	820
1878	1,062,670	1-5th 212,534	1,275,204	1,883	677
1879	1,075,049	" 215,009	1,290,058	2,124	607
1880	844,856	" 168,971	1,013,827	1,955	518
1881	872,281	" 174,456	1,046,737	1,898	551
1882	795,071	" 159,014	954,085	1,738	548
1883	661,877	" 132,375	794,252	1,965	404
1884	613,304	" 122,861	736,165	1,858	396
1885	594,782	" 118,956	713,738	2,902	246
1886	753,043	" 150,608	903,651	3,147	287
1887	578,924	" 115,785	693,709	2,342	296
1888	513,943	" 102,788	616,731	2,007	307

Total known and estimated yield, 1858 to 1888, $54,108,804.

* Waddington's estimate.

Nova Scotia. The statistics of the production of gold in Nova Scotia are very kindly furnished by the Inspector of Mines of that province. In table D will be found a general statement of 1888 production etc. Tables E and F illustrate the total production by districts and the yearly production since 1862.

GENERAL STATEMENT OF GOLD PRODUCTION IN NOVA SCOTIA FOR THE YEAR 1888.

TABLE D.

Districts.	Number of mines.	Days' labor.	Mills.	Steam power.	Water power.	Tons of quartz crushed.	Yield per ton.			Maximum yield per ton.			Total yield of gold.		
							oz.	dwts.	gr.	ozs.	dwts.	grs.	ozs.	dwts.	grs.
Sherbrooke........	4	8,980	3	2	1	2,858	0	3	18	0	4	22	535	8	18
Salmon River.....	1	20,594	1	..	1	9,925	0	6	18	0	10	1	3,354	10	0
Oldham..........	3	15,570	1	..	1	2,106	0	16	3	1	9	22	1,699	9	19
Waverley.........	0	4,132	2	..	2	619	0	7	12	0	12	9	232	9	10
Caribou..........	4	22,171	2	1	1	6,313	0	8	16	1	9	9	2,729	10	15
Uniacke........	2	8,661	4	4	.	612	1	0	16	4	14	13	632	7	1
Rawdon..........	..	......	1	1	.	2,760	0	6	22	0	15	16	952	15	20
Lake Catcha	1	14,713	3	3	..	1,611	1	8	2	2	17	21	2,284	17	3
Whiteburn.	1	9,502	3	3	..	1,292	2	3	8	4	12	3	2,799	4	8
15 Mile Stream...	1	8,141	1	1	.	2,151	0	8	19	0	10	12	946	8	0
Stormont.........	1	12,495	1	1	..	1,904	1	3	8	1	13	14	2,222	6	0
Tangier..........	0	5,966	2	2	..	539	0	9	18	0	16	5	263	1	0
Renfrew..........	1	6,095	2	..	2	1,145	0	11	6	0	18	5	642	16	10
Wine Harbor......	1	5,543	1	1	..	324	0	14	18	1	5	22	239	2	0
Unproclaimed, &c.	3	21,209	8	8	..	2,019	1	8	11	4	14	14	2,872	17	2
Totals.......	23	163,772	35	27	8	36,178	0	15	21	4	14	14	22,407	3	10

GOLD PRODUCTION OF THE DIFFERENT DISTRICTS IN NOVA SCOTIA FROM 1862 TO 1888 INCLUSIVE.

TABLE E.

Districts.	Tons of quartz crushed.	Total Yields.				Average yield per ton of 2,000 lbs.
		ozs.	dwts.	grs.	Value at $19.50 per oz.	
Caribou	29,960	20,335	10	19	$396,542	$13.23
Montague	13,828	28,417	0	10	554,133	40.07
Oldham	35,634	35,758	11	13	697,293	19.57
Renfrew	44,241	30,863	4	23	601,834	13.60
Sherbrooke..........	164,213	119,404	6	9	2,328,384	14.13
Stormont.	18,259	20,878	12	17	407,132	22.30
Tangier.............	28,695	19,014	11	6	370,782	12.92
Uniacke.	32,532	18,848	3	6	367,540	11.29
Waverley...........	89,572	53,391	7	14	1,041,131	11.62
Salmon River........	20,527	6,612	10	0	128,944	6.28
Brookfield	1,691	1,418	1	15	27,652	16.31
Whiteburn..........	2,386	5,104	16	21	99,544	41.71
Lake Catcha........	2,212	5,244	1	3	102,260	46.22
Rawdon	8,062	4,460	9	4	86,979	10.79
Wine Harbor.......	39,268	27,526	18	19	536,774	13.67
Darr's Hill..........	39,909	18,715	19	19	364,962	9.14
15 Mile Stream......	4,068	1,904	19	23	37,148	9.18
Unproclaimed.......	46,190	38,135	7	17	743,641	16.10
Totals.........	621,247	456,034	13	22	$8,892,675	$14.31

YEARLY PRODUCTION OF GOLD IN NOVA SCOTIA SINCE 1862.

TABLE F.

Year.	Tons of quartz crushed.	Total Yields.				Average yield per ton of 2,000 lbs.
		Quantity.			Value at $19.50 per oz.	
		Ozs.	Dwts.	grs.		
1862	6,473	7,275	8	0	$141,871	$21.91
1863	17,000	13,971	13	17	272,448	16.02
1864	21,431	20,017	18	13	390,349	18.11
1865	24,421	25,454	3	22	496,357	20.32
1866	32,157	25,204	13	2	491,491	15.28
1867	31,384	27,310	18	11	532,563	16.96
1868	32,259	20,541	6	10	400,555	12.41
1869	35,144	17,868	0	19	348,427	9.91
1870	30,824	19,866	5	5	387,392	12.56
1871	30,787	19,229	7	4	374,972	12.17
1872	17,089	13,094	17	6	255,349	14.81
1873	17,708	11,852	7	18	231,122	13.05
1874	13,844	9,140	13	10	178,244	12.87
1875	14,810	11,211	14	19	218,629	14.89
1876	15,490	11,978	13	18	233,585	15.08
1877	17,369	16,882	6	1	329,205	19.01
1878	17,989	12,577	1	22	245,253	13.63
1879	15,936	13,760	8	21	268,328	16.83
1880	13,997	13,221	13	22	257,823	18.42
1881	16,556	10,756	13	2	209,755	12.66
1882	21,081	14,107	3	20	275,090	13.04
1883	25,954	15,446	9	23	301,207	11.60
1884	25,186	16,079	14	10	313,554	12.44
1885	28,890	22,203	12	20	432,971	14.98
1886	29,010	23,362	5	15	455,564	15.70
1887	32,280	21,211	17	18	413,631	12.81
1888	36,178	22,407	3	10	436,939	12.08
Totals	621,247	456,034	13	22	$8,892,675	$14.31

No production is reported from Ontario, though sample shipments were made from several locations in the vicinity of Sudbury and it is believed small quantities of gold were extracted from some of the ores of Hastings Co., Ont. Ontario.

As in previous years a small amount of gold was obtained from the alluvions of the Saskatchewan River near Edmonton. North-West Territory and Yukon District.

Mr. R. G. McConnell reports a very poor season for gold washing on the Yukon and neighboring streams, and estimates the total output at $40,000 as against $120,000 last year.

NOTE.—The production of the Yukon district is given last year as $60,000; this has been corrected in this year's report, as the estimate is now considered to have represented only half the total output.

Quebec.

Gold was obtained from the alluvions of Mill River in Beauce County, and in Ditton Township in Compton County, and prospecting was carried on to a large extent on the Des Plantes and Cumberland Rivers.

The following table shows the output of gold from the Chaudière district as reported to the Mining Inspector up to 1886; the last two years being from direct returns received at this office. The table is, however, considered incomplete:—

PRODUCTION OF GOLD IN THE CHAUDIÈRE DIVISION SINCE THE YEAR 1877.

TABLE G.

Year.	Total output as reported.			Value at $17.50 per oz.
	ozs.	dwts.	grs.	
1877*	688	19	11	$12,057
1878	1024	19	5	17,937
1879	1884	2	7	32,972
1880	1895	13	4	33,174
1881	3237	15	17½	56,661
1882	976	15	0	17,093
1883	1016	1	21½	17,787
1884	498	9	3	8,720
1885	120	19	19	2,120
1886	227	9	22	3,981
1887	90	18	10	1,604
1888	203	12	16	3,563

* Second half of 1877 only.

Exports and imports.

The following table shows the exports of gold-bearing quartz, ore, dust, nuggets &c., for the years 1887 and 1888:—

TABLE 1.

Province.	1887.	1888.
Ontario	$ 6,650	......
Nova Scotia....................	321,379	$163,412
Manitoba..	......	50
British Columbia.............	592,300	464,696
Totals....................	$920,329	$628,158

The imports of gold in ore or bullion could not be ascertained, as they are not kept separate by the Customs Department, but included in "Coin and Bullion."

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GRAPHITE.

Production.

The amount of graphite mined and marketed during the year 1888 was 150 tons, valued at $1,200, all reported from mines in the vicinity of St. John, New Brunswick. There was a small quantity produced in the township of Buckingham, Ottawa County, Quebec; none of which was shipped. Prospecting was carried on to a small extent near St. John, N.B., and in various parts of Ontario.

Exports and imports.

The exports from New Brunswick for the last three years are given below, and show that the production has materially fallen off since 1886. No graphite has been exported from any of the other provinces during these years :—

1886	8142 cwts.	$3,586
1887	6294 "	3,017
1888	2700 "	1,080

In the following tables are shown the imports of the various products of plumbago :—

Imports of Raw and Manufactured Plumbago for the Years 1887 and 1888.

Table 1

Province.	Plumbago.		Manufactures of Plumbago.	
	1887.	1888.	1887.	1888.
Ontario	$1,473	$1,170	$5,140	$6,811
Quebec	534	2,859	4,033	8,811
Nova Scotia	61	1,066	1,739	4,831
New Brunswick	......	......	657	3,116
Prince Edward Island	......	......	44	17
Manitoba	......	35	96	517
British Columbia	35	118	232	465
Totals	$2,103	$5,248	$11,941	$24,568

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IMPORTS OF BLACKLEAD FOR THE YEARS 1887 AND 1888. Blacklead.

TABLE 2.

Province.	1887.	1888.
Ontario	$7,001	$3,811
Quebec	2,683	3,349
Nova Scotia............	2,121	......
New Brunswick........	3,559	2,254
Prince Edward Island....	745	315
Manitoba..............	165	......
British Columbia........	602	142
Totals......	$16,876	$9,871

IMPORTS OF LEAD PENCILS, IN WOOD OR OTHERWISE, FOR THE YEARS 1887 AND 1888. Pencils.

TABLE 3

Province.	1887.	1888.
Ontario	$33,458	$29,720
Quebec	21,263	20,218
Nova Scotia............	2,769	2,655
New Brunswick.........	3,028	3,017
Prince Edward Island....	......	85
Manitoba	833	1,180
British Columbia........	987	1,010
Totals.	$62,338	$57,885

GYPSUM.

Production.

Owing to inadequate returns having been received from Nova Scotia, the exports from that province, as shown by the Customs Department returns, have been taken as representing the total production; the output of the mines of the other provinces, according to direct returns, was 51,069 tons, valued at $58,964, this with the Nova Scotia exports gives a total production, during the year, of 175,887 tons valued at $179,393. This shows an increase over the previous year of 21,879 tons and $22,116, due, in a great measure, to New Brunswick, where there is an increase of 13,027 tons and $17.548.

The production by provinces is as follows:—

Province.	Tons.	Value.	Number of producers.	Number of hands.
New Brunswick.........	44,369	$ 48,764	4	232
Nova Scotia.............	124,818	120,429	?	?
Ontario	6,700	10,200	5	45

Plaster of Paris.

The returns show that plaster of paris to the extent of 59,885 bbls. was manufactured in Canada, having a value of $61,485. This was made principally at the Albert Manufacturing Company's works at Hillsboro', N.B., a small quantity being made in Ontario.

The other products of gypsum are "Alabastine," made at Paris, Ontario, and "Terra Alba" produced by the Albert Manufacturing Company.

Nova Scotia.

The Department of Mines of Nova Scotia reports the shipments from that province as follows:—

Windsor......................................	105,815 tons
Cheverie....................................	17,125 "
Lennox Passage.............................	2,000 "

and a small quantity from Walton and St. Anns Harbor.

New Brunswick.

The production from New Brunswick is altogether from Victoria and Albert Counties, divided as follows:—

Albert Co....................................	40,460 tons
Victoria Co..................................	3,909 "

The gypsum of Victoria County is principally ground and used as land plaster, and is to a great extent shipped to and used in Maine, U.S. Of that of Albert County, only some 3,000 tons are so used.

Ontario.

There has been a slight decrease in the production in Ontario owing to the introduction of high grade fertilizers, used in preference to land plaster, into which nearly all Ontario gypsum is manufactured. The producing mines are all situated on the Grand River between Paris and Gypsum Mines, the works being at Paris, Mount Healy, York, Caledonia, and Gypsum Mines.

Tables of exports and imports of crude and manufactured gypsum are given below :— Exports and imports.

EXPORTS OF CRUDE GYPSUM DURING THE YEARS 1887 AND 1888.

TABLE 1.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario	225	$337	670	$910
Nova Scotia.............	112,557	106,910	124,818	120,429
New Brunswick..........	19,942	39,295	20	50
Totals.............	132,724	$146,542	125,508	$121,389

The amount credited to Nova Scotia in above table includes probably the amount exported from New Brunswick, as there was the usual quantity shipped from that province to the United States, viz., about 40,000 tons.

IMPORTS OF GROUND GYPSUM DURING THE YEARS 1887 AND 1888.

TABLE 2.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario.................	5,506	$ 73	56,502	$261
Quebec	14,476	157	2,400	9
New Brunswick..........	1,900	7	31,500	70
Manitoba	......	......	300	4
British Columbia.........	15,000	138	......	......
Totals..............	36,882	$375	90,702	$344

IMPORTS OF PLASTER OF PARIS DURING THE YEARS 1887 AND 1888.

TABLE 3.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario.................	243,350	$1,282	310,407	$1,749
Quebec	2,458	13	400	2
Nova Scotia.............	650	6	2,600	17
New Brunswick..........	52,800	225	40,700	190
Prince Edward Island....	......	......	400	3
Manitoba	146,300	733	132,900	585
British Columbia........	363,607	3,363	390,913	3,682
Totals......	809,165	$5,622	878,320	$6,228

There was an importation of crude gypsum into Ontario during the year amounting to 1,184 tons, valued at $2,262.

IRON.

Iron ore was produced in Canada during 1888 to the extent of 78,-587 tons valued at $152,068, showing an increase over 1887 of 2,257 tons and $5,871. Iron ore.

By Provinces the production is as follows :—

Province.	Tons.	Value.	No. of hands employed.	No. of producers.	No. of mines producing.
Nova Scotia....	42,611	$74,509	176	3	3
Quebec	10,710	24,899	(?)	2	2
Ontario	16,894	37,710	70	1	4
British Columbia	8,372	14,950	12	1	1
Totals........	78,587	$152,068	....	7	10

According to the report of the Department of Mines of Nova Scotia the production is divided as follows :— Nova Scotia.

Londonderry, East and West mines	41,619 tons
East River, Pictou	342 "
Brookfield	650 "

Prospecting was carried on in various parts of the province.

The following are the total yearly productions of iron in this province since 1876 :—

	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

The furnaces at Three Rivers and Drummondville consumed during the year 10,710 tons of bog iron ore. Work was carried on at the Bristol mine in Pontiac County, but no shipments were made during the year. Quebec.

Ontario.

Iron mining in Ontario was confined to the district penetrated by the Kingston and Pembroke Railway, and was carried on by the Kingston and Pembroke Iron Mining Company, who shipped ore from four different mines along the line of railway. This company did a considerable amount of development work at some four or five other properties in their possession. Their production this year shows a small increase over last year, viz., 1,416 tons. There were no other producers in Ontario in 1888.

British Columbia.

Operations were resumed at the Texada Island mine in July, and as a result 8,372 tons were mined and shipped during the last half of the year to Irondale, W.T., where 4,350 tons of pig iron and car wheels were made from this Canadian ore.

The following table shows the exports of iron ore for the last three years:—

Exports and imports.

EXPORTS OF IRON ORE FROM CANADA DURING THE LAST THREE YEARS.

TABLE 1.

Province.	1886.		1887		1888.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario...............	16,032	$51,175	12,244	$38,990	13,161	$36,397
Quebec...............	2	10	38	119	10	380
British Columbia.......	3,130	7,225	1,410	3,525	7,300	18,400
Totals..............	19,164	$58,410	13,692	$42,634		$55,177

No iron ore is imported.

Pig Iron.

The following table is a summary of the production of pig iron in Canada during 1888, comparatively with that of 1887:—

PIG IRON PRODUCTION, AND CONSUMPTION OF ORE, FUEL, ETC., IN 1887 AND 1888.

TABLE A.

Number of Furnaces in blast, 4.

Production and Consumption.		1887.		1888.	
		Quantity.	Value.	Quantity.	Value.
Pig Iron made.............	Tons.	24,827	$366,192	21,799	$313,235
Iron Ore consumed.........	"	60,434	130,808	54,956	102,343
Fuel consumed.	Charcoal—Bush.	940,400	48,593	804,286	41,800
	Coke, Tons.	30,248	89,123	28,031	82,986
	Coal, "	3,333	5,877	2,197	4,709
Flux consumed...........	"	17,171	17,500	16,857	16,533

Practically no pig iron was exported during the year.

In the table following are given the imports of pig iron for the years 1887 and 1888, with amount of duty paid thereon:—

IMPORTS OF PIG IRON FOR THE YEARS 1887 AND 1888.

TABLE 2.

Province.	1887.			1888.		
	Tons.	Value.	Duty.	Tons.	Value.	Duty.
Ontario........	19,450	$298,083	$61,291	26,939	$386,945	$107,748
Quebec	25,317	263,098	77,903	35,177	358,039	140,706
Nova Scotia....	1,197	16,171	3,613	3,310	36,432	13,242
New Brunswick.	5,981	36,771	5,362	2,321	51,587	9,282
British Columbia	557	5,981	1,211	586	7,602	2,348
Totals......	48,250	$620,104	$149,380	68,333	$840,605	$273,326

The imports for 1888, as shown in above table, include pig iron, iron kentledge, and cast scrap iron, making comparison with the previous year impossible as the amount of scrap iron included is quite considerable. From information received at this office there has been, however, no falling off in the imports of pig iron during 1888.

Iron and Steel. Direct returns were received from the Nova Scotia Steel and Forge Company, Londonderry Iron Works, and five rolling mills and forges. Returns were not received from five rolling mills that were known to have been working, thus making our returns very incomplete. The following is a summary of returns received, and shows a large increase over last year's production as returned to us; notwithstanding that returns were last year received from a greater number of producers:—

IRON AND STEEL PRODUCTION, AND CONSUMPTION OF SCRAP AND OTHER IRON AND STEEL, ETC., IN 1887 AND 1888.

TABLE B.

No. of reheating furnaces	36
No. of trains of rolls	13
No. of steam hammers	5

Article made or consumed.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Iron, all sorts, made	31,527	$1,087,728	44,949	$1,592,931
Steel, all sorts, made	7,326	331,[illegible]99	9,553	472,611
Puddled iron bars, consumed	2 312	58,700	6,256	148,715
Scrap and all other iron, consumed	40,274	636,487	42,083	656,448
Scrap and all other steel, consumed	8,407	149,177	11,567	260,323
Fuel, consumed	58,112	146,986	64,350	161,566

Number of hands in 1887, about 850; in 1888, 1,155.

Exports and Imports. The following tables give the exports and imports of iron and steel goods:—

EXPORTS OF IRON AND STEEL GOODS, MANUFACTURED IN CANADA, DURING 1887 AND 1888.

TABLE 3.

Province.	Pig Iron.	Scrap Iron.	Iron Stoves.	Iron Castings.	Iron, all other and hardware.	Steel and manuf'r's of.	1888. Total.	1887. Total.
Ontario	$10	$6,958	$1,145	$ 7,934	$13,267	$ 5,952	$ 35,266	$95,930
Quebec	.....	224	564	13,675	49,665	45,958	110,086	82,191
Nova Scotia....	......	......	1,503	819	14,507	12,349	29,178	64,276
New Brunswick.	......	.....	......	5	6,897	......	6,902	7,467
Prince Ed. Island	.	......	......	......	462	......	462	61
Manitoba..	......	......	204	......	134	967	1,305	1,296
British Columbia.	......	115	...	......	825	75	1,015	.. ...
Totals	$10	$7,297	$3,416	$22,433	$85,757	$65,301	$184,214	$251,221

IMPORTS OF IRON IN SLABS, BLOOMS, LOOPS, PUDDLED BARS, ETC., FOR THE YEARS 1887 AND 1888.

TABLE 4.

Province.	1887.			1888.		
	Cwt.	Value.	Duty.	Cwt.	Value.	Duty.
Ontario................	11,332	$8,995	$899	113	$488	$51
Quebec	348,557	285,233	50,520	103,176	79,764	46,428
Nova Scotia............	1,116	8,552	855	......	......	......
New Brunswick.........	6,548	3,948	395	......	......	......
Totals..............	367,553	$306,728	$52,669	103,289	$80,252	$46,479

IMPORTS OF SCRAP IRON AND SCRAP STEEL FOR THE YEARS 1887 AND 1888.

TABLE 5.

Province.	1887.			1888.		
	Cwt.	Value.	Duty.	Cwt.	Value.	Duty.
Ontario	19,775	$ 81,091	$11,425	85,904	$ 52,726	$ 9,878
Quebec	252,042	161,167	13,623	324,428	217,196	32,442
Nova Scotia	84,349	43,904	5,275	33,751	18,010	3,300
New Brunswick	54,718	40,169	3,331	85,169	49,786	8,516
British Columbia	440	262	......	20	20	2
Totals	411,324	$326,593	$33,654	529,272	$337,738	$54,138

It must be understood that in the imports for 1887, as shown in above table, the duty was collected only in the latter half of the year, and does not show fairly in comparison with the duty collected in 1888.

IMPORTS OF FERRO-MANGANESE, FERRO-SILICON, SPEIGEL, STEEL BLOOM ENDS AND CROP ENDS OF STEEL RAILS, FOR THE YEARS 1887 AND 1888.

TABLE 6.

Province.	1887.			1888.		
	Tons.	Value.	Duty.	Tons.	Value.	Duty.
Ontario	......	......	......	2	$ 37	$ 4
Quebec	1,121	$16,772	$2,242	559	9,239	1,118
Nova Scotia	274	3,531	549	2,957	34,506	5,914
New Brunswick	277	4,385	553	30	493	60
Totals	1,672	$24,688	$3,344	3,548	$44,275	$7,096

The following tables show the imports of the various manufactures of iron and steel into Canada during the year 1888. There is but slight change in the classification since last year so that the comparisons given are considered quite correct:—

IMPORTS OF IRON (ARTICLES WHOLLY OR PRINCIPALLY MADE OF IRON) DURING THE YEAR 1888.

TABLE 7.

Article.	Quantity.	Value.	Duty.
Bar iron, rolled or hammered......cwt.	367,270	$446,174	$238,839
Boiler plate and other plate........cwt.	58.022	82,186	37,758
Tacks, brads and sprigs..............	....	6,379	1,379
Band and hoop iron..............cwt.	80,157	113,576	39,305
Iron bridges and structural iron work.lbs.	1,900,576	52,181	24,681
Nails, spikes and sheathing nails...lbs.	96,842	9,168	1,831
Nails and spikes, cut..............lbs.	570,467	20,827	9,157
Nails and spikes.................cwt.	238,294	9,255	2,384
Swedish rolled iron nail rods.......cwt.	18,707	36,171	7,233
Tubing of every description...........	....	529,164	154,357
Totals..................	....	$1,305,081	$516,924
1887 Totals..............	....	$1,584,529	$438,338

IMPORTS OF STEEL.

TABLE 8.

Articles.	Quantity.	Value.	Duty.
Wire of spring steel, coppered or tinned...cwt.	4,917	$ 10,648	$ 2,127
Steel ingots, blooms, slabs, billets, bars, etc., valued at 4 cts. or less, per lb..........cwt.	213,560	318,387	127,990
Steel, except the above................cwt.	89,602	77,000	35,840
Steel, of greater value than 4 cts. per lb...cwt.	65,983	235,674	29,461
Axes		7,558	2,643
" Chopping		6,906	2,351
Saws		73,527	22,075
Locomotive tires. ....cwt.	31,035	85,968	Free.
Home spring steel for mattresses..........lbs.	497,282	20,502	"
Steel for files.........................cwt.	3,191	15,897	"
" " skates.........................cwt.	901	3,514	"
" " saws and straw cutters..........cwt.	11,596	77,826	"
" " mower and reaper knives........cwt.	2,414	11,897	"
" " knobs, locks and cutlery ....cwt.	3,977	7,056	"
" " corsets, shoes and clock springs..cwt.	2,171	12,003	"
" " spades and shovels..............cwt.	2,192	9,608	"
Totals..................................	....	$973,971	$222,487
1887, Totals..............................	....	$773,821	$143,381

IMPORTS OF IRON AND STEEL FOR THE YEAR 1888.

TABLE 9.

Articles.	Quantity.	Value.	Duty.
Axles and springs of iron or steel........cwt.	7,214	$23,907	$13,239
Chains..............................cwt.	18,450	44,417	2,013
Iron or steel rivets, bolts, nuts, etc.......lbs.	130,987	6,848	4,327
Plate of iron and steel combined..........cwt.	18,918	15,764	4,726
Rolled iron or steel angles, etc...........lbs.	1,598,074	26,746	10,574
Rolled iron or steel beams, etc...........cwt.	87,536	119,607	15,049
Rolled iron or steel beams for manufacture of bridges..........................cwt.	59,089	66,579	10,822
Screws, iron or steel, "wood screws"......lbs.	67,575	12,179	5,437
Sheet iron, including Canada plate.......cwt.	346,600	660,447	82,570
Wire fencing, barbed, iron or steel........lbs.	120,089	4,626	1,799
Wire fencing, buckthorn, strip etc........lbs.	27,878	919	315
Wire, iron or steel, 15 gauge and coarser..cwt.	82,526	178,341	44,626
Wire rope, iron or steel, N.E.S...........cwt.	4,520	27,945	6,979
Wrought iron or steel nuts, bolts, etc......lbs.	1,390,437	73,714	32,443
Rolled round wire rods.................lbs.	169,499	222,916	Free.
Iron or steel beams for composite ships....lbs.	28,052	55,891	"
Wire, iron or steel, galvanized, 16 gauge or smaller ....lbs.	1,302,379	67,743	"
Wire rigging for ships..................lbs.	3,854	16,193	"
Wire, iron or steel for manf. of wire cloth..lbs.	239,472	11,143	"
Manufactures of iron or steel, N.E.S.......lbs.	....	723,117	217,132
Total..............................	....	$2,359,042	$452,051
1887 Total..........................	....	$1,704,778	$287,563

IMPORTS OF CASTINGS AND FORGINGS DURING THE YEAR 1888.

TABLE 10.

Article.	Quantity.	Value.	Duty.
Cast iron vessels, plates, &c............	....	$173,715	$ 52,851
Cast iron pipe....................cwt.	211,677	260,333	140,375
Forgings of iron or steel..........lbs.	531,789	19,758	8,808
Malleable iron castings..............	....	65,683	20,063
Stoves	....	18,886	4,953
Anchors	....	11,186	Free.
Totals........................	....	$549,561	$227,050
1887 Totals....................	....	$503,318	$169,279

IMPORTS OF RAILROAD IRON AND STEEL DURING THE YEAR 1888.

TABLE 11.

Article.	Quantity.	Value.	Duty.
Railway bars.................tons.	1,219	$ 39,547	$ 9,322
" fishplates ....tons.	3,338	79,652	40,005
Steel rails.....................cwt.	1,321,239	1,466,804	Free.
Totals........................	....	$1,586,003	$49,327
1887 Totals....................	....	$1,580,316	$30,233

The other manufactures of iron and steel, not enumerated in the foregoing tables, have been extracted from the report of the Customs Department, and are found to amount during the fiscal year of 1888, to about $3,700,000, the duty on which being about $1,150,000.

This value is inclusive of all other materials used in their manufacture, and of very highly finished articles of iron and steel, and does not therefore give any index to the amount of raw iron or steel consumed.

If this amount be taken as representing approximately the import during the calendar year, the total imports of iron and steel during the year will be found to be about $12,000,000 as follows:—

SUMMARY TABLE OF IMPORTS OF IRON AND STEEL FOR THE YEARS 1887 AND 1888.

TABLE 12.

Article.	1887.		1888.	
	Value.	Duty.	Value.	Duty.
Pig iron................	$620,104	$149,380	$840,605	$273,326
Slabs, blooms, etc........	306,728	52,669	80,252	46,479
Scrap iron and steel......	326,593	33,694	337,738	54,138
Ferro-manganese, etc....	24,688	3,344	44,275	7,096
"Iron"..	1,584,529	438,338	1,305,081	516,924
"Steel"..	773,821	143,381	973,971	222,487
"Iron and steel"........	1,704,778	287,563	2,359,042	452,051
Castings and forgings.....	503,318	169,279	549,561	227,050
Railroad iron and steel...	1,580,316	30,238	1,586,003	49,327
Highly finished articles about..............	3,400,000	940,000	3,700,000	1,150,000
Totals............	$10,824,875	$2,247,886	$11,776,528	$2,998,878

MANGANESE.

Production.

The production of manganese in 1888 amounted to 1,801 tons, with an approximate value of $47,944. This shows are increase over the year previous of 556 tons and $4,286, due altogether to the production in New Brunswick. The output of Nova Scotia shows a decrease of 200 tons, and as only Nova Scotia and New Brunswick produced manganese during the year the increase in the production of New Brunswick is therefore 756 tons.

Nova Scotia.

According to the report of the Inspector of Mines of Nova Scotia, the production is altogether from Tenny Cape and Onslow, and the reason of the decrease is the low price of the ore which is usually of a very high grade.

The production is as follows:—

Tenny Cape	42 tons	$2,120
Cheverie	6 "	240
Walton	18 "	1,100
East Mountain	40 "	3,000
	106 tons	$6,460
No. of hands employed about		30

New Brunswick.

The production is to a large extent that of the Markhamville mines which still continue to ship high grade ore, principally to the United States. Several small operators shipped from various points in King's and St. John counties, and prospecting and development work was carried on in the neighborhood of Sussex, King's County, and St. Martins and Quaco, in St. John County. A trial shipment of bog manganese was made from a deposit near Hillsboro', Albert County. This latter is suitable for the manufacture of steel, and as the deposit covers a very large area, and is adjacent to the Albert Railway, there seems every probability of a large trade in this mineral being developed.

The tables of exports and imports are given below:—

Exports and Imports.

EXPORTS OF MANGANESE ORE DURING 1887 AND 1888.

TABLE 1.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Nova Scotia	578 (*a*)	$14,240	87	$ 5,759
New Brunswick	837	20,562	1,094	16,073
Totals	1,415	$34,802	1,181	$21,832

(*a*) A certain quantity from Cornwallis, should more correctly be classed as an ochre.

IMPORTS OF OXIDE OF MANGANESE DURING THE YEARS 1887 AND 1888.

TABLE 2.

Province.	1887.		1888.	
	Lbs.	Value.	Lbs.	Value.
Ontario....	18,733	$ 903	18,893	$ 739
Quebec	48,977	2,171	34,091	1,533
Nova Scotia............	1,173	79	2,144	151
British Columbia........	1,010	16	10	1
Totals.............	69,893	$3,169	55,138	$2,424

MICA.

Production.

Complete returns of the production of mica have not been received. The total amounts approximately to 29,025 lbs., valued at $30.207. This shows an increase over 1887 of 6,942 lbs. and $391. The increase is altogether due to the output of Ontario, that of Quebec being about 25 per cent. lower than last year.

The production as reported to this office is for the last three years as follows:—

1886........	20,361 lbs.	..	$29,008	..	Average price	$1.42
1887........	22,083 "	..	29,816	..	" "	1.35
1888........	29,025 "	..	30,207	..	" "	1.04

The increase in the quantity produced is no doubt due to their being a larger market found for a lower grade of mica; this will also explain the depreciation in the average price.

Exports.

The exports of cut mica during the year amounted to 21,851 lbs., valued at $21,127, all of which went to the United States. There was an exportation of 362,630 lbs of ground mica with a declared value of $2,436, the greater part of which also went to the United States. This will make a total exportation during the year of $23,563 of which $23,313 was shipped to the United States.

MINERAL PIGMENTS.

The production of mineral pigments in Canada during 1888 was as follows:— Baryta, Mineral paint and Whiting.

Product.	Tons.	Value.	Where Produced.
Baryta..........................	1,100	$3,850	N. S.
Mineral paint........................	397	7,900	Que. and Ont.
Whiting...........................	30	240	Ont.

In the above there is an increase in Baryta of 700 tons and $1,450, and in mineral paint of 297 tons worth $6,400, while in whiting there is a decrease of 45 tons and in value of $360.

There were no exports of any of the above minerals. The imports of various pigments and allied substances are given below:—

IMPORTS OF MANUFACTURED BARYTA DURING THE YEARS 1887 AND 1888. Imports of Baryta.

TABLE 1.

Province.	1887.		1888.	
	Cwt.	Value.	Cwt.	Value.
Ontario.................	2	$ 24	625	$427
Quebec.................	....	....	17,810	756
New Brunswick..........	200	252	....	....
Totals..............	202	$276	18,435	$1,183

Imports of Paints.

IMPORTS OF PAINTS.

TABLE 2.

Variety.	Lbs.	Value.
Fire-proof paint, dry	170,683	$ 2,437
Paint ground in oil or any other liquid	....	93,349
White and red lead and orange mineral, dry	6,539,247	246,419
White lead in pulp, not mixed with oil	....	13,374
Ochres, dry, ground or unground, washed or unwashed, not calcined	1,407,006	17,070
Zinc, dry white	759,598	24,570
Other paints and colors, N.O.P.F	....	87,404

Imports of Whiting.

IMPORTS OF WHITING.

TABLE 3.

Province.	1887.		1888.	
	Cwt.	Value.	Cwt.	Value.
Ontario	8,868	$ 3,325	7,104	$ 2,817
Quebec	52,949	13,659	64,408	15,886
Nova Scotia	2,689	1,027	2,801	958
New Brunswick	2,494	1,038	2,477	866
Prince Edward Island	464	190	485	174
Manitoba	....	....	1	1
British Columbia	274	121	141	145
Totals	67,738	$19,360	77,417	$20,847

Imports of Chalk.

Table 4.

Imports of Chalk.

Province.	1887.	1888.
Ontario....	$2,483	$2,757
Quebec	1,864	2,060
Nova Scotia..........	213	257
New Brunswick.........	441	584
Prince Edward Island....	37	9
Manitoba	164	216
British Columbia........	21	53
Totals...............	$5,223	$5,936

Imports of Litharge.

Table 5.

Imports of Litharge.

Province.	1887.		1888.	
	Cwt.	Value.	Cwt.	Value.
Ontario	6,354	$21,034	3,793	$17,459
Quebec..................	2,353	7,440	3,889	13,832
Nova Scotia............	2	9	......	......
New Brunswick.........	11	74	2	9
Manitoba	33	122	20	88
British Columbia........	3	26	?	44
Totals...............	8,756	$28,705	7,704	$31,432

MISCELLANEOUS.

Production.

The following table gives the production of various minerals and products for the year, comparatively with 1887 :—

Product.	1887.		1888.	
	Quantity.	Value.	Quantity.	Value.
Lead (fine, contained in ore)...	204,800 lbs.	$9,216	674,500 lbs.	$27,472
Moulding sand..............	160 tons.	800	169 tons.	845
Platinum....	1,400 ozs.	5,600	1,500 ozs.	6,000
Soapstone......	100 tons.	800	140 tons.	280
Mineral water...............	......	....	124,850 galls.	11,456
Glass and Glassware..........	......	....	......	375,000

Lead.

The lead is altogether the production of British Columbia, and includes principally the results of certain sample shipments from Kootenay and Illecillewaet Districts, and from the Monarch Mine at Field.

Small quantities of lead are believed to be saved from the silver ores of Port Arthur District in Ontario, but of these no return could be had. Development work was carried on to a large extent at Wright's mine on Lake Temiscamingue, Quebec, where a small smelting furnace has been erected and all arrangements made to produce large quantities of matte. At Petrolea, Ontario, Mr. William Wilson has erected a small smelting plant. He purposes reducing the lead contained in the refuse from the oil refiners. The lead is probably a sulphide, having been used in the first place as litharge in the refining of the distillates into illuminating oil. This refuse makes an excellent flux, and Mr. Wilson purposes working Canadian ores in connection with it.

Moulding Sand.

The moulding sand shown in foregoing table is altogether the production of Nova Scotia, though large quantities are used from the other provinces, of which no returns were received.

Platinum.

The platinum production is that of Granite and adjacent creeks in the Similkameen Division, British Columbia, the only district in Canada where it occurs in sufficient quantities to be considered a commercial article. It occurs with the gold in the placers of the above division, and contains generally a small percentage of iron, osmium and iridium. The production is taken from the report of Mr. Tunstall, Gold Commissioner for Similkameen Division, B.C.

The soapstone is altogether the production of the Asbestus mines of the Eastern Townships or in their vicinity, where it occurs in considerable quantities. Soapstone.

The quantity of mineral water shown, viz:—124,850 gallons includes only that sold and shipped, in bulk or otherwise. Immense quantities are of course annually used at the different sanitariums in Canada, and of which not even an approximation could be obtained. Mineral Water.

The amount of glass and glassware shown in foregoing table does not by any means represent the total yearly production which would probably reach $700,000. Returns were not received from all the works, unfortunately rendering this statement incomplete. Glass and Glassware.

The exports of lead were too small to be of importance.

The exports of glass and glassware amounted to $1.739 against $1,-030 for the year previous. Exports and Imports.

The imports of lead, platinum, zinc, tin, mercury, spelter, mineral water, and glass and glassware are given below:—

IMPORTS OF LEAD.

TABLE 1.

Articles.	1887.		1888.	
	Cwts.	Value.	Cwts.	Value.
Lead, old, scrap and pig......	69,866	$182,059	71,911	$213,077
" bars, blocks and sheets..	20,048	58,283	10,588	33,737
" pipe....	1,783	6,322	1,229	4,905
" shot........	1,260	4,204	805	2,809
" mfrs. of N.O.P.F........	....	6,772	......	5,836
Totals..............	....	$257,640	......	$260,364

IMPORTS OF PLATINUM.

TABLE 2.

Province.	1887.		1888.	
	Ozs.	Value.	Ozs.	Value.
Ontario, wire............	207	$1,555	220	$1,202
Quebec, "	4	68	74	636
" pans, retorts, etc..	....	....	....	12,268
New Brunswick.........	*64	13	....	......
British Columbia.........	....	....	....	2
Totals.............	275	$1,636	294	$14,108

* Returns for New Brunswick considered incorrect.

IMPORTS OF ZINC IN BLOCKS, PIGS AND SHEETS.

TABLE 3.

Province.	1887.		1888.	
	Cwts.	Value.	Cwt.	Value.
Ontario.................	5,981	$25,947	4,428	$16,357
Quebec.....	10,731	38,081	8,551	35,052
Nova Scotia.............	2,221	6,668	1,049	4,294
New Brunswick..........	2,022	7,890	1,304	5,371
Prince Edward Island....	154	578	46	189
Manitoba......	825	2,820	....	....
British Columbia.........	67	379	196	933
Totals.	22,001	$83,263	15,574	$62,196

IMPORTS OF MANUFACTURES OF ZINC.

TABLE 4.

Province.	1888.
Ontario..................	$3,823
Quebec......	1,271
Nova Scotia..............	122
New Brunswick..........	371
Manitoba.................	122
British Columbia..........	534
Totals.......... ...	$6,243

IMPORTS OF SPELTER IN BLOCKS AND PIGS.

TABLE 5.

Province.	1888.	
	Cwt.	Value.
Ontario..................	628	$ 2,767
Quebec	8,982	35,756
Nova Scotia..............	109	539
New Brunswick...........	371	1,808
British Columbia.........	21	10
Totals................	10,111	$40,880

IMPORTS OF TIN, IN BLOCKS, PIGS AND SHEETS, AND TIN-FOIL.

TABLE 6.

Province.	1887.			1888.		
	Blocks, pigs and bars.	Plates, and sheets.	Tin-foil.	Blocks, pigs and bars.	Plates and sheets.	Tin-foil.
Ontario	$78,908	$245,100	$ 8,774	$ 87,912	$244,445	$ 8,535
Quebec	83,562	286,670	13,289	147,480	305,742	16,582
Nova Scotia	21,260	74,879	832	38,917	86,981	199
New Brunswick	12,744	21,076	113	14,524	29,212	222
Prince Edward Island	4,114	6,731	2	3,674	7,363	....
Manitoba	....	5,246	119	....	1,592	62
British Columbia	21,092	54,210	16	28,151	119,768	87
Totals	$221,680	$693,912	$23,145	$320,658	$795,103	$25,687

IMPORTS OF TIN CRYSTALS AND TINWARE.

TABLE 7.

Province.	Tinware.	Tin Crystals.
Ontario	$39,991	$245
Quebec	22,821	170
Nova Scotia	7,287	....
New Brunswick	8,253	536
Prince Edward Island	459	....
Manitoba	5,019	....
British Columbia	4,208	....
Totals	$88,038	$951

IMPORTS OF MERCURY.

TABLE 8.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario	25,062	$12,778	8,088	$4,702
Quebec	2,307	1,210	3,239	1,782
Nova Scotia.............	1,851	1,222	4,992	728
New Brunswick.........	......	......	10	6
Manitoba	3	2	1	1
British Columbia........	1,866	1,174	2,161	1,111
Totals...............	31,089	$16,386	18,491	$8,330

IMPORTS OF GLASS AND GLASSWARE.

TABLE 9.

Description.	1887.	1888.
Carboys, demijohns, bottles and decanters, flasks and phials, telegraph and lightning rod insulators, jars and glass balls, and cut, pressed, or moulded table ware	$303,002	$175,471
Flasks and phials of eight ounces capacity and over, telegraph and lightning rod insulators, jars and glass balls, and cut, pressed, and moulded table ware	99,099	185,406
Lamp and gas-light shades, lamps and lamp-chimneys, side-lights, and head-lights, globes for lanterns, lamps, and gas-lights	214,691	188,217
Ornamental, figured, and enamelled stained glass	4,446	8,311
Stained, tinted, painted, and vitrified glass and stained glass windows, figured enamelled, and obscured white glass	13,419	12,306
Common and colorless window glass	302,122	351,550
Coloured glass, not figured, painted, enamelled, or engraved	3,426	1,958
Photographic dry plates	4,221	9,646
Plate glass, not coloured, in panes not over 30 sq. feet.	56,456	75,777
" " " over 30 and not over 70 sq. feet	55,136	48,885
" " " over 70 sq. ft	69,703	73,684
Silvered plate glass	8,366	7,911
Porcelain shades, imitation	12,488	10,216
All other mfrs. of glass, N. O. P. F	87,947	69,926
Totals	$1,234,522	$1,219,264

IMPORTS OF MINERAL WATER.

TABLE 10

Province.	1888.
Ontario	$ 4,461
Quebec..................	19,240
Nova Scotia..............	427
New Brunswick...........	1,023
Prince Edward Island.....	21
Manitoba	42
British Columbia..........	1,937
Total...............	$27,151

PETROLEUM.

Production and inspection.

The amount of Canadian oil (refined petroleum and naphtha) inspected during the year 1888 was as follows :—

217,298	packages at..................	10	cts. inspection fee
16	" "	5	" " "
23,900	" "	2½	" " "

Assuming that the packages contain 42, 10, and 5 gallons respectively, there is an approximate inspection of 9,246,176 gallons, this being converted into crude equivalent, at 38 gallons refined for every 100 crude, gives as a result 695,203 bbls. of 35 imp. galls. The average price for the year was $1.03 per barrel, therefore the value may be considered to be approximately $716,059.

The statistics of the industry derived from direct returns from refiners are as follows :—

PRODUCTION OF CANADIAN OIL REFINERIES IN 1887 AND 1888.

TABLE A.

Products.	1887.		1888.	
	Quantity.	Value.	Quantity.	Value.
Illuminating oils...galls.	10,387,825	$991,290	9,833,228	$1,059,614
Benzine and naphtha. "	344,570	31,447	492,886	29,354
Paraffine oils .... "	6,793,461 (Paraffine oils, Gas oils, Lubricating oils and tar)	240,851	690,729	82,238
Gas oils............ "			3,107,306	68,477
Lubricating oils and tar............. "			3,284,273	132,601
Paraffine wax........lbs.	400,036	24,521	585,651	29,175
Totals	....	$1,288,109	....	$1,401,459

CONSUMPTION OF CANADIAN OIL REFINERIES IN 1887 AND 1888.

TABLE B.

Article.	1887.	1888.
Crude Petroleum...galls.	26,737,668	22,947,369
Sulphuric Acid......lbs.	3,215,410	4,082,076
Soda.............. "	331,898	317,436
Litharge .... "	496,163	520,793
Sulphur .... "	96,816	104,479

The returns of the three tanking companies are as follows :— Tanking Co's.

Stocks, 1st January, 1888......................	217,793 $\frac{8}{35}$	bbls.
Quantity of oil received......................	464,014 $\frac{20}{35}$	"
" " delivered....................	383,093 $\frac{22}{35}$	"
Stocks, 31st December, 1888..................	298,714 $\frac{6}{35}$	"

It has been found impossible to obtain returns of stocks carried over by the different refiners, but it is supposed that the amounts carried over at the beginning and end of the year are equal.

The amount of crude oil received at the refineries was 22,492,499 gallons or 642,643 barrels, and as the returns of the tanking companies show a net balance of 80,921 barrels at the end of the year, it may be stated that there was a production during 1888 of 733,564 barrels valued at $755,571.

The following table kindly furnished by Mr. Jas. Kerr, Secretary of the Petrolea Oil Exchange, shows the business and ruling prices of the exchange for the year. It is followed by a list of the average closing prices for the last three years :— Prices of crude oil.

PETROLEA OIL EXCHANGE.

Crude Petroleum Business for the Year 1888.

Month.	Opening price.	Highest price.	Lowest price.	Closing price.	Average closing price.	Average price.	Sales (Barrels.)
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	
January	.75½	.75½	.71	.73¼	.73⅓	.76⅔	76,080
February....	.72¾	.75	.71½	.74½	.73⅔	.76½	43,866
March	.75	1.08	.75	1.08	.89¾	.98⅓	62,703
April.	1.11	1.22	1.11	1.15½	1.17	1.19¼	62,056
May	1.14	1.15	1.04½	1.09	1.08	1.15¾	37,730
June	1.10	1.13	1.07	1.11¾	1.11¼	1.13¼	48,144
July..	1.07	1.09	1.05¼	1.06½	1.08¼	1.09½	22,989
August	1.06	1.06	1.00	1.06	1.04½	1.06½	25,221
September ..	1.07	1.09	.99¾	1.00	1.02¾	1.03¾	13,721
October	.98¾	1.14	.98¾	1.12	1.04	1.05	18,529
November...	1.09¾	1.20½	1.09¾	1.20½	1.15	1.19½	51,320
December ...	1.19½	1.23½	1.18	1.23	1.21⅞	1.20⅓	53,648
Year 1888...	.75½	1.23½	.71	1.23	1.02⅔	1.03¾	516,007
Puts and calls	....	....	....	....	....	....	114,500
				Total Business...		....	630,507

AVERAGE CLOSING PRICE OF CRUDE OIL ON PETROLEA OIL EXCHANGE.

Month.	1886.	1887.	1888.
	$ cts.	$ cts.	$ cts.
January	.88¼	.84¾	.73⅓
February	.88¼	.81¾	.73⅜
March	.89½	.76¾	.89¾
April	.90	.75	1.17
May	.90	.69¼	1.08
June	.90	.67¼	1.11¼
July	.80	.67½	1.08¼
August	.75½	.71¼	1.04½
September	75	.81	1.02¾
October	.84¼	.77¼	1.04
November	.93¾	.72¼	1.15
December	.97	.76¼	1.21⅞
Year	.86¾	.78	1.02⅜

The exports for the years, from 1873 to 1888 inclusive, and the imports for 1887 and 1888 are given below:— Exports and imports.

EXPORTS OF CANADIAN PETROLEUM FROM 1873 TO 1888.

TABLE 1.

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
Totals...........	13,086,280	$2,442,269

IMPORTS OF CRUDE AND REFINED PETROLEUM DURING THE YEARS 1887 AND 1888.

TABLE 2.

Province.	1887.		1888.	
	Gallons.	Value.	Gallons.	Value.
Ontario	1,688,611	$174,768	1,709,142	$168,770
Quebec.	805,197	69,527	918,760	84,864
Nova Scotia............	762,346	63,096	763,510	62,375
New Brunswick.........	820,639	61,697	776,920	64,668
Prince Edward Island....	173,852	13,793	215,899	15,761
Manitoba.	15,486	1,905	254,976	35,557
British Columbia........	198,913	44,826	213,359	49,775
Total................	4,465,044	$429,612	4,852,566	$481,770

The following table shows the amount of refined petroleum and naphtha imported and inspected during 1887 and 1888:—

1887.................................... 1,511,433 gallons
1888.................................... 1,789,044 "

Subtracting these two amounts from the total imports shown in above table, there will be found to be an importation as follows of other oils, principally crude and lubricating:—

1887.................................... 2,953,611 gallons
1888.................................... 3,063,522 "

PHOSPHATE AND MANUFACTURED FERTILIZERS.

The total amount of phosphate (apatite) mined and marketed during the year was 22,485 tons valued at $242,285, showing a decrease of 1,205 tons since last year. This decrease is altogether due to Ontario, there being a slight increase in the mines of the province of Quebec.

The production during 1888 is divided as follows :—

	Tons.	No. of Producers.	No. of Men Employed.
Quebec mines............	20,396	10	about 550
Ontario "	2,089	4	" 50

In regard to the number of men employed it must be understood that they were in many cases employed for only part of the twelve months.

Exports and imports.

The exports of phosphate since 1878 are given in the following table :—

Exports of Phosphate since 1878.

Table 1.

Year.	Ontario.		Quebec.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1878.	824	$12,278	9,919	$195,831	10,743	$208,109
1879.	1,842	20,565	6,604	101,470	8,446	122,035
1880.	1,387	14,422	11,673	175,664	13,060	190,086
1881.	2,471	36,117	9,497	182,339	11,968	218,456
1882.	568	6,338	16,585	3 ·2,019	17,153	338,357
1883.	50	500	19,666	427,168	19,716	427,668
1884.	763	8,890	20,946	415,350	21,709	424,240
1885.	434	5,962	28,535	490,331	28,969	496,293
1886.	644	5,816	19,796	337,191	20,440	343,007
1887.	705	8,277	22,447	424,940	23,152	433,217
1888.	2,643	30,247	16,133	268,362	18,776	298,609
Total...	12,331	$149,412	181,801	$3,350,665	194,132	$3,500,077

These exports do not of a necessity show the export trade of either province, as a large quantity of Ontario phosphate is cleared from the port of Montreal, and is included in the exports from Quebec.

The destinations of the 1888 exports were as follows:—

Great Britain........................	14,957 tons	$247,371
United States............	2,643 "	30,248
Germany..........................	1,176 "	20,990

The following table shows the imports of Canadian phosphate into Great Britain, compared with all imports of phosphate into that country. The figures are taken from "The Mining and Mineral Statistics of Great Britain and Ireland":— Canadian phosphate in Great Britain.

IMPORTS INTO GREAT BRITAIN OF CANADIAN PHOSPHATE COMPARED WITH TOTAL IMPORTS INTO THAT COUNTRY.

TABLE 2.

Year.	Canadian Apatite.		Total Phosphates.		Per cent. of Canadian Apatite to total quantity.
	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 "
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 "

Returns were received from three manufacturers of fertilizers, showing a production of 548 tons valued at $21,600. This shows an increase over last year of 50 tons. The value has however, decreased, being $4,000 less than that of last year. Fertilizers.

The minerals used in the manufacture were, about 175 tons of phosphate (apatite) and small quantities of sulphate of ammonia, muriate of potash, kainite, calcic sulphate, bones and bone dust. A table of the imports of these minerals is given as follows:— Imports.

IMPORTS OF FERTILIZERS AND RAW MINERALS USED IN THEIR MANUFACTURE, DURING 1887 AND 1888.

TABLE 3.

Articles.	1887.		1888.	
	Quantity.	Value.	Quantity.	Value.
Fertilizers	....	$ 7,749	....	$16,621
Ground Gypsum ....lbs.	36,882	375	90,702	344
Bones (crude and dust)........ "	11,760	677	134,000	861
Potash, German mineral....... "	15,313	935	11,627	234
" muriate & bichromate of. "	573,773	31,641	540,307	21,990
Kainite......	2,700	112	247,080	2,405
Sulphate of Ammonia............	53,555	1,526	68,156	2,363
Totals....................	....	$43,015	....	$44,818

PYRITES AND SULPHURIC ACID.

The amount of pyrites mined and shipped as available for acid making in 1888 was 63,479 tons, valued at the average price of $4.50 per ton at $285,656, an increase over 1887 of 25,436 tons and $114,462. Pyrites.

This increase is, in a great measure, due to Messrs. G. H. Nichols & Co., who during the previous year were devoting a great deal of their labor to surface work, during which time their production was below the average.

The pyrites production is as heretofore that of the Capelton mines in Quebec.

There was a small importation of iron pyrites used in acid making from the United States, probably not over 1,000 tons.

The total production of sulphuric acid for 1888 amounted to 8,727,-220 pounds valued at $121,515, showing an increase over 1887 of 3,249,270 pounds and $50,906. Sulphuric Acid.

No returns were received during 1886, but there was an estimated increase in 1887 of 50 per cent over the previous year, there is therefore an increase in 1888 of over 100 per cent over that of 1886. Nearly all of the above acid was made from pyrites, a small quantity being made from imported brimstone, of which some 75 tons were used.

The following table shows the imports of sulphuric acid during the years 1887 and 1888. Imports.

There were no exports:—

IMPORTS OF SULPHURIC ACID DURING THE YEARS 1887 AND 1888.

TABLE 1.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario	1,658,860	$26,233	105,825	$1,661
Quebec	725,749	8,914	3,699	100
Nova Scotia	186,451	1,941	60,334	602
New Brunswick	138,264	1,484	107,868	1,125
Manitoba	197	4	33,123	392
British Columbia	21,402	634	20,709	555
Totals	2,730,923	$39,210	$331,558	$4,430

IMPORTS OF BRIMSTONE OR CRUDE SULPHUR.

TABLE 2.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario..................	1,097,882	$13,279	1,139,743	$17,022
Quebec...................	776,237	11,698	880,660	9,399
Nova Scotia.............	371,625	5,566	413,461	5,443
New Brunswick.........	58,287	936	66,063	1,091
Prince Edward Island....	1,752	36	1,608	35
Manitoba...............	941	27	2,220	55
British Columbia	1,818	74	44,125	434
Totals............	2,308,542	$31,616	2,547,880	$33,479

SALT.

The production of salt, according to direct returns for the year 1888, was 59,070 tons, valued at $185,460, a decrease in quantity as compared with 1887 of 1,103 tons. There is, however, an increase in value of $19,066, which goes to show that the market price for salt was very much higher than during the year previous. Production.

In 1887 the average price was $2.76 per ton, whereas for this year the average price is $3.14. As incomplete returns were received from some of the producers, it is impossible to state the exact number of packages used, but it is estimated that about 175,000 barrels, valued at about $32,000, were used, as well as a large number of sacks of all sizes, aggregating about $15,000 making the value of packages to be about $47,000. The value of the salt, as prepared for market in packages, is therefore about $232,460.

There were in operation during 1888, 18 producers employing about 260 men, this includes one producer in New Brunswick who made only dairy salt.

The production for the last three years is as follows :—

	Barrels. (280 lbs.)	Tons.	Value.	Average Price per Ton.
1886	445,421	62,359	$227,195	$3.65
1887	429,807	60,173	166,394	2.76
1888	421,930	59,070	185,460	3.14

The following figures, kindly furnished by the Grand Trunk Railway, show the shipments from the various stations of that railway where salt is manufactured :— Shipments by rail.

1883	35,961 tons
1884	34,850 "
1885	39,600 "
1886	41,577 "
1887	36,311 "
1888	37,120 "

There were also shipped from Wingham, by the Canadian Pacific Railway in 1888, 4,391 tons: making 41,511 tons shipped by rail during 1888. Exports and imports.

The following tables show the exports and imports of all kinds of salt for 1888 :—

EXPORTS OF SALT DURING THE YEARS 1887 AND 1888.

TABLE 1.

Province.	1887.		1888.	
	Bushels.	Value.	Bushels.	Value.
Ontario	153,475	$11,425	14,968	$3,921
Quebec	......	......	133	36
New Brunswick..........	570	101	......	......
Prince Edward Island....	......	......	150	30
Totals..............	154,045	$11,526	15,251	$3,987

IMPORTS OF COARSE SALT PAYING DUTY FOR THE YEARS 1887 AND 1888.

TABLE 2.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario................	683,270	$2,110	937,600	$3,397
Quebec	7,240	32	478,844	1,198
New Brunswick.........	2,260	9	......	......
British Columbia........	72,000	368	190,000	834
Totals..............	764,770	$2,519	1,606,444	$5,429

IMPORTS OF FINE SALT, PAYING DUTY, FOR THE YEARS 1887 AND 1888.

TABLE 3.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario................	1,000,842	$ 3,349	376,713	$ 1,539
Quebec................	4,989,918	14,748	5,676,807	15,012
Nova Scotia............	841.782	1,981	309,608	2,195
New Brunswick..........	1,662,300	5,110	1,366,736	4,283
Prince Edward Island....	27,138	75	17,268	84
Manitoba..............	5,900	33	3,384	25
British Columbia........	561,100	3,468	1,178,838	5,397
Totals..............	9,088,980	$28,764	8,929,354	$28,535

IMPORTS OF SALT (DUTY FREE) FOR FISHERIES, DURING THE YEARS 1887 AND 1888.

TABLE 4.

Province.	1887.		1888.	
	Pounds.	Value.	Pounds.	Value.
Ontario................	1,668,942	$ 2,765	2,092,290	$ 5,028
Quebec................	69,118,737	92,194	66,780,742	69,293
Nova Scotia............	81,982,510	112,031	89,970,848	101,322
New Brunswick..........	28,207,140	42,300	38,859,120	50,379
Prince Edward Island....	4,578,787	2,626	1,062,520	2,614
Manitoba..............	252,100	998	458,200	2.138
British Columbia........	1,038,452	2,479	3,605,600	5,647
Totals..............	186,846,668	$255,393	202,829,320	$236,421

SILVER.

Production. Assuming that the Ontario exports of silver represent the total output of silver in that province, the production in Canada during the year 1888 is approximately $395,377, an increase over the last year of $46,047, and over 1886 of $186,287. This is due to a great extent to the development of the Badger mine and others in the Rabbit Mountain and Silver Mountain districts in Ontario, and to the mines in Kootenay district, British Columbia.

British Columbia. In British Columbia, small shipments, aggregating, $37,925, were made from the various camps in Kootenay and Illecillewaet districts, as well as from Stump Lake and the Monarch mine at Field.

From the report of the Minister of Mines of this province it is reasonable to infer that large shipments of silver and other minerals will be made during the ensuing season, as development and prospecting have been carried on to a considerable extent in various parts of the province, notably in the Kootenay district and Kamloops division.

Ontario. Owing to our inability to obtain direct returns from all the produce in the district west of Port Arthur, the exports for the year are taken as representing the total production in Ontario. As all the silver is exported to the United States there is every reason to believe that this estimate is correct. Silver was produced only in the Rabbit, and Silver Mountain districts, west of Port Arthur, principally from the Beaver, Badger, Rabbit and Silver Mountain mines.

The exports amounted to $208.064.

Quebec. The silver from this province is obtained altogether from the copper deposits of Capelton, where it occurs in about the proportion of one ounce of silver to each per cent of copper. The production is estimated at $149,388.

Exports. The exports of silver ore for the last three years are as follows :—

EXPORTS OF SILVER ORE.

Province.	1886.	1887.	1888.
Ontario....	$16,505	$184,763	$208,064
Quebec....	8,000	450	5
Manitoba....	1,452	3,741	......
British Columbia..	......	17,331	10,939
Totals........	$25,957	$206,284	$219,008

STRUCTURAL MATERIALS.

Granite—Granite was produced during 1888 to the extent of 21,352 tons, valued at $147,305, showing an increase over last year of 135 tons and $4,799. The greater part of the above production is used in the manufacture of monuments and other decorative work, the estimated value of which is about $350,000. Granite.

The output is that of twelve producers, who employ about 240 hands.

Marble and Serpentine.—The production as reported to this office was 191 tons, valued at $3,100. This return being considered incomplete no comparison is made with the production of the previous year. Marble and Serpentine.

The following tables show the imports of marble and granite into Canada during the past two years. As the exports of these two stones are not kept separate it has been found impossible to give them:— Exports and Imports.

IMPORTS OF MARBLE.

TABLE 1.

Province.	1887.	1888.
Ontario	$39,673	$51,284
Quebec......	22,840	26,817
Nova Scotia.............	9,580	11,744
New Brunswick.........	6,682	8,081
Prince Edward Island.....	1,997	3,074
Manitoba	110	492
British Columbia........	2,076	3,550
Totals............	$82,958	$105,042

IMPORTS OF MANUFACTURES OF STONE OR GRANITE, N. E. S.

TABLE 2.

Province.	1887.	1888.
Ontario....................	$15,253	$40,502
Quebec	3,286	14,340
Nova Scotia................	491	1,343
New Brunswick.........	465	1,397
Prince Edward Island...	117	264
Manitoba	1,059	397
British Columbia.........	940	722
Totals..............	$21,611	$58,965

Slate.

Slate.—The production during 1888 amounted to 5,314 tons, valued at $90,689. This production is altogether that of the province of Quebec. There is a slight decrease in the quantity produced, though there is an increase in value of $1,689.

Exports and Imports.

The following tables show the exports of slate for the past five years, and the imports for 1887 and 1888:—

EXPORTS OF SLATE FOR THE LAST FIVE YEARS.

TABLE 3.

Year.	Tons.	Value.
1884	539	$6,845
1885	346	5,274
1886	34	495
1887	27	373
1888	22	475

IMPORTS OF SLATE.

TABLE 4.

Province.	1887.	1888.
Ontario	$17,299	$30,704
Quebec	2,211	2,025
Nova Scotia	927	694
New Brunswick	3,909	2,379
Prince Edward Island	88	172
Manitoba	191	149
British Columbia	589	2,382
Totals	$25,214	$38,505

Flagstones.—Returns were received showing the production to be 64,800 feet, valued at 6,580. This return is very incomplete, and does not at all represent the total output for the year. Flagstones.

It is impossible to show the amount of flagstone exported, if any, as it is not kept separate by the Customs Department. The imports during the year amounted to $16,343, all into the province of Ontario. Building Stone.

Building Stone.—Notwithstanding that fewer returns were received than last year, there is an increase in the reported production of building stone of 148,978 cubic yards and $89,445, proving that there was a great increase in the total production during the year. The total amount of stone quarried in the Dominion is estimated to have been about 600,000 cubic yards, valued at about 750,000.

The production during the year 1888, as returned to this office, is as follows:—

PRODUCTION OF BUILDING STONE DURING 1888 (AS RETURNED TO THIS OFFICE.)

TABLE 5.

Province.	Number of returns.	Cubic yards.	Value.
Ontario..................	50	165,231	$310,949
Quebec	20	199,778	185,027
Nova Scotia.............	18	42,059	120,245
New Brunswick.........	3	1,953	19,680
Prince Edward Island....	1	300	300
Manitoba................	1	297	981
North-West Territories...	2	1,952	4,530
Totals................	About 95	411,570	$641,712

Exports and Imports.

In the following tables are shown the exports and imports of stone for the last two years:—

EXPORTS OF STONE AND MARBLE, WROUGHT AND UNWROUGHT.

TABLE 6.

Province.	1887.		1888.	
	Wrought.	Unwrought.	Wrought.	Unwrought.
Ontario	$ 17	$ 4,490	$ 1,660	$23,284
Quebec	670	......	490	90
Nova Scotia.............	425	24,476	505	17,496
New Brunswick.........	12,827	24,925	19,442	15,135
British Columbia........	70	95	17	......
Totals...............	$14,009	$53,986	$22,114	$56,005

IMPORTS OF DRESSED FREESTONE AND OTHER BUILDING STONES.

TABLE 7.

Province.	1887.	1888.
Ontario..................	$3,189	$1,268
Quebec..................	74	8,200
Nova Scotia..............	....	252
Prince Edward Island....	2	....
British Columbia........	148	....
Totals..............	$3,413	$9,720

IMPORTS OF ROUGH FREESTONE, SANDSTONE AND BUILDING STONE.

TABLE 8.

Province.	1887.	1888.
Ontario..................	$47,610	$68,196
Quebec	22,014	25,330
New Brunswick..........	254	546
Totals.............	$69,878	$94,072

Lime.—As in the case of the building stone returns, it has been found impossible to obtain full returns of the amount of lime manufactured throughout the Dominion, but it is estimated that there was 2,500,000 bushels valued at about $375,000. Lime.

Direct returns received at this office give the following result:—

PRODUCTION OF LIME DURING 1888 (AS RETURNED TO THIS OFFICE.)

TABLE 9.

Province.	Number of returns.	Bushels.	Value.
Ontario..................	59	1,296,343	$169,194
Quebec	7	356,646	61,489
Nova Scotia.............	About 10	29,450	6,480
New Brunswick..........	7	440,225	82,993
Prince Edward Island....	2	20,300	6,075
Manitoba	5	57,600	8,940
North-West Territories...	2	3,200	880
British Columbia........	1	13,000	3,900
Totals...............	93	2,216,764	$339,951

Cement.

Cement.—Direct returns show a production of cement amounting to 50,668 barrels valued at $35,593, a decrease from the previous year of 19,175 barrels and $46,316. This is supposed to represent very nearly the total production in the Dominion.

Exports and Imports of Lime and Cement.

In the following tables will be found the exports and imports of lime and cement:

EXPORTS OF LIME AND CEMENT DURING 1887 AND 1888.

TABLE 10.

Province.	1887.	1888.
Ontario	$4,269	$12,262
Quebec..................	83	398
Nova Scotia...............	142	278
New Brunswick	77,518	97,318
Prince Edward Island.....	4	......
Manitoba	241	......
British Columbia.........	4	......
Totals...............	$82,261	$110,256

IMPORTS OF LIME DURING 1887 AND 1888.

TABLE 11.

Province.	1887.		1888.	
	Barrels.	Value.	Barrels.	Value.
Ontario	4,379	$3,487	6,616	$4,016
Quebec	3,441	2,501	3,148	2,223
Nova Scotia............	450	407	399	366
New Brunswick.........	46	44	104	105
Manitoba	904	791	450	394
British Columbia........	700	860	1,251	1,251
Totals...............	9,920	$8,090	11,968	$8,355

IMPORTS OF HYDRAULIC CEMENT.

TABLE 12.

Province.	1887.		1888.	
	Barrels.	Value.	Barrels.	Value.
Ontario......	3,505	$3,705	3,102	$3,360
Quebec	46	163	1,051	2,038
Nova Scotia	31	70	506	785
New Brunswick..........	1,476	2,054	1,208	1,553
British Columbia........	35	136	22	74
Totals.............	5,093	$6,128	5,889	$7,810

IMPORTS OF CEMENT IN BULK OR IN BAGS.

TABLE 13.

Province.	1887.		1888.	
	Bushels.	Value.	Bushels.	Value.
Ontario	6,029	$1,554	3,220	$824
Nova Scotia............	18,666	4,456	27,066	9,434
Totals............	24,695	$6,010	30,286	$10,258

IMPORTS OF PORTLAND CEMENT.

TABLE 14.

Province.	1887.		1888.	
	Barrels.	Value.	Barrels.	Value.
Ontario	5,705	$ 7,761	10,896	$15,570
Quebec....................	98,760	139,409	79,045	109,736
Nova Scotia...............	6,911	11,124	12,174	20,104
New Brunswick.........	2,846	4,307	3,899	5,977
Prince Edward Island....	123	186	703	1,249
British Columbia........	2,515	6,682	4,358	8,247
Totals.............	116,860	$169,469	111,075	$160,883

Bricks and Tiles.

Bricks and Tiles.—There were received direct from the producers 231 returns of bricks made, and 63 of tiles, showing in the case of the brick production an increase in the amount reported to this office of $50;057, and a decrease in the reported production of tiles of $116,011 These differences do not necessarily show any increase or decrease in the production of these two articles, though it is supposed that, in view of the great amount of building that was carried on in the cities of Ontario and Quebec, there was a considerable increase over the previous year.

It is estimated that there were about 200,000 of bricks made during the year, valued at about $1,500,000, and about 10,000 of tilos, valued at about $150,000

The production is summarized in the two following tables :—

PRODUCTION OF BRICKS DURING 1888 (AS REPORTED TO THIS OFFICE.)

TABLE 15.

Province.	Number of returns.	Thousands.	Value.
Ontario..................	179	123,179	$736,684
Quebec	22	24,925	167,591
Nova Scotia.............	14	7,060	46,695
New Brunswick..........	7	5,064	32,294
Prince Edward Island....	4	940	6,900
Manitoba	1	200	2,400
North-West Territories...	1	150	1,650
British Columbia........	3	4,300	42,532
Totals...............	231	165,818	$1,036,746

PRODUCTION OF TILES DURING 1888 (AS RETURNED TO THIS OFFICE.)

TABLE 16.

Province.	Number of returns.	Thousands.	Value.
Ontario.................	59	7,330	$111,117
Quebec	1	38	570
Nova Scotia............	1	30	300
New Brunswick..........	2	120	2,070
Totals...............	63	7,518	$114,057

Imports.

IMPORTS OF BUILDING BRICK.

TABLE 17.

Province.	1887.	1888.
Ontario..................	$1,861	$1,619
Quebec..................	13.444	22,137
Nova Scotia..............	82	95
New Brunswick..........	64	329
Manitoba.................	18	14
British Columbia.........	33	....
Totals..............	$15,502	$24,194

IMPORTS OF DRAIN TILES AND SEWER PIPES.

TABLE 18.

Province.	1887.	1880.
Ontario.................	$71,424	$65,675
Quebec..................	16,041	27,095
Nova Scotia.............	554	252
New Brunswick..........	914	789
Manitoba................	809	629
British Columbia	638	4,793
Totals.............	$90,380	$99,233

IMPORTS OF FIRE BRICKS, TILES, ETC.

TABLE 19.

Province.	1887.	1888.
Ontario....	$21,221	$38,343
Quebec.................	31,240	35,033
Nova Scotia.............	687	11,372
New Brunswick..........	7,778	950
Prince Edward Island.....	263	248
Manitoba................	178	484
British Columbia..........	962	3,881
Totals............	$62,329	$90,311

IMPORTS OF FIRE CLAY.

TABLE 20.

Province.	1887.	1888.
Ontario	$ 7,285	$ 8,797
Quebec.................	17,861	12,884
Nova Scotia.............	1,106	1,144
New Brunswick..........	312	968
Prince Edward Island.....	36	37
Manitoba................	120	160
British Columbia.........	724	739
Totals	$27,444	$24,929

IMPORTS OF CLAYS, ALL OTHER N. E. S.

TABLE 21.

Province.	1887.	1888.
Ontario	$5,502	$3,224
Quebec	473	3,562
Nova Scotia	......	26,051
New Brunswick	233	......
British Columbia	3	13
Totals	$6,211	$32,850

IMPORTS OF EARTHENWARE.

TABLE 22.

Articles.	1887.	1888.
Brown and colored Earthen and Stoneware and Rockingham ware	$ 29,563	$ 36,224
Decorated, printed or sponged, and all Earthenware, N. E. S.	171,836	167,860
Demijohns or jugs, churns and crocks	6,448	5,905
Totals	$207,847	$209,989

Miscellaneous Clay Products.

Miscellaneous Clay Products.—Returns of the manufacture of miscellaneous clay products to the amount of $343,870 were received for the year 1888, divided as follows:—

Silver pipes and Tiles	$266,320
Terra-cotta	49,800
Pottery ware	27,750
	$343,870

Sand and Gravel.

Sand and Gravel.—No returns were received of these two products. The following tables show the exports and imports:—

EXPORTS OF SAND AND GRAVEL.

TABLE 23.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario....	180,699	$29,470	260,759	$38,043
Quebec................	......	22	......	......
Nova Scotia............	161	815	170	355
Totals............	180,860	$30,307	260,929	$38,398

IMPORTS OF SAND AND GRAVEL.

TABLE 24.

Province.	1887.		1888.	
	Tons.	Value.	Tons.	Value.
Ontario	10,361	$16,956	9,194	$13,536
Quebec................	6,586	7,931	14,556	12,937
Nova Scotia............	1,264	4,271	1,459	3,815
New Brunswick.........	1,014	1,300	1,371	1,795
Manitoba...............	15	40	25	81
British Columbia........	1	10	21	73
Totals............	19,241	$30,508	26,626	$32,237

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

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

DIVISION OF

MINERAL STATISTICS & MINES

ANNUAL REPORT

FOR

1889

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.

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1890.

NOTES

The year used throughout this report is the calendar year, and the ton that of 2,000 pounds, unless otherwise stated.

The fiscal year begins the 1st of July.

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 shew discrepancies, which there are no means of correcting, however.

The figures given in the tables of exports and imports under the headings of each province do not necessarily represent the production and consumption of these provinces; e. g., material produced in Ontario is often shipped from Montreal and entered there for export, so falling under the heading, Quebec.

To Dr. Alfred R. C. Selwyn, C.M.G., F.R.S., etc.,
Director Geological Survey of Canada.

Dear Sir,—I beg herewith to submit the annual report of the division of Mineral Statistics and Mines for 1889.

I regret that it has to be handed in somewhat later than usual, but owing to an unfortunate complication of circumstances this could not be avoided.

My predecessor, Mr. Coste, ceased all active participation in the work in March, 1889, whilst I was placed in charge of the work of the division in the November following. In this way, for about six months the office was short-handed, Mr. Brumell, the assistant to the division, being left to carry on the work on the lines previously followed by my predecessor, whilst his time and attention were largely occupied in collecting data and making enquiries in connection with the Petroleum and Natural Gas industries.

Thus the routine and other work of the division has unavoidably fallen in arrears, and it will yet take some time and considerable effort to bring it up to a state of efficiency whilst not neglecting the current business of the office, which matters have absorbed all my own attention and effort for the past few months.

The accompanying report will, for these reasons, be found less full and interesting and more purely statistical than I could have wished; for, outside of Mr. Brumell's studies before alluded to, and apart from the statistical data of past years, the division was found to be furnished with little or no information relating to the Mines and Mining industries of the Dominion.

A beginning has been made towards rectifying this state of things, and if I can get an opportunity during the present summer season I shall make myself familiar, personally as far as possible, with the districts and people with whom we have to deal in the prosecution of the work. I hope thus to be able to deal more efficiently and satisfactorily with the information coming to hand and to better perform the functions of my office.

The report will be found to contain articles on Petroleum and Natural Gas, by Mr. Brumell, assistant to the Division, which, in view of his investigations of these subjects for the past two years, I entrusted to him.

Thanks are also due to him for his very able and willing fulfilment of the duties of his office.

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, as well as to all those, too numerous to specify, who supplied us so willingly with statistical and other information.

I remain, Sir,

Your obedient servant,

ELFRIC DREW INGALL.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1889.

PRODUCT.	QUANTITY.	VALUE.	COMPARED WITH 1888 (a).
Antimony Ore ....tons.	55	$ 1,100	Decrease.
Asbestus .... "	6,113	426,554	Increase.
*Bricks ....thousands.	200,561	1,273,884	do
*Building Stone............cub. yds.	341,337	913,691	do
Cement.....................bbls.	90,474	69,790	do
Charcoal.................bush.	1,593,300	93,463	do
Coal ....tons.	2,719,478	5,584,182	do
Coke...................... "	54,539	155,043	do
Copper (fine, cont'd. in ore).lbs.	6,809,752	885,424	do
Fertilizers................tons.	775	26,606	do
Fire Clay........... ...... "	400	4,800	
Flagstones.................sq. feet.	14,000	1,400	Decrease.
Glass and Glassware..................	....	150,000	do
Gold.......................ozs.	72,328	1,295,159	Increase.
Granite....................tons.	10,197	79,624	Decrease.
Graphite.................. "	242	3,160	Increase.
Grindstones............... "	3,404	30,863	Decrease.
Gypsum.................... "	213,273	205,108	Increase.
*Iron...................... "	73,231	2,763,062	do
Iron Ore.................. "	84,181	151,640	Decrease.
Lead (fine, contained in ore).lbs.	165,100	6,604	do
*Lime......................bush.	2,948,249	362,848	Increase.
Limestone for flux.........tons.	22,122	21,909	do
Manganese Ore............ "	1,455	32,737	Decrease.
Marble .... "	980	980	do
Mica (exports of cut and crude).................lbs.	36,529	28,718	
Mineral Paints.............tons.	794	15,280	Increase.
Mineral Water.............galls.	424,600	37,360	do
*Miscellaneous clay products	....	239,385	Decrease.
Moulding Sand............tons.	170	850	Increase.
Petroleum..................bbls.	639,991	612,101	Decrease.
Phosphate ....tons.	30,988	316,662	Increase.
Pig Iron.................. "	25,921	499,872	do
Platinum...................ozs.	1,000	3,500	Decrease.
Pyrites....................tons.	72,225	307,292	Increase.
Salt...................... "	32,832	129,547	Decrease.
Sand and Gravel (exports).. "	283,044	52,647	Increase.
Silver.....................ozs.	383,318	343,848	Decrease.
Slate......................tons.	6,935	119,160	Increase.
Soapstone................. "	195	1,170	do
*Steel.................... "	27,873	973,282	do
Sulphuric Acid............lbs.	10,998,713	152,592	do
*Tiles.....................thousands.	10,526	134,265	do
Estimated value of mineral products not returned (principally nickel, iron and structural materials)..........	....	992,838	
Total....................	....	$19,500,000	Increase.
Total, 1888	....	16,500,000	

* Incomplete.
(a) Comparison of values only.

Exports.

Minerals and Mineral Products, Mined or Manufactured in Canada, during 1889.

Product.	Value.	Product.	Value.
*Acid, Sulphuric........	$ 1,152	Lime and Cement........	$ 161,249
Asbestus, first class	319,461	Mica, crude and cut......	28,718
do second class....	27,308	do ground	1,879
do third class.....	13,375	Oil, crude and refined....	10,777
Barytes..................	80	Ore, Antimony..........	695
*Brick	1,906	do , Iron.............	39,887
Coal....................	2,334,905	do , Manganese........	29,350
Coke	1,050	do , Silver............	212,163
Copper.................	168,457	Phosphate.............	394,768
*Fertilizers	1,411	Plumbago (graphite)....	538
Gold......	609,250	Salt....................	2,390
Glass and Glassware.....	6,287	Sand and gravels	52,647
Grindstones	29,982	Slate......	3,303
Gypsum (crude).........	194,404	Stone, unwrought.........	21,374
do (ground)	772	Stone, wrought..........	28,204
Iron and Steel, about.....	310,000	Other articles...........	30,407
		Total.............	$5,038,149

* For last six months of year only.

Exports.

Products of the Mine during the Fiscal Year 1889.

Exported to	Value.	Exported to	Value.
United States...........	$3,753,351	British West Indies......	$ 4,130
Great Britain...........	422,355	Japan	4,000
Newfoundland....	153,311	Norway and Sweden......	1,200
Sandwich Islands	17,380	United States of Columbia	796
St. Pierre...............	16,564	British Guiana..........	702
Germany................	15,856	Danish West Indies......	586
Mexico	10,118		
Spanish West Indies	7,640	Total.............	$4,419,170
Belgium	6,000		
France	5,181	1888 "	$4,110,937

IMPORTS.

MINERALS AND MINERAL PRODUCTS DURING 1889.

PRODUCT.	VALUE.	PRODUCT.	VALUE.
Alum and Aluminous Cake	$ 26,395	Iron and Steel, all sorts..	$1,908,966
Antimony..............	14,342	Lead and mfrs. of	356,732
Arsenic......	3,999	Lime.....	7,835
Asbestus and mfrs. of....	15,602	do Chloride of........	59,533
Ashes, Pot, Pearl and Soda.	3,462	Litharge..............	24,652
Asphaltum	33,550	Lithographic Stone	3,625
Baryta.......	611	Manganese Oxide	2,833
Borax......	23,544	Marble......	109,099
Brass and mfrs. of	548,563	Mercury...............	8,534
Bricks.................	11,459	Mineral waters..........	37,969
do Bath.............	2,765	Nickel.................	101
do and Tiles, fire......	18,502	Paints.................	533,351
Buhrstones.	5,850	Paraffin wax............	6,424
Building Stone..........	128,108	Petroleum and mfrs. of...	505,995
Cement	12,959	Plaster of Paris.........	9,755
do Portland........	243,134	Platinum......	4,155
Chalk......	6,169	Potash Salts............	13,354
Clay, all sorts...........	23,877	Precious Stones	159,948
Coal, Anthracite.........	4,808,230	Pumice......	3,526
do Bituminous	3,257,437	Salt..................	306,064
do Dust	43,641	Sand and Gravel........	33,766
Coal Tar and Pitch.......	102,476	"Silex"......	991
Coke..................	130,921	Slate......	25,093
Copper and mfrs. of......	443,235	Soda Salts..............	302,194
Copperas................	3,096	Stone or Granite, N.E.S..	78,090
Earthenware	275,371	Spelter......	50,267
Emery......	15,945	Sulphur	40,677
Fertilizers	47,706	Sulphuric Acid	2,854
Flagstones..............	46,741	Tiles, Sewer, etc	82,127
Fuller's Earth...........	508	Tin and mfrs. of........	1,334,577
Glass and Glassware......	1,257,661	Whiting................	28,225
Graphite and mfrs. of.....	28,577	Yellow Metal...........	94,937
do Pencils.........	57,300	Zinc and mfrs. of	106,095
Grindstones.............	24,742		
Gypsum	2,158	Total.............	$17,910,980

ABRASIVE MATERIALS.

The total production of grindstones during 1889 was 3,404 tons, with a value of $30,863. These figures show a very considerable decrease of 2,360 tons and $20,266 from last year.

New Brunswick.

The returns received from New Brunswick give a total production of grindstones for that province of 2,692 tons, having a value, at the quarries, of $23,735. This is the production of six operators, or one less than last year, and shows a decrease in production of 1,101 tons and in value of $6,994.

Nova Scotia.

The returns, as given by the Inspector of Mines of Nova Scotia, show a production of but 712 tons of grindstones, valued at $7,128. Here also, as in New Brunswick, we find a very considerable decrease, amounting to 1.259 tons and $13,272.

Exports and imports.

The exports and imports of grindstones, as well as of buhrstones, emery, pumice stone and silex are detailed in the following tables :—

ABRASIVE MATERIALS.

TABLE 1.

EXPORTS OF GRINDSTONES.

PROVINCE.	1887.	1888.	1889.
Ontario	$ 500	$ 252	......
Quebec	12	......	$ 1,387
Nova Scotia	10,425	11,430	7,150
New Brunswick	17,832	16,494	21,437
Manitoba	......	......	8
Totals	$28,769	$28,176	$29,982

Abrasive Materials.

Table 2.

Imports of Grindstones.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario	1,390	$15,915	1,404	$16,065
Quebec	505	6,094	471	6,719
Nova Scotia	....	199	55	935
New Brunswick	1	9	1	8
Manitoba	56	786	24	359
British Columbia	6	199	30	656
Totals	1,958	$23,202	1,985	$24,742

Abrasive Materials.

Table 3.

Imports of Buhrstones.

Province.	1887.	1888.	1889.
Ontario	$1,184	$ 239	$ 917
Quebec	2,325	3,507	4,933
British Columbia	26	....	....
Totals	$3,535	$3,746	$5,850

Abrasive Materials.

Table 4.

Imports of Pumice Stone.

Province.	1888.	1889.
Ontario....................	$1,629	$ 1,832
Quebec	1,255	1,575
Nova Scotia..................	23	35
New Brunswick...............	26	80
Prince Edward Island..........	....	4
Manitoba	5	....
British Columbia...............	19	....
Totals................	$2,957	$3,526

Abrasive Materials.

Table 5.

Imports of Emery.

Province.	1888.	1889.
Ontario......	$10,337	$12,164
Quebec....	1,915	2,076
Nova Scotia...........	232	270
New Brunswick	1,603	1,421
Manitoba	......	2
British Columbia	12	12
Total	$14,099	$15,945

Plate I.

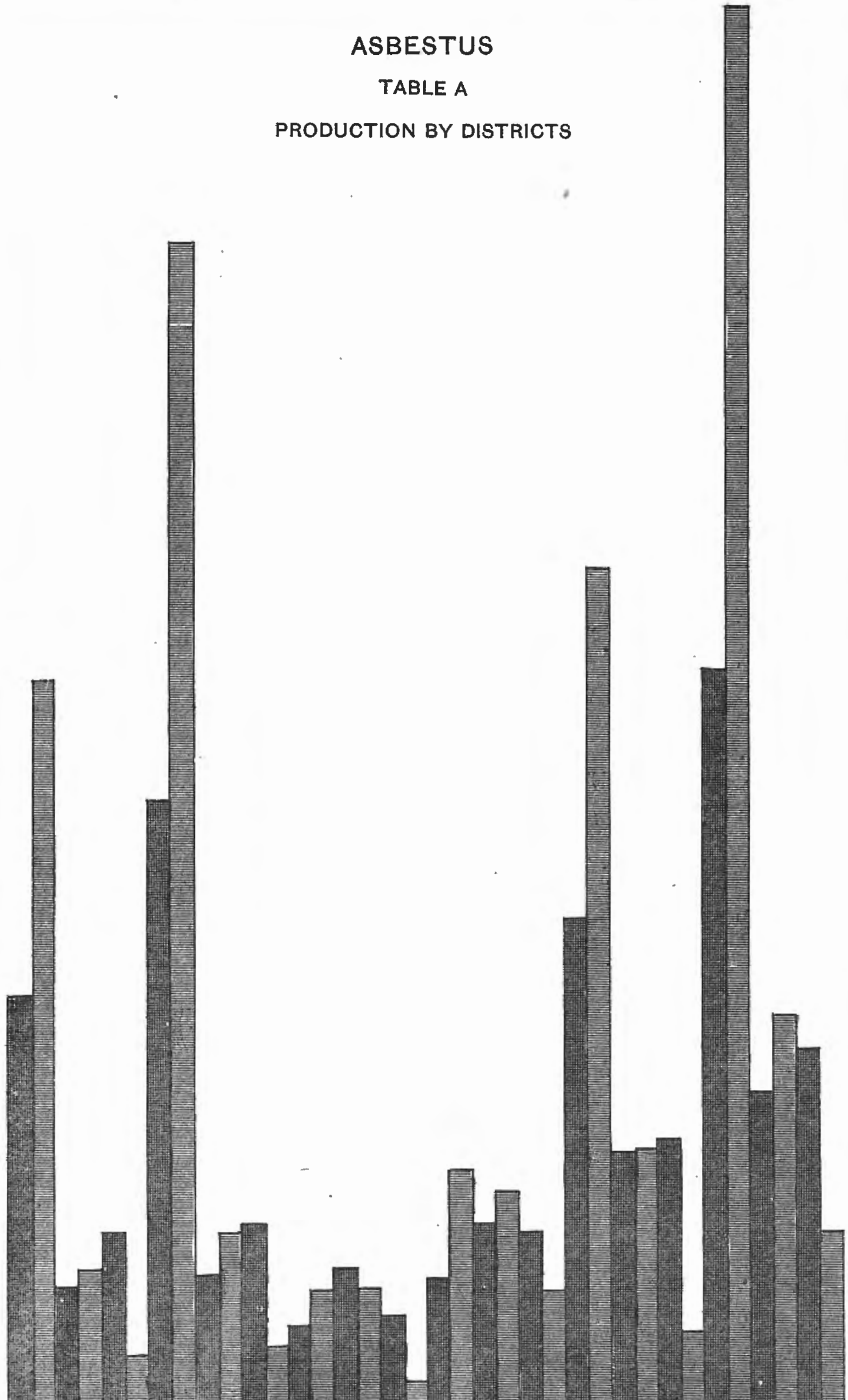
GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

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

ASBESTUS

TABLE A

PRODUCTION BY DISTRICTS



DISTRICT	YEAR	VALUE $	QUALITY	QUANTITY TONS.
THETFORD.	1888	157,040	1ST	1,786
		29,740	2ND	519
		11,430	3RD	762
	1889	252,005	1ST	2,629
		37,884	2ND	570
		13,340	3RD	801
COLERAINE, ETC.	1888	25,040	1ST	337
		26,495	2ND	601
		5,262	3RD	399
	1889	51,230	1ST	563
		46,815	2ND	797
		25,280	3RD	753
TOTALS.	1888	182,080	1ST	2,123
		56,235	2ND	1,120
		16,692	3RD	1,161
	1889	303,235	1ST	3,192
		84,699	2ND	1,367
		38,620	3RD	1,554

ANNUAL REPORT; DIVISION OF MINERAL STATISTICS AND MINES.—E. D. INGALL, M.E., IN CHARGE.—PART S. ANNUAL REPORT, 1889.

IMPORTS OF "SILEX" OR CRYSTALLIZED QUARTZ.

TABLE 6.

Province.	1888.		1889.	
	Cwts.	Value.	Cwts.	Value.
Ontario	5,699	$1,154	935	$597
Quebec	263	237	368	11
Nova Scotia	2	11	151	66
New Brunswick	239	147	287	299
Manitoba	......	......	43	18
Totals	6,203	$1,549	1,784	$991

Mr. R. Chalmers, of the Survey staff, in his preliminary report, to the Director, on his work in Southern New Brunswick, mentions occurrences of infusorial earth, and says :—" Infusorial earth has been reported as occurring at Fitzgerald Lake, St. John County, and at Pollet River and Pleasant Lakes, King's County. The deposits at the two first mentioned places are quite large."

ANTIMONY.

Production.

Outside of the small amount of the ore of this metal produced in Nova Scotia, as per returns from the Inspector of Mines for that province, nothing was done. The returns received from owners of the mines in New Brunswick and Quebec report their properties as being still idle. The total production was 55 tons, worth $1,100, all the production of the Rawdon mine in Hants County. This mine only worked a part of the year, which accounts for the small yield. This amounts to a decrease in the production of 290 tons and $2,596.

Enquiries were made at this office recently, by manufacturers of Babbitt metal, for Canadian sources of antimony, and they were put in communication with owners of mines, which it is hoped will lead to business.

Of the above quantity produced 30 tons, valued at $695, were entered in the Customs Department as exported from the Province of Nova Scotia.

ANTIMONY.

TABLE 1.

IMPORTS.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario	50,481	$4,754	51,027	$6,198
Quebec	96,690	10,127	68,665	7,407
Nova Scotia	552	162	1,460	132
New Brunswick	3,908	417	4,166	533
Manitoba	180	6	73	3
British Columbia	264	36	327	69
Totals	152,075	$15,502	125,718	$14,342

ARSENIC.

The production of refined arsenic, which has been carried on for some years past at the Deloro mine, Ont., was suspended during 1889, so that there is no production to report, there being no other producer in the Dominion.

The accompanying table of imports will show what demand there is for this article in the Dominion.

ARSENIC.

TABLE 1.

IMPORTS.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario	3,944	$125	63,732	$2,096
Quebec	17,244	610	50,374	1,759
Nova Scotia	2,272	82	3,925	137
New Brunswick	....	....	100	4
Manitoba	35	4	20	3
Totals	23,495	$821	118,151	$3,999

ASBESTUS.

Production.

The returns of the producers of this mineral in 1889 show a total output of 6,113 tons, valued at $426,554. This is a considerable increase over last year, amounting to 1,708½ tons, and in value of $171,547.

As against 11 producers last year, returns were received of the operations of 13 for 1889, employing 575 hands.

The contributions of the different districts to this grand total are as follows :—

Thetford.................................4,000 tons
Black Lake and Coleraine, etc...............2,113 "

Under the latter heading are included the produce of various scattered and outlying mines which are not, however, actually in the Black Lake district.

A comparative statement for 1888 and 1889 of the amounts, etc., of the different grades of asbestus produced by the different districts is shown in Graphic Table A.

Exports and imports.

The exports and imports are set forth in tables Nos. 1 and 2 :—

Asbestus.

Table 1.

Exports.

Quality.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
First Class	3,625	$262,552	4,579	$319,461
Second "	110	5,306	593	27,308
Third "	201	9,884	416	13,375
Totals..............	3,936	$277,742	5,588	$360,144

ASBESTUS.

TABLE 2.

IMPORTS.

PROVINCE.	1888.	1889.
Ontario....................	$3,557	$7,128
Quebec....................	4,302	3,929
Nova Scotia................	265	......
New Brunswick..............	591	3,335
Prince Edward Island.......	......	906
Manitoba..................	46	......
British Columbia...........	149	304
Totals................	$8,910	$15,602

Dr. Ells, in the preliminary report of his summer's work done in that district, states that an effort is being made to open up new mines on the "asbestus areas on the east side of Brompton Lake, on lot 26, range X, Brompton Gore, but at present this locality is accessible with difficulty, and the indications are not equal to those presented at Thetford and Coleraine."

Dr. Selwyn, also, in speaking of an area visited by himself during the summer in the northern peninsula of Newfoundland, says :—"Diorites and Serpentines appear to be somewhat largely developed, and it seems quite likely that valuable deposits of asbestus may accompany them as they do in the Eastern Townships of Quebec."

COAL.

Production. The production of this mineral for the whole Dominion amounted to 2,719,478 tons, valued at $5,584,182 at the pit's mouth.

This shows an increase over last year of 61,344 tons and $324,350. Although the production has increased, it has not done so at the same rate as in the past few years, a fact which will be apparent by reference to the accompanying graphic table A. It will there be noticed also that the total value has increased at a greater rate than the tonnage, which is due to the greater production from British Columbia, the price of whose product is always higher than that of the eastern coal fields.

The proportions yielded to the grand total by the different provinces are given in Table B., where they are graphically represented and speak for themselves.

Table C. represents the number of men employed in each province in the production of these amounts of coal, together with the proportionate number of tons produced per man per year.

The following tables give details of the production, sales and distribution of the two principal coal producing provinces, viz., Nova Scotia and British Columbia, as supplied by the mining departments of those provinces.

The graphic tables D and E represent the production of these two provinces and the fluctuations of the past years, and for purposes of comparison both these and the other three are constructed on the same scale.

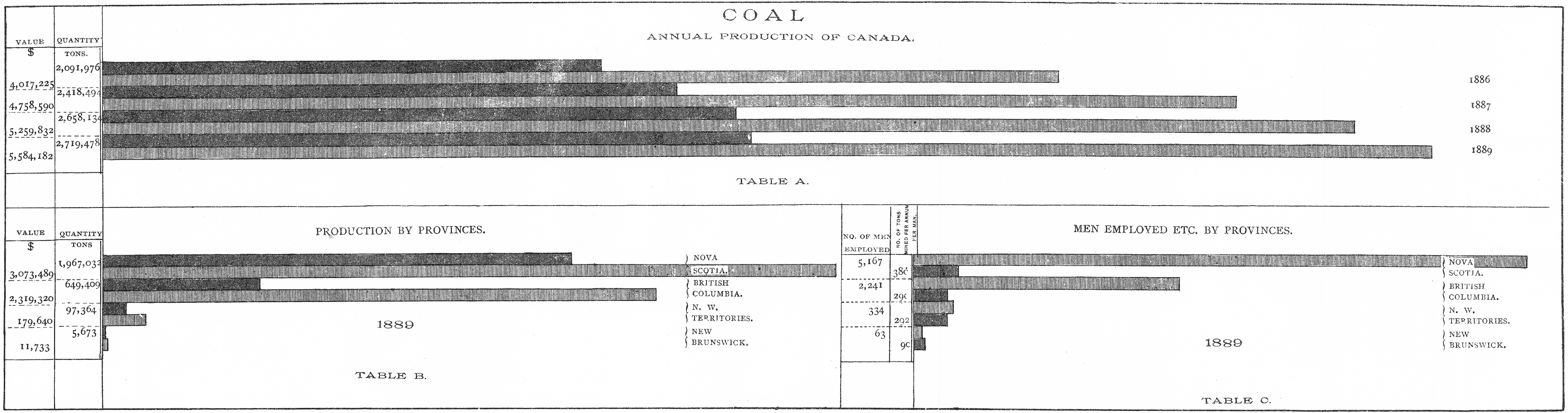
COAL.

TABLE 1.

NOVA SCOTIA.

PRODUCTION, SALES AND COLLIERY CONSUMPTION.

Period.	Production.	Sales.	Colliery Consumption.
1889—First quarter. Tons...........	350,707	203,130	43,453
1889—Second " "	481,004	419,649	45,383
1889—Third " "	624,773	640,008	39,260
1889—Fourth " "	510,548	478,933	49,010
Totals "	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
ANNUAL PRODUCTION OF CANADA.
VALUE
$
QUANTITY
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
1886
1887
1888
1889
TABLE A.
VALUE
$
QUANTITY
TONS
PRODUCTION BY PROVINCES.
1,967,032
3,073,489
649,409
2,319,320
97,364
179,640
5,673
11,733
NOVA SCOTIA.
BRITISH COLUMBIA.
N. W. TERRITORIES.
NEW BRUNSWICK.
1889
TABLE B.
NO. OF MEN EMPLOYED
NO. OF TONS MINED PER ANNUM PER MAN.
5,167
386
2,241
334
292
63
MEN EMPLOYED ETC. BY PROVINCES.
NOVA SCOTIA.
BRITISH COLUMBIA.
N. W. TERRITORIES.
NEW BRUNSWICK.
1889
TABLE C.

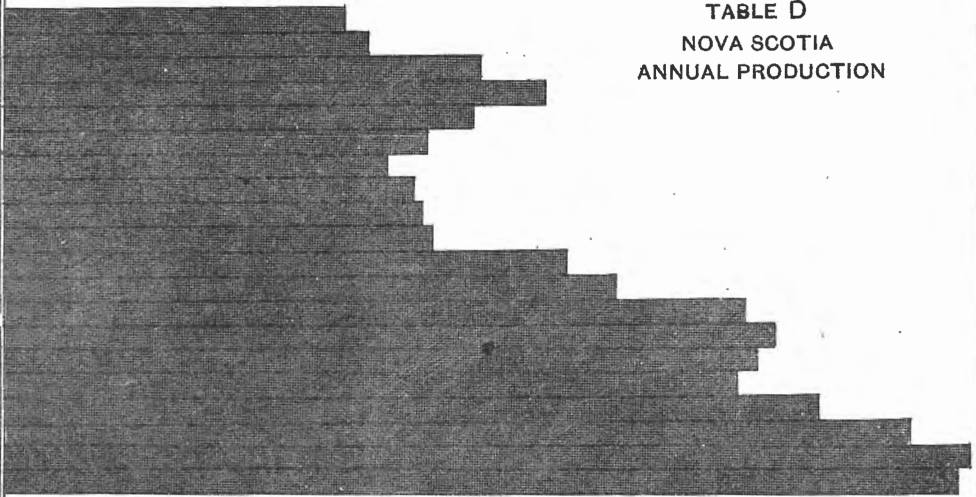
GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

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

Plate III.

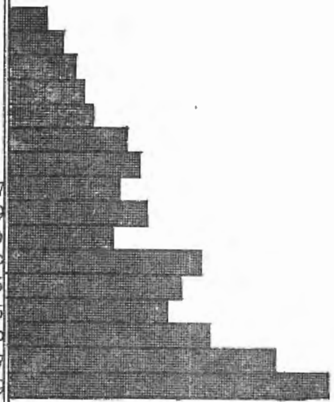
COAL
TABLE D
NOVA SCOTIA
ANNUAL PRODUCTION

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



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



Coal.

Table 2.

Nova Scotia.

Distribution of Coal sold.

Market.	Tons.
Nova Scotia :—	
Transported by land.............	351,995
" " sea.............	264,481
Total.................	616,476
New Brunswick.....................	218,595
Newfoundland........................	98,048
Prince Edward Island.................	61,533
Quebec.............................	707,612
West Indies.......................	4,461
United States.......................	33,584
Other Countries.....................	1,411
Total...............	1,741,720

Coal.

Table 3.

Nova Scotia.

Coal Trade by Counties.

Year 1889.	Cumberland.		Pictou.		Cape Breton.		Total.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
First quarter.	122,064	109,375	112,761	83,835	115,882	9,920	350,707	203,130
Second "	123,720	103,775	99,432	88,573	257,852	227,301	481,004	419,649
Third "	133,519	113,086	137,803	127,540	353,451	399,382	624,773	640,008
Fourth "	169,991	143,747	133,149	129,552	207,408	205,634	510,548	478,933
Totals...	549,294	469,983	483,145	429,500	934,593	842,237	1,967,032	1,741,720

COAL.

TABLE 4.

NOVA SCOTIA.

PRODUCTION BY DISTRICTS, 1889.

Colliery.	Tons.	Colliery.	Tons.
Chignecto	20,801	Caledonia..............	128,015
Joggins......	50,870	Francklyn	4,531
Minudie	1,456	Glace Bay..............	90,630
Springhill..............	476,167	Gowrie.................	125,104
Acadia.................	301,960	International.	138,785
Black Diamond.........	38,097	Ontario.................	3,210
East River.............	1,730	Reserve	136,247
Intercolonial...........	141,072	Sydney	162,362
Holmes................	286	Victoria................	121,633
Bridgeport............	24,076	Total	1,967,032

COAL.

TABLE 5.

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

The number of producers making returns was 41, of whom 19 operated in Nova Scotia, 4 in British Columbia, 10 in the North West Territories and 8 in New Brunswick.

North-West Territories.

The mines at Lethbridge and Anthracite still continue to be the main producers, the other operators contributing but a small proportion to the total output for the district. The production for this year, compared with that of last, shows a decrease of 17,760 tons and $3,714.

New Brunswick.

The greater proportion of the coal produced by this province was due to the operations of two companies, viz., the Newcastle Mining Co. and the Grand Lake Coal Co. As against last year's results, this province shows a decrease in the production of 57 tons and an increase in value of $683. The decrease in the production is due to a number of the smaller operators having suspended operations, whilst the better quality of the material produced by a more careful system of mining under the larger companies, who have taken their places, will account for the increase in the prices realized.

Exports.

Of the total produce of the Dominion, 2,719,478 tons, 24.4 per cent., or 665,315 tons, were exported, as shown in Table 7, as compared with 22.1 per cent. exported in 1888.

COAL.

TABLE 6.

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
Totals..	3,001,764	$5,886,522	3,564,814	$13,781,929

COAL.

TABLE 7.

EXPORTS: THE PRODUCE OF CANADA.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario	25	$ 107	55	$ 193
Quebec................	17,506	38,281	7,249	17,848
Nova Scotia.	165,863	330,115	186,608	396,830
New Brunswick..........	3	15	710	1,728
Prince Edward Island....	105	214	9	32
Manitoba...............	54	349	1	11
British Columbia	405,071	1,605,650	470,683	1,918,263
Totals............	588,627	$1,974,731	665,315	$2,334,905

The coal exported as given above was distributed as follows :—

	Tons.
Great Britain..	27,705
United States..	533,593
Newfoundland..	79,105
St. Pierre..	8,741
France..	291
Germany	460
Sweden and Norway..................................	102
Spanish West Indies..................................	3,088
British West Indies..................................	2,055
Danish West Indies..................................	302
Sandwich Islands..................................	1,218
Japan..	1,800
Mexico	2,875
Brazil	1,260
Spain	250
British Guiana..................................	615
Hong Kong..	1,855
Total..	665,315

COAL.

TABLE 8.

EXPORTS: NOT THE PRODUCE OF CANADA.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario	70,198	$165,816	72,008	$173,382
Quebec	9,864	20,179	12,625	31,181
Nova Scotia............	4,024	11,180	4,483	10,154
New Brunswick.........	230	409	178	500
Totals............	84,316	$197,584	89,294	$215,217

The above was shipped to the following places :—

Destinations.	Tons.
Great Britain..................................	14,364
United States..................................	74,874
Newfoundland..................................	56
Total..................................	89,294

COAL.

TABLE 9.

IMPORTS OF ANTHRACITE.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario	900,776	$3,746,081	803,390	$3,156,757
Quebec	348,350	1,401,904	350,633	1,338,049
Nova Scotia............	22,923	94,122	26,916	124,674
New Brunswick.........	51,074	195,287	44,463	168,673
Prince Edward Island....	2,518	9,904	4,269	8,257
Manitoba	523	3,447	2,135	11,820
British Columbia........	....	3	......	......
Totals	1,326,164	$5,450,748	1,231,806	$4,808,230

COAL.

TABLE 10.

IMPORTS OF BITUMINOUS COAL.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario	1,195,736	$3,258,113	1,180,202	$3,007,896
Quebec................	82,667	175,127	80,413	195,043
Nova Scotia.............	1,423	10,001	535	3,614
New Brunswick.........	4,715	13,336	3,828	10,018
Manitoba	2,293	7,620	8,870	31,878
British Columbia........	355	4,828	884	8,988
Totals.............	1,287,189	$3,469,025	1,274,732	$3,257,437

COAL.

TABLE 11.

IMPORTS OF COAL DUST.*

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario	37,195	$41,027	48,345	$43,372
Quebec	10,649	14,170	23	172
Nova Scotia	82	375	12	97
New Brunswick	6	170	....	....
Manitoba	55	267	....	....
British Columbia.......	......	10	....	....
Total............	47,987	$56,019	48,380	$43,641

*All slack and small coal is thus entered in the books of the Customs Department.

There were 54,539 tons of oven coke produced in 1889, valued at $155,043, showing an increase in tonnage of 9,166 over 1888, and in value of $20,862. Nova Scotia still remains the only district producing any notable quantity of this material. Coke.

There were 350 tons of this product, valued at $1,050, exported during 1889, from Nova Scotia to Newfoundland.

The following Table shows the home market for coke, as illustrated by the importation, and as compared with last year.

COKE.

TABLE 1.

IMPORTS OF OVEN COKE.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario................	22,948	$80,841	33,283	$113,117
Quebec	5,171	16,068	4,399	15,221
New Brunswick.........	198	827	314	1,419
Manitoba.	198	816	165	940
British Columbia........	155	939	19	224
Totals.............	28,670	$99,491	38,180	$130,921

There were 1,593,300 bushels of charcoal produced during 1889, valued at $93,463. Of this nearly 50 per cent. is produced at the Drummondville and Radnor Forges in the Province of Quebec for use at those works. The remainder is made in Ontario and principally exported. Charcoal.

In reporting on the work done in their various districts, the officers of the Geological Survey, in their preliminary reports to the Director, make mention of various points of interest connected with coal and its allied substances, as follows :—Mr. McConnell, speaking of the country north of the Lesser Slave Lake, N.W.T., and along the Peace River, above Lake Athabaska, says ;—" Lignite was found in several places along Peace River, but in seams too small to be workable. It was also found in the Laramie plateau south of the Lesser Slave Lake. Here four seams were found ranging in thickness from one to four feet, besides a number of smaller ones scattered through about 1,000 feet of Development and discovery. North-West Territory.

shales and sandstone. This lignite is apparently of fair quality, but has not yet been analysed. Drift lignite was also found in Martin River, near the base of Martin Mountain" (at N.E. corner of Lesser Slave Lake), "but was not traced to its source."

Nova Scotia.

Mr. Hugh Fletcher, speaking of his work in Pictou and Colchester Counties, N.S., mentions the albertite found on the north side of the Cobequid Hills, and of its associations thus :—"Along the north side of the hills, as far west as Waugh River, runs a belt of red conglomerate, described as Permian in previous reports, of the same geological age as that of New Glasgow, interstratified with red grit, sandstone and marl, and overlaid by grey sandstones, like those of Pictou and West River. These are succeeded in turn by brownish red sandstones and marls, with one or two thin layers of limestone. * * * All are affected by important east and west faults. Associated with the conglomerate, and also occasionally with the grey sandstones, are veins of albertite and of baryte. The veins of albertite are not, however, confined to these rocks. Hitherto no veins of greater thickness than four inches have been found, and these are lenticular and irregular." Speaking of the grey sandstone of Hodson, near River John, he says :—"Small seams of bituminous coal have been discovered in the grey sandstone, but none seem to be persistent."

Speaking of the southern part of Colchester County, he continues :—"The small coal seams of West River, Riverdale and Kemptown, with their associated slaty shales and quartzites, have been traced in the North, Chiganose and Debert Rivers, where much money has been spent in attempts to find them in workable shape."

He also visited the reported occurrence of coal at Kennetcook Corner, in Hants County, and found that "the seams are all apparently too small to be workable, and the basin in which they lie, between lower carboniferous limestone and gypsum, is very narrow."

Other points with regard to new features in the Nova Scotia coal fields are given in the report for the Department of Mines for that province as follows :—

"*Cumberland Co.*—During the past year explorations were carried on to the east of the Styles mine by Messrs. Sharp, Hickman *et al.*, and several seams said to vary in thickness up to eight feet were discovered. The coal is of good quality, and the results of the explorations, it is claimed, prove the extension of the Cumberland coal field for a considerable distance east of the limits hitherto generally assigned to it. Discoveries made to the north-west of the old General Mining Association area appear to show an anticlinal, having the Springhill Basin to the south, and the Maccan and Styles Basin to the north. If these results are confirmed a much greater portion of the Cumberland coal field will be accessible to the miner than has hitherto appeared possible. Some little work was also done in tracing the Oxford seams, which appear to form a basin, having a general east and west course.

" The Minudie mine worked a little during the first of the year, and was re-opened towards its close.

"*Colchester Co.*—At Coal Brook, about 12 miles from Truro, Mr. George Ross, of Truro, secured a lease, and has opened a seam of coal of good quality, said to be 3 feet 9 inches thick. Some prospecting was also done at Middle Stewiacke.

" *Pictou Co.*—At the Intercolonial Colliery arrangements were made for working the coal in an adjoining area belonging to Mr. S. H. Holmes, included between the line of the Intercolonial Company and the supposed southerly extension of the McCullock Brook fault.

" Some small prospecting was done by Wm. P. McNeil, on the area lying immediately north of the East River area.

" *Cape Breton Co.*—Mr. Greener has continued his explorations in the vicinity of North Sydney, in the measures lying on the prolongation of the Low Point coal strata. From analyses made of two of the seams by Mr. Maynard Bowman, Dominion Analyst, they are of excellent quality, when it is considered that the samples were taken from the outcrop, the percentage of ash running as low as 2.06, and of sulphur less than one per cent. Toward the close of the year I understand that Mr. Greener drove in some distance on one of the seams and found that it was thickening, and was then 5 feet 3 inches thick. The importance of the discovery of a workable seam of good quality at this point is apparent, for a large tract of coal-bearing measures becomes proved, and encouragement is given to others to search outside the hitherto recognized limits of the Sydney coal field. Explorations were also carried on in the district west of the Gardiner mine and a license to work selected."

The Department of Mines of British Columbia reports as follows of the operations in coal mining in the coal fields of Vancouver Island:— British Columbia.

" During the year the following collieries have been in operation, namely :—

" Nanaimo Colliery, of the New Vancouver Coal Mining and Land Co., Limited.

" Wellington Colliery, of Messrs. R. Dunsmuir & Sons.

" East Wellington Colliery, of the East Wellington Coal Co.

" Union Colliery, of the Union Colliery Co.

" Very extensive and encouraging prospecting operations, involving a large outlay of capital, have been carried on by the above-named companies, and also by the Oyster Harbor Coal Company, during the present year, by means of diamond drills of great power (capable of boring to 4,000 feet), to prove and establish an extension of the Nanaimo coal fields, and also those of Comox; and the Tumbo Island Coal Company are prospecting their coal land on the island of that name in the Gulf of Georgia by sinking a shaft.

" *Nanaimo.*—There has been some very extensive boring in this district during the past year. Amongst them was the continuation of the bore-hole * * * * in No. 2 Esplanade Shaft. This was put down to the depth of 1,263 feet, the depth of shaft being 617 feet, makes the total from the surface 1,880 feet. From not having struck any coal, there was another bore-hole put down by the same company in the South Field. In this bore they passed through a seam of hard coal 12 feet thick, at 469 feet from the surface. This bore has been continued till the present time, and is 1,460 feet down. This bore shows a good prospect, and is very encouraging.

" *Oyster Harbor Coal Company.*—Exploration with two diamond drills have been in progress at Oyster Harbor and Chemainus Bay during nearly the whole of this year. The first bore, commenced in January, was put down at the head of Oyster Harbor, on the north-west side, and pierced a depth of 1,300 feet through sandstone and shale, and was stopped in a fine-looking sandstone. The rocks at this place are tilted at a high angle, the cores from the bore showing a dip of some 25 degrees. While in process of boring, inflammable gas extended from this hole in sufficient quantity to burn with a bright flame when a match was applied.

" A second bore was started on the eastern side of the harbor, which, after going down 690 feet, was stopped for want of water. The stream which fed the drill dried up and the machinery was removed.

" A third hole was bored on the north-west side of Chemainus Bay, close to the water's edge. This hole was sunk to a depth of 1,600 feet, using up all the rods available, and operations were suspended. The rocks, as shown by the cores, which are sandstone, mostly, with shale bands, are all said to be of the right kind, and we may expect to hear more of operations in this neighborhood.

" At Chemainus Bay, after getting down 300 feet about, the measures were found to be lying horizontally, and very nicely bedded the whole depth of the bore.

" *Tumbo Island Coal Mining Company.*—This island, lying at the south-east entrance of the Straits of Georgia, is being prospected for coal by the above named company. They commenced by putting a bore-hole down close to the water's edge; in this they passed through about five feet of hard coal. This prospect so encouraged them that they went down to the dip and started to sink a shaft, in which they are now down fully 100 feet. They have a steam engine, pit head gear, and other necessary appliances. Owing to the location of this shaft being so far to the dip of the bore-hole they do not expect to get to the coal at less than about 600 feet from the surface. This is a large undertaking, and will take a large amount of capital to reach the coal and put everything in order. It is to be hoped that when they get the shaft down they will find the coal as good as expected."

Mr. R. Chalmers, who has been working up the surface geology of the southern part of New Brunswick, in drawing attention to the deposits of peat there, thus mentions a somewhat new use to which this material can be put :— New Brunswick.

"Peat Bogs are numerous and well developed near the Bay of Fundy coast and in many places inland. Those near Musquash, Popelogan and Digdeguash Rivers are quite extensive. Lying just east of Musquash Harbor is a bog, covering an area of 450 acres, and 20 feet in depth, which is now about to be utilized in the preparation of 'moss litter.' This is an article used in stables as bedding for horses. Owners of studs in the United States have for some time been looking for a material for this purpose sufficiently light and porous to be an absorbant of the liquids, moisture and ammonia which collect in stables, and which could afterwards be used as a fertilizer in gardens, etc. A few capitalists from St. John, St. Stephen and other places have formed what is known as the Musquash Moss Litter Company, and, having purchased this bog, are now erecting buildings and machinery there for the preparation of this article, which, it is claimed, is well adapted for the object intended, and as good as the imported European moss litter. The kind of peat used is not the upper or living peat, nor the deep-lying, decayed material, but that between the two, in which the mosses and rootlets are only partially decomposed, and which has the fibres nearly whole. The chief process in its preparation is depriving it of the water, of which it contains 90 to 95 per cent. This is done by a plunger, by pressing it between rollers and by evaporation. When thoroughly dried it is packed in bales for shipment, and is worth $15 to $17 per ton in the principal United States cities. This new enterprise promises to be successful."

COPPER.

The returns received at this office for this metal are unfortunately not quite complete, owing to the failure of one of the operators to send in a return. As, however, it is known that very little was done at this place, other than prospecting and development work, its absence will affect the grand total very little.

Production.

There were * 111,774 tons of ore marketed during the year, having a copper content of 6,809,752 lbs., which, calculated at an average price of 13c. on the ground, equals $885,424.

The above represents the production, outside of an included 28,000 lbs. from British Columbia mines, of some four operators in the Provinces of Ontario and Quebec. Besides the returns received from the above, three others were heard from who, whilst operating, were not producing, making a total of seven, giving employment to 1,035 men, to which must be added 39 returned as employed by the Coxheath Copper Mining Co., of Cape Breton, and an unknown number for the mines of British Columbia.

The above figures of production show a considerable increase over last year, when it was reported as 5,562,864 lbs. contained in 63,479 tons of ore.

Exports and Imports.

The exports and imports of copper for 1889 are given in the following tables :—

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

*Over 60 per cent of this amount was concentrated by smelting to the condition of matter ranging from 22 to 25 per cent in copper content and shipped in this form.

COPPER.

TABLE 2.

IMPORTS: PIGS, BARS, ETC.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario................	761,600	$130,730	1,003,538	$137,551
Quebec................	944,800	88,438	1,694,796	216,831
Nova Scotia.............	45,200	6,276	77,922	8,658
New Brunswick.........	5,100	1,291	......	9,642
Prince Edward Island....	400	63	3,200	404
Manitoba	......	......	95,562	18,371
British Columbia..	10,700	2,007	33,945	6,257
Totals.............	1,767,800	$228,805	......	$397,714

Note.—Under this heading are included the items specified by the Customs Department as follows,—"Bars, rods, bolts, ingots and sheathing not planished or coated." "Old and scrap," "pigs," "copper in sheets," "wire of copper, round or flat."

COPPER.

TABLE 3.

IMPORTS: MANUFACTURES.

Province.	1888.	1889.
Ontario	$41,748	$15,306
Quebec	79,763	17,909
Nova Scotia.............	4,710	3,935
New Brunswick..........	10,371	2,878
Prince Edward Island.....	76	54
Manitoba	2,592	1,660
British Columbia.........	4,654	3,779
Totals................	$143,914	$45,521

Note.—Under this heading are included the items specified by the Customs Department as follows:—"Seamless drawn tubing," "wire cloth," all other manufactures of, not elsewhere specified."

Development and Discovery.

The mining of copper has been carried on with considerable vigour the older districts continuing to produce as usual, viz., those of the eastern townships of Quebec, and of Sudbury, whilst a little development work was done in Nova Scotia. The main feature of note consists of the entry of a new producing district into the field, namely, that of Kootenay in British Columbia, the Toad Mountain group of mines in this district having shipped some 70 tons of argentiferous copper ore, consisting chiefly of the sulphurets, the copper content averaging 20 per cent.

Ontario.

Coming further west, we find an interesting discovery of a native copper-bearing area, reported by Dr. Lawson, of the Geological Survey staff, as having been examined by him, and occurring in the townships of Blake and Crooks on Thunder Bay. This is the more interesting as seeming to indicate a detached area of the Keweenian, or native copper-bearing formation proper of that region, in the midst of the higher Animikie or silver-bearing formation of Thunder Bay.

The other officers of the staff also indicate various interesting features from their several fields of work. Dr. Bell mentions the continued activity in the Sudbury district, where, besides the producing mines, a number are actively engaged prospecting and developing. He says :—" Five mines are in operation at present. Three of them are worked by the Canadian Copper Company, namely, the Stobie, three miles and a half north-north-east of Sudbury Junction, the Copper Cliff, three miles and a half south-west of the same point, and the Evans, one mile further south. The Dominion Mineral Company is working a mine situated about a mile north-east of the Stobie, and the Messrs. Vivian, of Swansea, are opening the Murray mine, on the main line of the Canadian Pacific Railway, three miles and a half north-west of Sudbury Junction.

" Two smelting furnaces, capable of reducing 300 tons of ore a day, are in operation at the Copper Cliff mine. One of them has been running without interruption for nearly a year. The other went into blast on the 4th September. Both the Dominion Mining Company and the Vivians are erecting similar blast furnaces."

Quebec.

Speaking of the eastern townships district, Dr. Ells says :—" The new mine of the Memphremagog Mining Company, lot 28, range ix., Potton, was examined. It shows a body of ore, mostly iron and copper pyrite, about sixteen feet thick, and extending for several hundred yards. This is capped by a considerable body of bog iron ore, which should be valuable if facilities for shipping and smelting were afforded. But little work, other than exploratory, has yet been done at this place."

Mr. Fletcher, speaking of the district on the north side of the Cobequid Hills, in Colchester County, Nova Scotia, speaks as follows : —" Reference has often been made to the grey sulphide and carbonate of copper found associated with carbonized plants in calcareous, concretionary beds among the grey sandstones of this formation, or as nodules in red and green marls. In many places, but particularly on Waugh River and French River, these ores have been largely but not profitably worked." Nova Scotia.

Little or nothing was done in the way of mining of this metal in this province, and that little was done at the Coxheath mines in Cape Breton, the operations being thus described by Mr. Gilpin, the Inspector of Mines for the province :—

" No work of note has been done this year, the failure of the French Copper Syndicate having upset all basis of price, etc. At the Coxheath mines the Eastern Development Company have, since the opening of their mine on what may be considered a working basis, turned their attention to preparations for building a railway and smelters. The county of Cape Breton has released them from taxation on all real and personal property for 25 years. At the mine a carpenter's shop, dynamite magazine and dryhouse have been put up. Below ground the shaft has been deepened about 50 feet, and more cross-cuts driven, which have proved the continuation in depth and quality of the valuable veins referred to in my last report. The ore extracted in the underground levels has been dressed, and the amount of ore now in stock is about 2,000 tons.

" During the summer explorations have shown a valuable vein about 1,500 feet south of the present workings. This vein is about 10 feet wide and runs 17 per cent. of copper, and holds per ton 5 dwts. gold, and ½ ounce of silver. The discovery has added greatly to the resources of the company "

GOLD.

Production.

The production of the above metal for 1889 shows an increase again, the quantities being 72,328 ozs., with a total value of $1,295,159, as against 61,310 ozs. and $1,098,610 for 1888. We have thus an increase of 11,108 ozs. and $196,549.

The following table gives the production by provinces :—

GOLD.

TABLE 1.

PRODUCTION BY PROVINCES.

Province.	Ozs.	Value.	Number of men.
British Columbia........	34,642	$588,923	1,929
Nova Scotia..............	26,155	510,029	682
Quebec.	60	1,207	26
North-West Territory (including Yukon District)	11,471	195,000	about 250
Totals................	72,328	$1,295,159	2,887

British Columbia.

Tables A. and B. and No. 2 give the details of the gold production of British Columbia, both for 1889 and the yield of past years, and are compiled from figures given in the official reports of the Minister of Mines for that province, which also gives the following figures of the value of gold exported by the banks at Victoria during 1889 :—

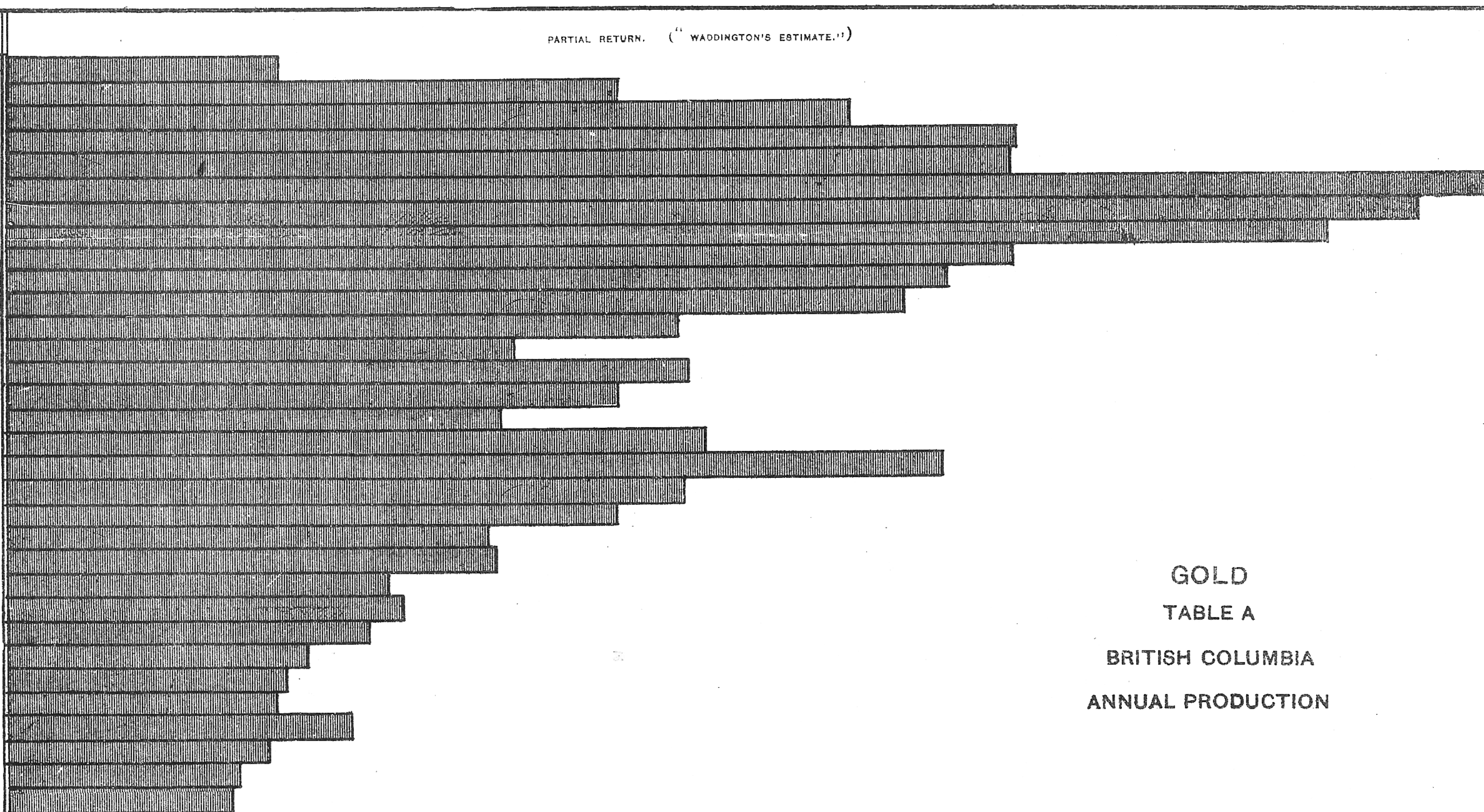
Bank of British Columbia........................	$254,816
" " British North America......................	47,373
Garesche, Green & Co............................	188,580
Total......................	$490,769

The graphic tables bring out many interesting features, the most noticeable being the considerable falling off in the product since the palmy days of 1863-1865. This is due to the fact that nearly all the gold is obtained from placer deposits, attention having been directed to the quartz ledges only quite recently, and the result has been as usual a continuous falling off of the amount of gold produced as the richer and more easily worked placer deposits become exhausted.

The data for tables A., B. and C. are taken from the "Mineral Wealth of British Columbia," by Dr. G. M. Dawson, Part R, Annual

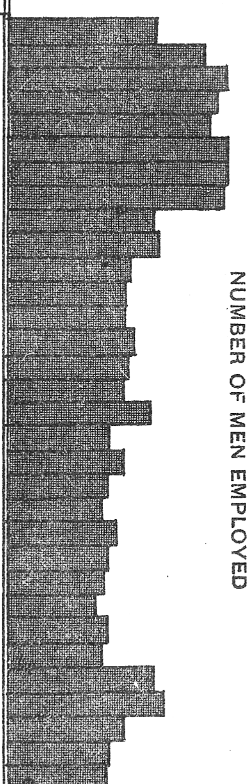
GOLD
TABLE A
BRITISH COLUMBIA
ANNUAL PRODUCTION

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



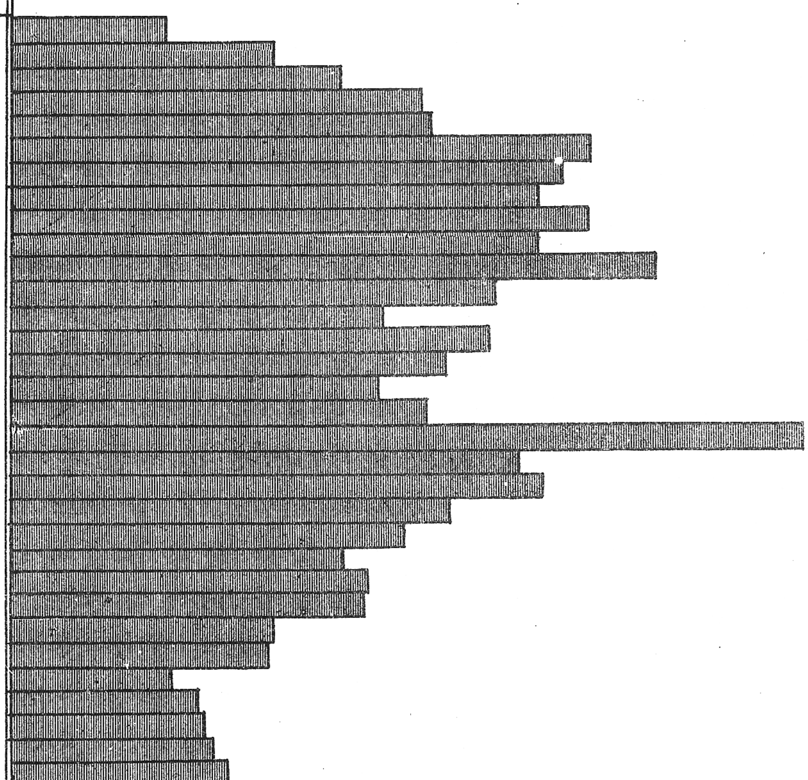
GOLD
TABLE C
BRITISH COLUMBIA
NUMBER OF MEN EMPLOYED

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	2007
1889	1,929



GOLD
TABLE B
BRITISH COLUMBIA
EARNINGS PER MAN

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



Report of the Geological Survey for 1887, with added figures for 1888 and 1889, which brings the total known and estimated yield of gold from 1858 to 1889 inclusive up to $54,697,727.

GOLD.

TABLE 2.

BRITISH COLUMBIA.

YIELD, ETC., BY DISTRICTS.

Districts.	Divisions.	Whites.	Chinese.	Yield of Gold by divisions.	Total yield by districts.
Cariboo......	Barkerville..........	89	181	$78,542	
	Lightning Creek......	28	134	41,150	
	Quesnellemouth	5	127	37,000	
	Keithley Creek.......	32	205	61,200	$217,892
		154	647		
Cassiar.......	....	33	64	54,910	54,910
Kootenay	Western..............	361	25	12,700	
	Eastern..	31	58	36,300	49,000
		392	83		
Lillooet......	....	30	150	60,364	60,364
Yale........	Osoyoos...............	137	57	10,500	
	Similkameen.	75	104	35,800	46,300
		212	164		$428,466
	Total Whites......	821	....		
	" Chinese.	....	1108		
	Total employed....	1,929			

The statistics for Nova Scotia are, as usual, furnished by the Inspector of Mines for that province, and as set forth in the tables D. and E. and Nos. 3 and 4 which follow, give necessary details relating to the industry there. Nova Scotia.

A comparison of table D. with table A. shows some interesting points of difference, but it must be borne in mind that the scale of the former is twice that of the latter. The gold of Nova Scotia is altogether obtained from veins, so that we find no general falling off as in British Columbia.

The addition of the figures for this year brings the totals for the 28 years from 1862 to 1889 inclusive up to the following figures :—Total tons of quartz crushed, 660,407. Total ounces yielded, 482,190. Total value of same at $19.50 per oz., $9,402,697.

GOLD.

TABLE 3.

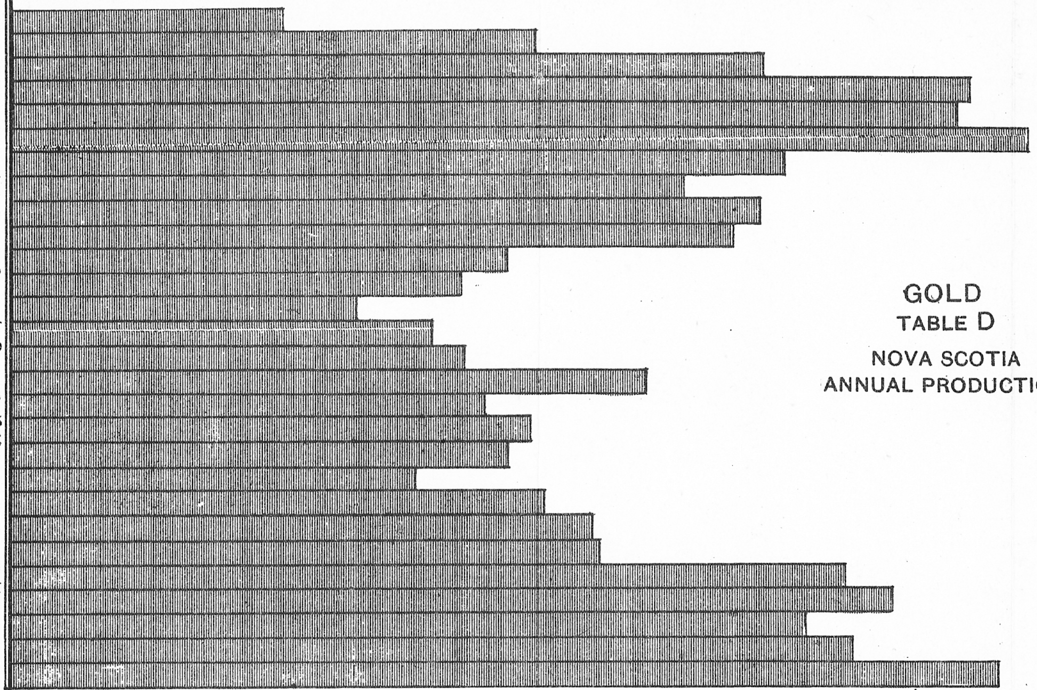
NOVA SCOTIA.

DISTRICT DETAILS.

Districts.	Number of mines.	Days' labor.	Mills.	Tons of quartz crushed.	Yield per ton.			Maximum yield per ton.			Total yield of gold.		
					oz.	dwts.	grs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.
Brookfield	1	4,688	2	1,472	1	4	9	1	19	13	1,796	17	18
Caribou and Moose River	4	20,819	5	7,338	0	5	4	0	7	12	1,906	1	10
Fifteen Mile Stream	1	3,634	1	1,416	0	11	2	0	14	6	786	9	0
Lake Catcha	1	10,764	2	807	0	15	1	2	9	10	607	10	0
Malaga Barrens	2	28,686	2	4,388	0	18	2	1	5	13	3,976	3	13
Montague	2	10,286	3	953	1	19	21	26	11	20	1,901	10	6
Oldham	1	8,405	1	1,391	1	18	22	5	11	18	2,709	0	18
Rawdon	1	7,192	2	925	2	10	23	3	18	19	2,358	10	0
Renfrew	2	8,141	2	1,070	0	13	1	1	15	18	697	17	15
Salmon River	1	17,393	1	7,633	0	5	7	0	7	14	2,032	14	0
Sherbrooke	2	5,257	4	1,618	0	3	0	0	3	21	243	17	17
Stormont	2	16,319	1	2,925	0	11	22	0	15	19	1,745	6	0
Tangier and Mooseland	1	3,168	2	427	0	5	6	0	15	9	112	4	12
Uniacke	2	13,207	3	2,296	0	12	2	4	15	0	1,390	11	9
Whitburn	4	28,593	2	1,639	1	9	18	2	3	15	2,440	15	18
Wine Harbor	1	2,355	2	707	0	11	17	1	0	0	413	18	6
Unproclaimed, &c	5	22,541	15	2,155	0	9	14	0	19	14	1,035	18	15
Totals	33	211,548	50	39,160	0	17	22	26	11	20	26,155	6	13

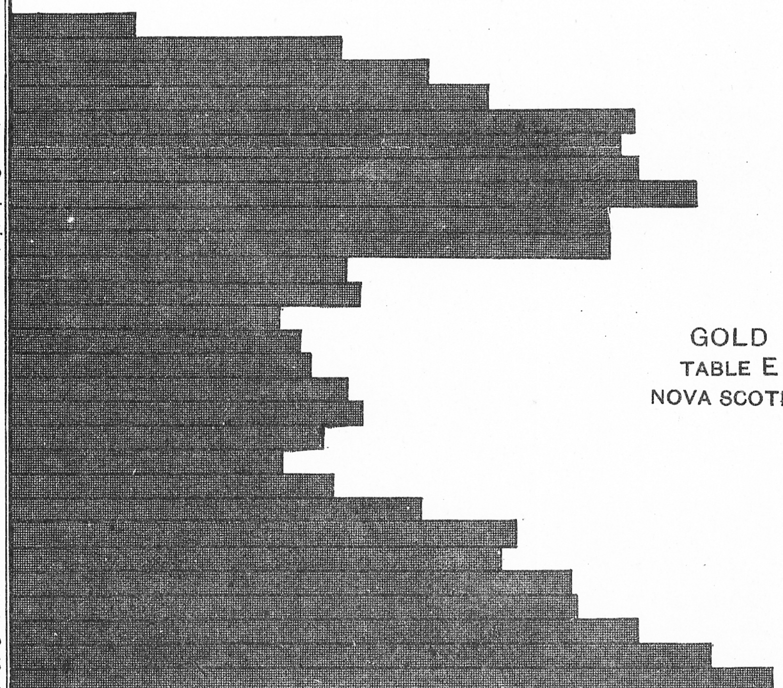
GOLD
TABLE D
NOVA SCOTIA ANNUAL PRODUCTION

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



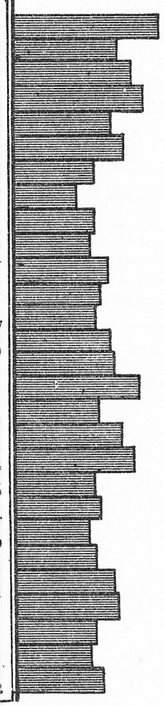
GOLD
TABLE E
NOVA SCOTIA

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



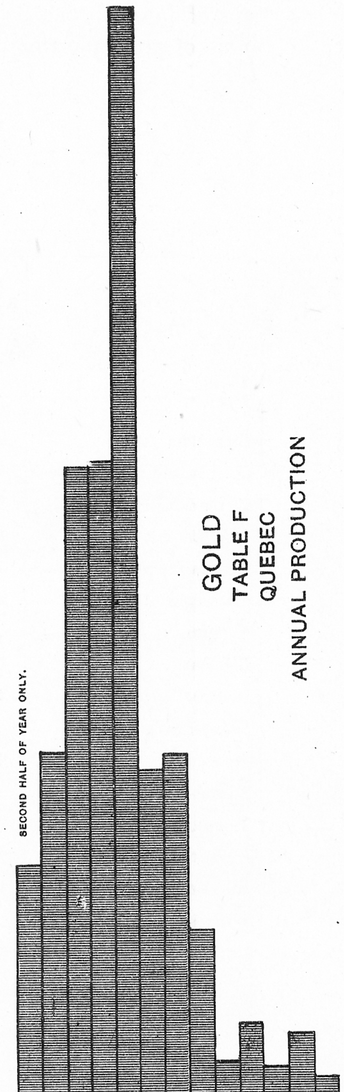
TONS OF QUARTZ CRUSHED.

YEAR	VALUE
	$
1862	21.9
1863	16.02
1864	18.11
1865	20.32
1866	15.28
1867	16.96
1868	12.41
1869	9.91
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



AVERAGE YIELD OF GOLD PER TON (2000 LBS.) CRUSHED

GOLD
TABLE F
QUEBEC ANNUAL PRODUCTION



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

Gold.

Table 4.

Nova Scotia.

Production of the Different Districts from 1862 to 1889 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	37,298	22,241	12	5	$433,711	$11.63
Montague	14,781	30,318	10	16	591,211	39.99
Oldham	37,025	38,467	12	7	750,118	20.27
Renfrew	45,311	31,561	2	14	615,441	13.58
Sherbrooke..........	165,831	119,648	4	2	2,333,140	14.09
Stormont.	21,184	22,623	18	17	441,165	20.82
Tangier............	29,122	19,126	15	18	372,970	12.80
Uniacke.	34,828	20,238	14	15	394,656	11.33
Waverley...........	89,572	53,391	7	14	1,041,131	11.62
Salmon River........	28,160	8,645	4	0	168,582	5.98
Brookfield	3,163	3,214	19	9	62,691	19.80
Whiteburn..........	4,025	7,545	12	15	147,139	36.55
Lake Catcha........	3,019	5,851	11	3	114,105	37.79
Rawdon	8,987	6,818	19	4	132,970	14.79
Wine Harbor.......	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......	5,484	2,691	8	23	52,484	9.57
Malaga.............	4,388	3,976	3	13	77,535	17.67
Unproclaimed, etc...	48,345	39,171	6	8	763,841	15.79
Totals.........	660,407	482,190	0	11	$9,402,697	$14.24

The item of $195,000 for the North West Territories and the Yukon Territory is made up from estimates kindly furnished me by residents. N. W. T. and Yukon Districts.

The amount from the former district is put at $20,000, and this is considered a low estimate. It is all washed out of the Saskatchewan

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River in the neighbourhood of Fort Saskatchewan and Edmonton by a certain number of regular miners, and also by the farmers of these districts at odd intervals whenever they have a little spare time.

Quebec.

Table F. shows the gold produced from the Chaudiere district for several years, which, coming from placer and river workings, shows a similar falling off to that shown in the British Columbia table. The figures represent the amounts of gold obtained as reported to the Mining Inspector for the province up to 1886, the last three years being from direct returns to this office. The figures can, however, only be taken as approximately correct. Table F is drawn to the same scale as table A.

Exports.

The exports of gold bearing quartz, dust, nuggets, etc., as given in the books of the Customs Department are set forth in table 5.

GOLD.

TABLE 5.

EXPORTS.

Province.	1887.	1888.	1889.
Ontario	$ 6,650	......	$ 2,660
Nova Scotia	321,379	$163,412	191,671
Manitoba	......	50	261
British Columbia	592,300	464,696	414,658
Totals	$920,329	$628,158	$609,250

Imports.

The Customs Department books make no distinction between gold in ore or bullion, so that the imports of gold ore, if any, cannot be ascertained.

With regard to the progress in the mining for this metal for the year, the main features for the different provinces are as follows :—

British Columbia.

As gleaned from the report of the Minister of Mines for British Columbia, placer mining is still the main source of the metal, although it is beginning to be neglected to a certain extent, and more attention is being turned to prospecting for veins and their development. This is more especially the case amongst the white miners, as distinguished from the Chinese, and is also more marked in some districts. More seems to have been done in this respect in the S. E. part of the province in the district of Yale, and especially in E. and W. Kootenay.

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The greater number of the veins found lately in these districts are rather silver than gold veins, although the ores carry a little of the latter metal and in a few cases to a considerable value.

Besides the gold occurring in this way other discoveries of gold-bearing veins and deposits have been found, of one of which Dr. Dawson speaks as follows :—

" At the east end of Toad Mountain, a wide belt of rusty schistose rocks, containing more or less quartz and much iron pyrites, has been discovered. The superficial portions of this belt have been completely oxidized and afford free-milling gold. This property has been acquired by an English company, known as the Cottonwood Company, and a Huntingdon mill has been erected for the purpose of treating, in the first place, the decomposed surface material, of which there is, in the aggregate, a great quantity in sight. The results of trials so far carried out have not been made public. Should it prove, however, that the deeper pyritous portion of the deposit contains sufficient gold to pay for concentration, roasting and chlorination, the quantity of the ore appears to be almost unlimited. Another gold-bearing deposit, in the form of a well-defined vein traversing a granite rock, is situated on Eagle Creek, toward the west end of Toad Mountain. Work is being carried on here and a stamp mill is in process of erection."

The erection of smelting works at several places throughout the province ought to materially assist the development of the vein mining part of the industry. The Provincial Government has erected one at Barkerville to work and test the ores of the Cariboo District This commenced work on July 22nd and was operating at the close of the year. Another was erected at Revelstoke on the C. P. Railway, and arrangements are being made for the erection of a third at Golden, some distance further east on the same railway, to both of which the districts of East and West Kootenay will be tributary.

Gold was as usual obtained from the Yukon River district, where it is estimated some 175 miners worked during the season, whilst the estimated product from the Saskatchewan River, near Edmonton and Fort Saskatchewan, resulted from the work of about 75 miners supplemented by the spasmodic efforts of the farmers of the vicinity.

Mr. McConnell, speaking of his work for the Survey on the Peace River above Lake Athabaska, says :—" Gold was found in many of the bars along Peace River and in several places in sufficient quantities to deserve some attention. Four miles above the mouth of Battle River is a large bar, nearly a mile long, from which we obtained fifteen or twenty *colors* of fine gold by washing a few handfulls 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 1,000 feet wide, the bar might be easily and inexpensively worked on a large scale. A few miles further up the river another bar was examined which yielded from twenty to forty *colors* when washed in the way just mentioned.

" A couple of *colors* of gold were washed out in one place on Loon River. This is of some interest as the Loon heads in a south-easterly direction, and has no connection whatever with the mountains."

Ontario.

Beyond some prospecting for gold veins, and a little testing work on those already found in the Lake of the Woods, Lake Shebandowan, Lake Superior, North Shore of Lake Huron and Sudbury districts, there is nothing to report from this province. Nothing was done around the Madoc and Marmora districts of Hastings County.

Quebec.

In this province, nothing was done beyond a little washing of the alluvions of the Counties of Compton and Beauce.

Nova Scotia.

The industry in this province continues about the same as in other years, presenting no particular features of interest.

GRAPHITE.

The production of this mineral for the year 1889 amounted to 242 tons with a value of $3,160, As compared with the figures for the previous year, this shows an encouraging increase, that period showing only 150 tons, valued at $1,200. Production.

This is largely due to the resumption of activity at the mines of the Walker Plumbago Mining Co., in Ottawa County, P.Q., the balance being produced at two other mines, one situated in the County of Argenteuil, P.Q., and the other near St. John, N.B.

It is hoped that the returns for this mineral will make a much better showing next year, as the Walker mines have been prepared for extensive work. The mill has been thoroughly renewed and renovated and the prospects of the mine are good.

The returns give the number of men employed in the industry altogether as 40, but these were only employed part of the year.

GRAPHITE. Exports.

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

No graphite is entered in the books of the Customs Department as exported from any of the other provinces.

The following tables show the imports of the various products of plumbago :— Imports.

Imports.

GRAPHITE.

TABLE 2.

IMPORTS OF RAW AND MANUFACTURED PLUMBAGO.

Province.	Plumbago.		Manufactures of Plumbago.	
	1888.	1889.	1888.	1889.
Ontario.................	$1,170	$1,220	$6,811	$9,428
Quebec	2,859	1,449	8,811	7,240
Nova Scotia.............	1,066	......	4,831	......
New Brunswick.........	......	7	3,116	1,591
Prince Edward Island....	......	......	17	......
Manitoba.................	35	24	517	589
British Columbia........	118	84	465	942
Totals..............	$5,248	$2,784	$24,568	$19,790

GRAPHITE.

TABLE 3.

IMPORTS OF BLACKLEAD.

Province.	1888.	1889.
Ontario	$3,811	$3,555
Quebec	3,349	687
New Brunswick	2,254	3,335
Prince Edward Island....	315	906
British Columbia........	142	304
Totals......	$9,871	$ 8,787

GRAPHITE.

TABLE 4.

IMPORTS OF LEAD PENCILS, IN WOOD OR OTHERWISE.

Province.	1888.	1887.
Ontario	$29,720	$30,896
Quebec	20,218	18,381
Nova Scotia............	2,655	2,800
New Brunswick.........	3,017	2,665
Prince Edward Island....	85	62
Manitoba	1,180	1,533
British Columbia........	1,010	963
Totals.	$57,885	$57,300

GYPSUM.

Production.

As in previous years the output of the gypsum mines was gathered from direct returns for Ontario and New Brunswick, whilst the exports as declared to the Customs Department have had to be taken as representing the production of Nova Scotia. We have thus, by direct returns, 48,248 tons, valued at $62,258, to add to exports 165,025 tons and $142,850, giving 213,273 tons and $205,108 as the total amount and value of the gypsum produced in Canada.

The direct returns received from New Brunswick and Ontario show the number of operators to have been 7, employing altogether 233 men.

The figures in the following table 1, represent the total production of all the products of gypsum reduced to terms of the crude material as to quantity and value.

GYPSUM.

TABLE 1.

PRODUCTION.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Nova Scotia.....(exports)	124,818	$120,429	165,025	$142,850
New Brunswick..........	44,369	48,764	40,866	49,130
Ontario	6,700	10,200	7,382	13,128

Land Plaster.

Of the above amount of crude gypsum a certain amount was converted into land plaster by grinding fine.

The direct returns received from New Brunswick and Ontario show the following amounts :—

New Brunswick..............	1,200	tons valued at	$ 3,000
Ontario	5,210	" " "	13,025
Total...............	6,410	"	$16,025

Plaster of Paris.

A further amount was converted into Plaster of Paris, producing 61,601 bbls. as follows:—

New Brunswick............	54,000	bbls. valued at	$81,000
Ontario....................	7,601	" " "	11,402
	61,601		$92,402

The exports and imports as compared with last year are set forth in the following tables :— Exports and Imports.

GYPSUM.

TABLE 2.

EXPORTS.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario	670	$910	483	$692
Nova Scotia	124,818	120,429	146,204	142,850
New Brunswick	20	50	31,495	50,862
Totals	125,508	$121,389	178,182	$194,404

Besides the above there were exported as follows small quantities of ground gypsum, as specified by the Customs Department :—

Ontario to the value of	$ 12
Quebec " " "	760
Total	$772

Small quantities of crude gypsum were reported into Ontario and Quebec as follows :—

Ontario	1,050	tons	valued	at	$1,928
Quebec	175	"	"	"	200
Total	1,225	"	"	"	$2,128

GYPSUM.

TABLE 3.

IMPORTS OF GROUND GYPSUM.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario	56,502	$261	54,040	$243
Quebec	2,400	9	2,000	10
New Brunswick	31,500	70	6,100	17
Manitoba	300	4	......	......
British Columbia	......	......	200	15
Totals	90,702	$344	117,240	$285

GYPSUM.

TABLE 4.

IMPORTS OF PLASTER OF PARIS.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario..................	310,407	$1,749	245,804	$1,389
Quebec	400	2	300	4
Nova Scotia................	2,600	17	4,170	47
New Brunswick..........	40,700	190	89,550	509
Prince Edward Island....	400	3	300	7
Manitoba	132,900	585	289,500	1,401
British Columbia........	390,913	3,682	614,305	6,398
Totals......	878,320	$6,228	1,243,929	$9,755

British Columbia.

Dr. Geo. M. Dawson in his preliminary report on his work in British Columbia calls attention thus to the discovery of this mineral hitherto unknown in the province. He says it has lately been discovered, and, "according to the accounts received, in large quantity. The locality is stated to be on the Salmon River, about twenty miles distant from the railway. From the excellent quality of the specimens which I have seen, this discovery may prove to be of importance."

Nova Scotia.

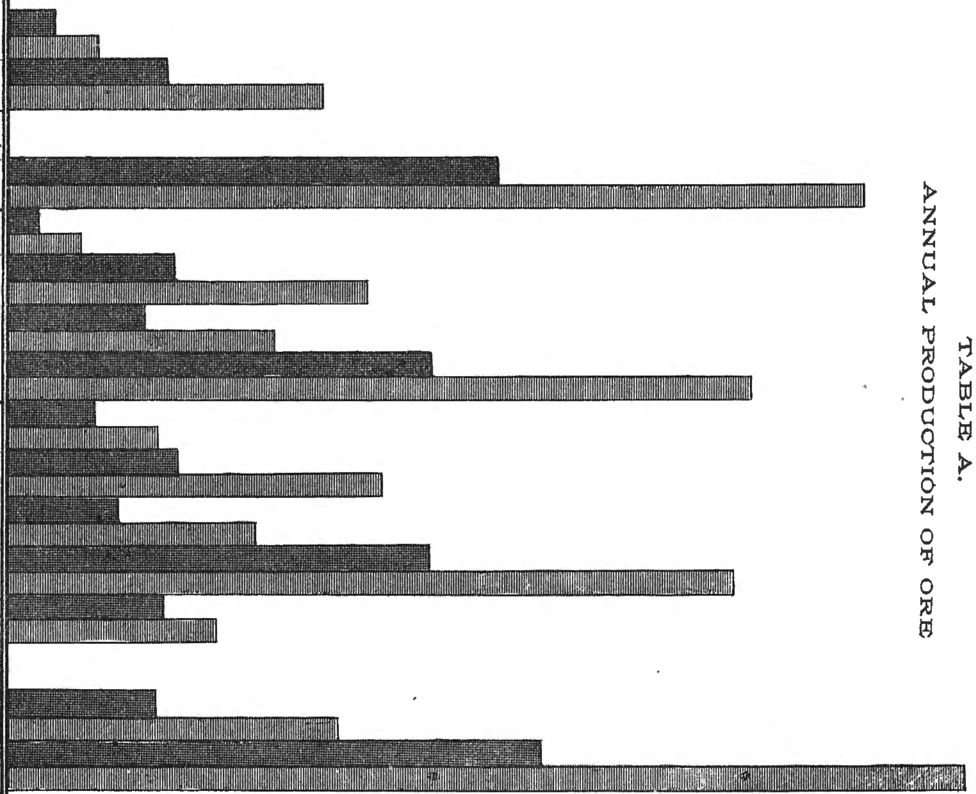
Mr. Faribault also calls attention to some extensive deposits of the same in Halifax and Colchester Counties, Nova Scotia, in the following words :—

"Narrow basins of lower carboniferous rocks extend along the Musquodoboit, Gay's, Stewiacke and St. Andrew's Rivers, containing large deposits of gypsum and limestone, and lie unconformably upon the sharply folded auriferous rocks of the lower Cambrian."

Plate VI.

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
1888	B.C.	2,796	6,990
	ONT	16,598	36,218
	QUE	13,404	26,808
	N.S.	43,532	76,181
1887	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



IRON.

(ORE.)

The total amount of iron ore produced throughout Canada was as follows :— Production.

1888	78,587	tons valued at	$152,068	
1889	84,181	" " "	151,640	
Increase	5,594	Decrease	$ 428	

It will be noticed that whilst there is an increase in tonnage, there is a decrease in values. This is due to the facts that none of the higher priced Ontario ores are included, and that some of the other returns give a lower price for their ores this year than last.

The graphic table A. appended, shows the proportions between the production of the different provinces for the past four years.

The report of the Department of Mines of Nova Scotia gives the following details as to the production in that province :— Nova Scotia.

Londonderry	41,619	tons.
Bridgeville, Pictou Co	*3,156	"
Brookfield, Colchester Co.	1,732	"
Newton Mills, Colchester Co	400	"
	46,907	"

The production of iron ore, year by year, is as follows :—

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

The exports are given in the following table No. 2. No iron ores are imported :—

IRON.

TABLE 2.

EXPORTS OF ORE.

Province.	1887.		1888.		1889.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario....................	12,244	$38,990	3,1161	$36,397	4,108	$10,407
Quebec	38	119	10	380	....	2,700
Nova Scotia............	....	....	....	....	....	100
British Columbia........	1,410	3,525	7,300	18,400	13,335	26,680
Totals..............	13,692	$42,634		$55,177		$39,887

British Columbia.

The mine on Texada Island in Puget Sound continues to produce ore and ship it to their works in Irondale in Washington Territory, U.S.A., where it is smelted into pig iron.

There does not seem to have been great activity in the matter of new discoveries, although in the report of the Provincial Department of Mines reference is made to a discovery of iron ore near Golden, on the C. P. Ry., and a discovery of magnetic iron ore on the Kootanie River, near Forty-nine Creek, is spoken of by Dr. Dawson as "a peculiar and apparently important occurrence of magnetic ore on the same" (North) "side of the river below the lower falls."*

North West Territories.

Mr. McConnell, of the Survey Staff, speaking of the country adjacent to the upper part of the Peace River above Lake Athabasca, says :—

"Clay iron stone is of universal occurrence in the Cretaceous shales exposed along the Peace Valley, and, in many places between Battle River and the mouth of the Smoky forms thick accumulations at the foot of the cliffs lining the valley, some of which may prove to be of economic value."

Manitoba.

The iron ore deposit on Black Island, in Lake Winnipeg, is described by Mr. J. B. Tyrell, as showing an outcrop for about 300 feet along the S. E. shore of the island, in a cliff that rises from the beach. It rises to a height of seven feet above the water, and dips inland about 30°. It occurs in an area of green cericitic schists and quartzite, presumably Huronian.

* See Vol. IV. Annual Report, Geological Survey (1890), page 65 B, for further details.

Speaking of the nature and quality of the ore, he says :—

"The ore is a more or less pure hematite, not very compact on any of the exposed surfaces, and with numerous little seams and particles of crystaline calcite scattered throughout the mass, along with which are also a number of small lenticules and crystals of quartz. In some places, especially near the outside of the mass, the hematite assumes quite a pisolitic or botryoidal structure, the spherules being often arranged in very well defined rows, the interspaces of which are filled with calcite.

"Towards the outside of the mass in places the ore has been converted for from a few inches to a foot into a hydrated oxide of iron or limonite.

"No analyses have yet been made of the typical specimens collected during the past summer, but a number of analyses have been made of specimens previously sent in from Black Island, both in the laboratory of the Geological Survey of Canada, and by Messrs. Gilchrist, Riley and Miller, in London, England.

"These show an amount of metallic iron ranging from 53.99 per cent. downwards. None were found to contain more than a trace of phosphorus. One specimen gave on analysis 2.026 per cent. of sulphur, the sulphur being present in the ore as finely disseminated iron pyrites, while three other specimens show respectively 0.07, 0.12 and 0.032 per cent. of this impurity. In the other five analyses the sulphur was not determined. No iron pyrites were seen in the general run of the ore, but indications of decayed nodules could be traced in a very few places as yellow incrustations on the surface of the rock, and two or three small nodules were seen lying loose at the bottom of the cliff."

Considerable interest still continues to be manifested in the iron ore deposits of the areas of Huronian rocks between Lake of the Woods and Port Arthur, and as soon as some of the various railways projected to open up this section are finished, it may be confidently expected that a flourishing iron mining district will be opened up there. Ontario.

In the Eastern Ontario districts, in the Counties of Victoria and Haliburton and those along the Central Ontario and Kingston & Pembroke Railway respectively, nothing but development and prospecting work has been done, so that there are no shipments of ore to report from this province.

In the province of Quebec, besides the operations carried on at the Bristol mine in Pontiac County, there were three other operators, the chief being, as in former years, the mining done in connection with the work at the Radnor Furnaces at Three Rivers and those at Drummondville. Quebec.

There are no reports to hand of any particularly important discoveries, although Dr. Ells records the following discoveries of interest, and says:—

"The new mine of the Memphremagog Mining Company, lot 28, range ix., Potton, was examined. It shows a body of ore, mostly iron and copper pyrite, about sixteen feet thick, and extending for several hundred yards. This is capped by a considerable body of bog iron ore, which should be valuable if facilities for shipping and smelting were afforded. But little work other than exploratory has yet been done at this place."

Nova Scotia.

The Department of Mines for Nova Scotia report as follows:—

"At Londonderry the returns show 40,823 tons of ore mined.

"On the East River of Pictou two companies have commenced preparations for mining and smelting iron ore, viz., The Nova Scotia Midland Railway Company and the New Glasgow Coal, Iron and Railway Company. The latter have turned their attention to the Limonite ores between Springville and Sunny Bræ and Mr. R. E. Chambers has developed some fine bodies of ore. About 3,000 tons of ore have been taken out during the progress of his work. One point tested on the D. McDonald property showed 25 feet of ore of excellent quality. The Midland Company did some work on the Specular areas belonging to Mr. Holmes. At Newton Mills, Stewiacke, the large bed of red hematite was tested by Mr. Chambers, and about 400 tons of ore taken out.

"At Brookfield, Colchester, about 1,700 were extracted for use at Londonderry. The vein was found too narrow going East, but going West it was proved to have a thickness of at least 30 feet.

"In the fall arrangements were made with a view to opening the Torbrook ores, in Annapolis County for use at Londonderry."

Mr, Hugh Fletcher, of the Geological Survey staff, gives the following further details:—

"During the past summer two companies began to work the iron ores of the East River of Pictou. One of these, under the management of Mr. H. V. Leslie, of New York, has begun the construction of a railway from Sunnybrae to New Glasgow, which is projected to extend to the harbor of Liscomb, on the Atlantic coast. The second company, under the management of Mr. Graham Fraser, of New Glasgow, has also surveyed a line of railway from the iron mines to the I. C. R., near the fork of the East River, and vigorously pushed the development of the mining areas. The mining has been done on a large vein of excellent limonite, which follows the contact of Silurian and Cambro-Silurian rocks with Carboniferous limestone in the valley of East River. The same company is also mining a vein of excellent red hematite at Newton Mills, Stewiacke, and another near Maitland. Other discoveries of red hematite havs lately been made in the hills at the head of French and Sutherland Rivers, in Pictou County."

MANUFACTURES.

The following table gives the details of the manufactures of pig iron as compiled from direct returns to this office :— Pig iron.

IRON.

TABLE 3.

PIG IRON PRODUCTION : CONSUMPTION OF ORE, FUEL, ETC.

Number of Furnaces in blast, 4.

Production and Consumption.	1888.		1889.	
	Quantity.	Value.	Quantity.	Value.
Pig Iron made............Tons.	21,799	$313,235	25,921	$499,872
Iron Ore consumed........ "	54,956	102,343	65,670	126,064
Fuel consumed. Charcoal—Bush.	804,286	41,800	755,800	41,568
Fuel consumed. Coke, Tons.	28,031	82,986	33,289	94,791
Fuel consumed. Coal, "	2,197	4,709	3,044	6,525
Flux consumed........... "	16,857	16,533	22,122	21,909

Men employed, 290.

Table 4 gives the imports of pig iron as given in the books of the Customs Department. According to their classification, however, it includes " Iron in pigs, iron kentledge, and cast scrap iron."

IRON.

TABLE 4.

IMPORTS OF PIG IRON, ETC.

Province.	1888.			1889.		
	Tons.	Value.	Duty.	Tons.	Value.	Duty.
Ontario........	26,939	$386,945	$107,748	41,900	$568,906	$167,606
Quebec	35,177	358,039	140,706	39,477	441,084	157,907
Nova Scotia....	3,310	36,432	13,242	4,734	56,064	18,858
New Brunswick.	2,321	51,587	9,282	1,855	36,957	7,414
P. E. Island....	....	....	....	12	160	47
British Columbia	586	7,602	2,348	1,381	16,875	5,526
Totals......	68,333	$840,605	$273,326	89,359	$1,120,046	$357,358

Iron and steel.

Table 5 gives a summary of the returns received from most of the chief operators in iron and steel throughout the Dominion; from the Nova Scotia Steel and Forge Co., the Londonderry Iron Works, and from eight rolling mills and forges. Unfortunately our returns still remain incomplete, as two firms known to have been in operation failed to reply. As the table for this year does not represent the same number of operators as last year, no attempt at comparison has been made.

IRON.

TABLE 5.

IRON AND STEEL MANUFACTURES.

Article made or consumed.	1889.	
	Tons.	Value.
Iron, all sorts, made..................	73,231	$2,763,062
Steel, all sorts, made.................	27,873	973,282
Puddled iron bars, consumed..........	9,028	293,185
Scrap and all other iron, consumed....	66,308	1,130,513
Scrap and all other steel, consumed....	32,189	628,269
Fuel, consumed........................	......	412,048

Men employed, 1,857.

The following tables, Nos. 6 to 15 inclusive, give the exports and imports of iron and steel of all sorts for 1889:— Exports and imports.

IRON.

TABLE 6.

EXPORTS OF IRON AND STEEL GOODS, MANUFACTURED IN CANADA.

Province.	Pig Iron.	Scrap Iron.	Iron Stoves.	Iron Castings.	Iron, all other and hardware.	Steel and manufr's of.	1889. Total.	1888. Total.
Ontario	$1	$13,443	$1,217	$ 3,326	$15,728	$ 6,964	$40,679	$ 35,266
Quebec	.....	1,239	1,085	4,451	50,768	9,027	66,570	110,086
Nova Scotia.....	......	......	507	408	7,721	6,278	14,914	29,178
New Brunswick.	......	.....	......	......	7,365	......	7,365	6,902
Prince Ed. Island	......	......	5	6	97	......	108	462
Manitoba..	......	......	489	35	325	810	1,659	1,305
British Columbia.	......	8,391	179	......	5,044	......	13,614	1,015
Totals	$1	$23,073	$3,482	$8,226	$87,048	$23,079	$144,909	$184,214

IRON.

TABLE 7.

IMPORTS: IRON IN SLABS, BLOOMS, LOOPS, AND PUDDLED BARS, ETC.

Province.	1888.			1889.		
	Cwt.	Value.	Duty.	Cwt.	Value.	Duty.
Ontario	113	$488	$51	74	$ 218	$ 33
Quebec	103,176	79,764	46,428	28,836	27,924	12,975
Totals	103,289	$80,252	$46,479	28,910	$28,142	$13,008

IRON.

TABLE 8.

IMPORTS OF SCRAP IRON AND SCRAP STEEL.

Province.	1888.			1889.		
	Cwt.	Value.	Duty.	Cwt.	Value.	Duty.
Ontario..................	85,904	$ 52,726	$ 9,878	167,777	$116,059	$19,540
Quebec..................	324,428	217,196	32,442	434,841	293,581	43,483
Nova Scotia............	33,751	18,010	3,300	77,521	47,405	7,552
New Brunswick.........	85,169	49,786	8,516	65,411	52,617	7,848
British Columbia.......	20	20	2	....	....	......
Totals.............	529,272	$337,738	$54,138	745,550	$509,662	$78,423

IRON.

TABLE 9.

IMPORTS: FERRO-MANGANESE, FERRO-SILICON, SPIEGEL, STEEL BLOOM ENDS AND CROP ENDS OF STEEL RAILS.

Province.	1888.			1889.		
	Tons.	Value.	Duty.	Tons.	Value.	Duty.
Ontario..................	2	$ 37	$ 4	......	......	......
Quebec..................	559	9,239	1,118	32	$ 629	$ 64
Nova Scotia............	2,957	34,506	5,914	3,223	47,457	6,447
New Brunswick........	30	493	60	3	55	6
Totals..............	3,548	$44,275	$7,096	3,258	$48,141	$6,517

IRON.

TABLE 10.

IMPORTS : ARTICLES WHOLLY OR PRINCIPALLY MADE OF IRON.

Articles.	Quantity.	Value.	Duty.
Bar iron, rolled or hammered......cwt.	186,604	$297,722	$121,644
Boiler plate and other plate........cwt.	43,579	75,554	28,330
Tacks, brads and sprigs................	75,641	4,703	1,488
Band and hoop iron..............cwt.	84,875	143,667	42,332
Iron bridges and structural iron work.lbs.	2,267,309	62,754	29,437
Nails, spikes and sheathing nails...lbs.	50,002	4,006	801
Nails and spikes, cut..............lbs.	234,982	7,738	2,349
Nails and spikes.................cwt.	1,508,190	44,520	23,277
Swedish rolled iron nail rods.......cwt.	169,334	255,425	7,432
Tubing of every description...........	....	442,921	135,302
1889 Totals..............	....	$1,339,010	$392,392
1888 Totals..............	....	$1,305,081	$516,924

IRON.

TABLE 11.

IMPORTS OF STEEL.

Articles.	Quantity.	Value.	Duty.
Wire of spring steel, coppered or tinned...cwt.	4,640	$ 13,608	$ 2,718
Steel ingots, blooms, slabs, billets, bars, etc., valued at 4 cts. or less, per lb..........cwt.	182,715	254,919	92,058
Steel, except the above.................cwt.	11,526	14,289	11,184
Steel, of greater value than 4 cts. per lb...cwt.	58,942	173,122	21,636
Axes	....	6,746	2,358
" Chopping	....	4,964	1,640
Saws................................	....	75,639	22,978
Locomotive tires. ....cwt.	20,862	40,526	Free.
Homo spring steel for mattresses..........lbs.	610,146	23,478	"
Steel for files.......................cwt.	2,660	13,611	"
" " skates.........................cwt.	819	3,226	"
" " saws and straw cutters..........cwt.	8,017	69,850	"
" " mower and reaper knives........cwt.	5,859	21,416	"
" " knobs, locks and cutlery ....cwt.	13,999	27,204	"
" " corsets, shoes and clock springs..cwt.	3,550	14,183	"
" " spades and shovels..............cwt.	2,193	8,282	"
1889 Totals..................	....	$765,063	$154,572
1888 Totals..................	....	$973,971	$222,487

IRON.

TABLE 12.

IMPORTS OF IRON AND STEEL.

Articles.	Quantity.	Value.	Duty.
Axles and springs of iron or steel........cwt.	4,487	$20,116	$ 8,822
Chains....................................cwt.	27,796	66,011	3,296
Iron or steel rivets, bolts, nuts, etc.......lbs.	85,086	6,312	100,359
Plate of iron and steel combined..........cwt.	17,070	23,984	7,255
Rolled iron or steel angles, etc............lbs.	1,649,657	26,303	10,724
Rolled iron or steel beams, etc...........cwt.	97,499	155,467	19,766
Rolled iron or steel beams for manufacture of bridges..........................cwt.	99,767	149,011	18,636
Screws, iron or steel, "wood screws"......lbs.	6,723	1,703	638
Sheet iron, including Canada plate.......cwt.	366,555	780,327	98,794
Wire fencing, barbed, iron or steel........lbs.	245,488	8,549	3,663
Wire fencing, buckthorn, strip, etc........lbs.	22,985	930	291
Wire, iron or steel, 15 gauge and coarser..cwt.	84,794	185,244	46,327
Wire rope, iron or steel, N.E.S...........cwt.	2,843	22,012	5,502
Wrought iron or steel nuts, bolts, etc......lbs.	1,927,192	95,781	43,201
Rolled round wire rods.................lbs.	149,677	218,260	Free.
Iron or steel beams for composite ships....lbs.	41,148	73,586	"
Wire, iron or steel, galvanized, 16 gauge or smaller ....lbs.	745,417	48,881	"
Wire rigging for ships..................lbs.	6,226	24,318	"
Wire, iron or steel for manf. of wire cloth..lbs.	487,400	23,118	"
Manufactures of iron or steel, N.E.S.......lbs.	....	946,496	283,948
1889 Totals..........................	....	$2,876,409	$651,222
1888 Totals..........................	....	$2,359,042	$452,051

IRON.

TABLE 13.

IMPORTS: CASTINGS AND FORGINGS.

Articles.	Quantity.	Value.	Duty.
Cast iron vessels, plate, &c............	....	$146,773	$ 43,660
Cast iron pipe....................cwt.	59,960	116,876	57,490
Forgings of iron or steel...........lbs.	326,851	15,315	6,312
Malleable iron castings..............	....	53,741	16,676
Stoves	....	18,172	5,480
Anchors	....	6,844	71,592
1889 Totals....................	....	$357,721	$201,210
1888 Totals....................	....	$549,561	$227,050

IRON.

TABLE 14.

IMPORTS: RAILROAD IRON AND STEEL.

Articles.	Quantity.	Value.	Duty.
Railway bars....................tons.	2,114	$ 60,829	$12,674
" fishplates ....tons.	3,465	96,601	41,590
Steel rails......................cwt.	2,026,805	2,449,029	Free.
1889 Totals....................	....	$2,606,459	$54,264
1888 Totals....................	....	$1,586,003	$49,327

In compiling table 15 for 1889, it has been decided to leave out the last item found in that table for the reports of previous years. This item represented highly finished articles, and although iron and steel entered largely into their composition, still a great variety of other substances being incorporated into their construction, the values given would give no fair idea of the real value of the iron and steel represented.

For purposes of comparison the totals of the same table for previous years, but with the said item deducted, have been annexed to the bottom of the table for 1889. It will be noticed that there is an encouraging and continuous growth of the market Canada offers for such goods.

IRON.

TABLE 15.

SUMMARY TABLE OF IMPORTS OF IRON AND STEEL.

Articles.	Value.	Duty.
Pig iron................	$1,120,046	$357,358
Slabs, blooms, etc........	28,142	13,008
Scrap iron and steel......	509,662	78,423
Ferro-manganese, etc....	48,141	6,517
"Iron"................	1,339,010	392,392
"Steel"...............	765,063	154,572
"Iron and steel"........	2,876,409	651,222
Castings and forgings.....	357,721	201,210
Railroad iron and steel...	2,606,459	54,264
1889 Totals............	$9,650,653	$1,908,966
1888 "	$8,076,528	$1,848,878
1887 "	$7,424,875	$1,307,886

MANGANESE.

Production.

The total amount of manganese marketed during 1889 amounted to 1,455 tons, valued at $32,737. This as compared with 1,801 tons and $47,944 for last year, shows a decrease of 346 tons and $17,207. Total hands employed about 83.

These amounts are altogether from the two provinces of Nova Scotia and New Brunswick, which contributed respectively 67 tons and 1,388 tons, valued at $3,947 and $28,790.

Nova Scotia.

From the report of the Inspector of Mines for this province, it is seen that there were only two mines operating, of which he gives the following report:—

" The returns show a falling off in the production of this mineral. Mr. John Stephens, of the Tenny Cape Mine, Hants County, returns a production of 81 tons of No. 1 ore, of which 36 tons (valued at $2,178) were shipped. An average of 5 men and 2 boys were employed.

" Mr. Moseley, of Sydney, sold 31 tons from his Loch Lomond mine, guaranteed 90 per cent., and some highly crystallised. An analysis of the ore from this mine yielded the chemist of the Geological Survey:—

" Available per oxide manganese	91.84
Per oxide of iron	.12
Insoluble residue	2.11

" I am not aware of any fresh discoveries of this ore of importance."

The production for this year thus shows a considerable falling off from that of 1889, when it was returned as 106 tons, a difference of 39 tons.

New Brunswick.

Returns were received from eight owners of mines. Of these, three made sales, two were prospecting and testing, and the remainder reported nothing doing this year.

Exports and Imports.

The following tables, Nos. 1 and 2, gives the exports and imports as compiled from the books of the Customs Department:—

MANGANESE.

TABLE 1.

EXPORTS OF ORE.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Nova Scotia.............	87	$ 5,759	59	$ 3,024
New Brunswick.........	1,094	16,073	1,377	26,326
Totals.............	1,181	$21,832	1,436	$29,350

MANGANESE.

TABLE 2.

IMPORTS : OXIDE OF MANGANESE.

Province.	1888.		1889.	
	Lbs.	Value.	Lbs.	Value.
Ontario....	18,893	$ 739	26,485	$1,168
Quebec	34,091	1,533	40,191	1,608
Nova Scotia...........	2,144	151	1,135	57
British Columbia........	10	1	......	......
Totals............	55,138	$2,424	67,811	$2,833

MICA.

The direct returns received of the production of the mineral for 1889, being incomplete, it is thought inadvisable to reproduce them here.

Exports. There were 36,529 lbs. of cut mica exported, with a declared value of $28,718. These figures show an increase over the previous year of 14,678 lbs. and $7,591.

The value of the ground mica returned as exported amounts to $1,879.

The productive operations in mining for mica have been almost altogether confined to Frontenac Co. in the Eastern Ontario mineral district.

MINERAL PIGMENTS.

Production. There were 794 tons of mineral paint produced, worth $15,280, as per direct returns. No returns were received for Barytes and Whiting, which have been included under this heading in the past. Thirty-five men were employed in this industry.

Exports and Imports. There were 40 tons of barytes entered as exported during 1889 from Ontario, valued at $80. As there was no production reported, this probaby represents a sale made last year but not reported until this.

The imports are given in the following tables :—

MINERAL PIGMENTS.

TABLE 1.

IMPORTS OF PAINTS.

Variety.	Lbs.	Value.
Fire-proof paint, dry	269,059	$ 2,974
Paint ground in oil or any other liquid	....	101,209
White and red lead and orange mineral, dry	8,875,013	313,971
White lead in pulp, not mixed with oil	....	1,325
Ochres, dry, ground or unground, washed or unwashed, not calcined	1,276,153	11,138
Zinc, dry white	670,412	23,782
Other paints and colors, N.O.P.F	....	78,952

MINERAL PIGMENTS.

TABLE 2.

IMPORTS OF BARYTA.

Province.	1888.		1889.	
	Cwt.	Value.	Cwt.	Value.
Ontario.................	625	$427	361	$295
Quebec.................	17,810	756	460	236
New Brunswick..........	....	....	46	80
Totals.............	18,435	$1,183	867	$611

MINERAL PIGMENTS.

TABLE 3.

IMPORTS OF LITHARGE.

Province.	1888.		1889.	
	Cwt.	Value.	Cwt.	Value.
Ontario	3,793	$17,459	4,885	$14,713
Quebec..................	3,889	13,832	2,906	9,790
New Brunswick.........	2	9	......	......
Manitoba	20	88	20	85
British Columbia........	?	44	9	64
Totals..............	7,704	$31,432	7,820	$24,652

Mr. Fletcher, in his preliminary report of his work in Pictou County, Nova Scotia. refers to the occurrence of veins of barytes occurring in the rocks of the north side of the Coquebid Hills, and says :—

"Barytes was quarried to some extent in the grey sandstone of Hodson, near River John, some years ago, but at present none of the known deposits are being worked, and none of them perhaps warranting a large expenditure for exploitation."

The operations on the large vein on McKellar's Island, in Thunder Ontario. Bay, which were carried on formerly, but suspended, were not carried on during 1889, although it is reported that arrangements are being made to mine there during 1890.

MISCELLANEOUS.

Production.

The following table, No. 1, gives the production of the various substances coming under this head for 1889 :—

MISCELLANEOUS.

TABLE 1.

PRODUCTION.

Product.	1888.		1889.	
	Quantity.	Value.	Quantity.	Value.
Glass and Glassware..........	......	$375,000	......	$150,000
Lead (fine, contained in ore)...	674,500 lbs.	27,472	165,100 lbs.	6,604
Mineral waters	124,850 galls.	11,456	424,600 galls.	37,360
Moulding sand..............	169 tons.	845	170 tons.	850
Platinum....................	1,500 ozs.	6,000	1,000 ozs.	3,500
Soapstone......	140 tons.	280	195 tons.	1,170

Lead.

The figures given under this head represents the amounts contained in the shipments of the argentiferous lead ores made from the West Kootenay mining district, as given in the report of the Minister of Mines for British Columbia.*

Considerable activity is being shown in this district and appears likely to be continued in the future, especially when the means of communication are improved. The discoveries already made are reported, on good authority, to be of deposits of considerable extent, so that British Columbia may be expected in a few years to much assist in bringing Canada to its proper place amongst the lead producing countries of the world.

Outside of a little prospecting and testing work on veins in a few other districts of the Dominion, there is nothing to report in regard to this metal.

Mineral Waters.

The amount shown is the produce of Quebec and Ontario, and represents, as formerly, the quantity sold, apart from that used in the sanitariums, situated at some of the springs.

Mr. Chalmers, of the Survey, speaking of his work in New Brunswick, makes mention of the following occurrences :—

* For furthur details respecting these ores, see the article on silver in this report.

" Medicinal springs are met with at Apohaqui and at Havelock Corner, King's County. The one at the former place, which is situated about a mile from Apohaqui station, Intercolonial Railway, has attained quite a reputation for its therapeutic properties. It is an alkaline water, and is said by chemists to resemble the famous Vichy water, and also to be a natural emulsifier. Favorable mention has been made of it in the *Canada Medical and Surgical Journal*, and it has been used in the General Public Hospitals of Montreal and St. John, N.B.

" The Havelock mineral water has, for some years, had a local reputation as a remedy for certain diseases; and as an extensive deposit of mud surrounds the spring, it might be utilized for the establishment of 'mud baths,' which are said to be beneficial in the treatment of some diseases."

Platinum. The amount and value given for this mineral is taken from the report of the Minister of Mines for British Columbia, where it is obtained in working the placer deposits for gold. This is the only part of Canada that has produced it so far, although it is reported as being also obtained at the gold washings of the Saskatchewan River, N.W.T. Mr. Greisbach, writing us from Fort Saskatchewan, gives as his opinion that, " There is a good deal of platinum found with the gold, but the miners, from ignorance of its value, or whatever cause, do not trouble to save it."

With regard to the uses of this metal, an interesting point is commented on in a recent issue of the " Photographic Art Journal, of London, Eng., where they allude to the increasing use of the platinum process, and the scarcity of the metal for such use.

Soapstone. This is altogether the produce of some three operators in the Province of Quebec, where it is obtained in the asbestus mines.

Exports and Imports. The following tables, Nos. 2 to 11, give the exports and imports of the various substances included under the head of miscellaneous :—

MISCELLANEOUS.

TABLE 2.

IMPORTS OF CHALK.

Province.	1888.	1889.
Ontario....	$2,757	$2,942
Quebec	2,060	2,087
Nova Scotia..........	257	320
New Brunswick.........	584	538
Prince Edward Island....	9	24
Manitoba	216	182
British Columbia........	53	76
Totals..............	$5,936	$6,169

MISCELLANEOUS.

TABLE 3.

IMPORTS OF GLASS AND GLASSWARE.

Description.	1888.	1889.
Carboys, demijohns, bottles and decanters, flasks and phials, telegraph and lightning rod insulators, jars and glass balls, and cut, pressed, or moulded table ware	$175,471	$116,156
Flasks and phials of eight ounces capacity and over. telegraph and lightning rod insulators, jars and glass balls, and cut, pressed, and moulded table ware	185,406	213,817
Lamp and gas-light shades, lamps and lamp-chimneys, side-lights, and head-lights, globes for lanterns, lamps, and gas-lights	188,217	208,298
Ornamental, figured, and enamelled stained glass	8,311	6,967
Stained, tinted, painted, and vitrified glass and stained glass windows, figured enamelled, and obscured white glass	12,306	22,598
Common and colorless window glass	351,550	296,778
Coloured glass, not figured, painted, enamelled, or engraved	1,958	6,458
Photographic dry plates	9,646	8,877
Plate glass, not coloured, in panes not over 30 sq. feet.	75,777	72,573
" " " over 30 and not over 70 sq. feet	48,885	76,029
" " " over 70 sq. ft	73,684	85,840
Silvered plate glass	7,911	22,330
Porcelain shades, imitation	10,216	9,873
All other mfrs. of glass, N. O. P. F	69,926	111,067
Totals	$1,219,264	$1,257,661

MISCELLANEOUS.

TABLE 4.

IMPORTS OF LEAD.

Articles.	1888.		1889.	
	Cwts.	Value.	Cwts.	Value.
Lead, old, scrap and pig......	71,911	$213,077	95,322	$269,974
" bars, blocks and sheets..	10,588	33,737	20,699	63,897
" pipe....	1,229	4,905	1,393	6,005
" shot........	805	2,809	1,013	3,886
" mfrs. of N.O.P.F........	......	5,836	....	12,970
Totals..............	......	$260,364	....	$356,732

MISCELLANEOUS.

TABLE 5.

IMPORTS OF MERCURY.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario	8,088	$4,702	5,864	$5,544
Quebec	3,239	1,782	1,928	1,178
Nova Scotia.............	4,992	728	8,343	1,192
New Brunswick.........	10	6	25	17
Manitoba	1	1	......	......
British Columbia........	2,161	1,111	1,131	603
Totals..............	18,491	$8,330	17,291	$8,534

MISCELLANEOUS.

TABLE 6.

IMPORTS OF MINERAL WATERS.

Province.	1888.	1889.
Ontario	$ 4,461	$ 2,328
Quebec	19,240	31,201
Nova Scotia	427	151
New Brunswick	1,023	932
Prince Edward Island	21	19
Manitoba	42	52
British Columbia	1,937	3,286
Totals	$27,151	$37,969

MISCELLANEOUS.

TABLE 7.

IMPORTS OF PLATINUM.

Province.	1888.		1889.	
	Ozs.	Value.	Ozs.	Value.
Ontario, wire	220	$1,202	220	$1,312
Quebec, "	74	636	191	2,743
" pans, retorts, etc.	....	12,268	....	....
Nova Scotia	....	......	12	100
British Columbia	....	2	....	....
Totals	294	$14,108	423	$4,155

MISCELLANEOUS.

TABLE 8.

IMPORTS OF TIN.

Province.	1888.			1889.		
	Blocks, pigs and bars.	Plates and sheets.	Tin-foil.	Blocks, pigs and bars.	Plates and sheets.	Tin-foil.
Ontario	$ 87,912	$244,445	$ 8,535	$75,849	$288,923	$ 9,552
Quebec	147,480	305,742	16,582	104,864	349,677	19,966
Nova Scotia	38,917	86,981	199	30,385	108,046	428
New Brunswick	14,524	29,212	222	11,038	28,595	148
Prince Edward Island	3,674	7,363	....	3,393	10,114	....
Manitoba	....	1,592	62	477	7,062	232
British Columbia	28,151	119,768	87	48,566	168,286	6
Totals	$320,658	$795,103	$25,687	$274,572	$960,703	$30,332

MISCELLANEOUS.

TABLE 9.

IMPORTS OF TINWARE, ETC.

Province.	1888.		1889.	
	Tinware	Tin Crystals.	Tinware.	Tin Crystals.
Ontario	$39,991	$245	$47,922	$190
Quebec	22,821	170	28,617	756
Nova Scotia	7,287	....	3,586	....
New Brunswick	8,253	536	9,414	555
Prince Edward Island	459	....	370	....
Manitoba	5,019	....	4,085	....
British Columbia	4,208	....	3,475	....
Totals	$88,038	$951	$97,469	$1,501

MISCELLANEOUS.

TABLE 10.

IMPORTS OF WHITING.

Province.	1888.		1889.	
	Cwts.	Value.	Cwts.	Value.
Ontario	7,104	$ 2,817	9,448	$ 2,873
Quebec................	64,408	15,886	86,465	23,201
Nova Scotia............	2,801	958	1,608	893
New Brunswick	2,477	866	3,422	999
Prince Edward Island....	485	174	63	26
Manitoba	1	1	1	1
British Columbia........	141	145	254	232
Totals..............	77,417	$20,847	101,261	$28,225

MISCELLANEOUS.

TABLE 11.

IMPORTS OF ZINC IN BLOCKS, PIGS AND SHEETS.

Province.	1888.		1889.	
	Cwts.	Value.	Cwts.	Value.
Ontario................	4,428	$16,357	4,026	$18,667
Quebec................	8,551	35,052	12,168	58,976
Nova Scotia............	1,049	4,294	2,045	11,634
New Brunswick..........	1,304	5,371	1,564	7,067
Prince Edward Island....	46	189	162	724
British Columbia........	196	933	341	1,785
Totals.	15,574	$62,196	20,306	$98,853

MISCELLANEOUS.

TABLE 12.

IMPORTS OF SPELTER IN BLOCKS AND PIGS.

Province.	1888.		1889.	
	Cwts.	Value.	Cwts.	Value.
Ontario................	628	$ 2,767	1,166	$ 5,812
Quebec	8,982	35,756	9,117	41,243
Nova Scotia............	109	539	55	255
New Brunswick..........	371	1,808	673	2,957
British Columbia.......	21	10	......	......
Totals...............	10,111	$40,880	11,011	$50,267

MISCELLANEOUS.

TABLE 13.

IMPORTS OF MANUFACTURES OF ZINC.

Province.	1888.	1889.
Ontario................	$3,823	$4,479
Quebec......	1,271	1,693
Nova Scotia.............	122	251
New Brunswick..........	371	540
Prince Edward Island.....	......	3
Manitoba................	122	233
British Columbia.........	534	43
Totals.......... ...	$6,243	$7,242

NATURAL GAS.

By H. P. Brumell,

Assistant, Division of Mineral Statistics and Mines.

Natural gas has been known to occur throughout Canada since the last century, though but little practical use was made of it till the year 1885. Numerous gas springs have been observed throughout Ontario, notably the "Gas Spring" at Caledonia Springs, in Prescott county, and the "Burning Spring" at Niagara Falls, in Lincoln county; these two localities are historical, having been known at the beginning of the present century. Gas is known to occur at several horizons in Canada, the most productive as yet appearing to be near that of the Clinton and Medina formation. The gas at Ruthven, in Essex county, is probably from the former; while that in Welland county, Ont., is from the Medina sandstones. The Trenton limestone has been pierced at many points throughout Ontario, but the gas obtained from it has been but in small quantities. In Quebec the greatest flow was obtained from rocks presumed to be near the base of the Medina formation, while in the wells of the North-West Territory the flow was from rocks of Cretaceous age. Gas springs. Gas horizons.

In the following notes, I wish to present in as concise a form as possible the more important work that has been done in exploring for natural gas throughout Canada up to the end of 1889.

Ontario.—On July 15th, 1885, a well was begun at Port Colborne, in Welland county, and in the following August gas from this well was being utilized in Mr. D. McGillivray's store in that place. Three wells in all were sunk in Port Colborne at that time, only two of which are, however, now available for a supply of gas. These two wells, known as Nos. 1 and 2, are situated respectively on Charlotte street and in the rear of M. Richardson's house and factory; the former having a total depth of 1,500 feet, and the latter 770 feet; gas was struck at 764 feet and 762 feet. It was found impossible to measure exactly the flow from these two wells; the estimate was, however, 50,000 c. ft. per diem. Port Colborne wells.

Following closely upon the find and first utilization of gas in Ontario, efforts were made to find gas at the town of Collingwood and the neighboring village of Delphi. In Collingwood, four wells were sunk during 1887 and 1888, from three of which gas was obtained. The well, known as "The West Well," had a flow of about 4,000 c. ft., the gas being utilized in two private residences immediately adjoining its site. An attempt was made to make use of that from "McDonell's Collingwood wells.

Well," but it was found that the flow was too meagre to be of economic benefit. At Delphi, a summer resort, about five miles west of Collingwood, a well was sunk which gave a flow of about 5,000 c. ft. per diem. No use has as yet been made of the gas obtained from this well, notwithstanding the fact of its being within a very short distance of a large summer hotel.

Two largely productive gas fields have been located in Ontario, but had not been drawn upon up to the end of 1889. In the Essex field, one well known as "Coste No. 1," situated near Ruthven, has a measured daily flow of 10,000,000 c. ft., and is owned by the Ontario Natural Gas and Fuel Co., Ltd., of which Mr. N. A. Coste, of Amherstburg, is president. This well has been closed, pending the settlement of some difference between the shareholders. It is confidently expected, however, that the gas from this and other wells which will be sunk by this company will ere long be made of great benefit to the country, as it is proposed to pipe it to various points throughout the district.

"Coste No. 1."

Specimens are to hand illustrating the rocks traversed in this drilling, but time has not allowed of their close examination. It is, however, presumed that the flow of gas is obtained from a vesicular dolomite, probably of the Clinton formation. The depth attained was 1,031 feet, a very strong flow of gas being struck at 1,017 feet; the boring was then continued to the total depth, when the pressure had increased to such proportions as to render it impossible to operate the tools.

The other field alluded to is situated in Welland county, in the townships of Bertie and Humberstone, and lies near the northern shore of Lake Erie in these townships. Up to the time of writing, seven wells had been sunk by the Provincial Natural Gas and Fuel Company of Ontario, Ltd., of which Mr. P. McLaren, of Perth, is president. From all of these wells gas has been obtained, the record being as follows:—

Provincial Nat. Gas and Fuel Co.

No. 1	2,050,000	cubic feet.
" 2	640,000	"
" 3	495,000	"
" 4	2,200,000	"
" 5	6,900,000	"
" 6	70,000	"
" 7	2,566,000	"
	14,921,000	"

This field is now under development, and it is the intention of the company to lay pipes for the supply of Port Colborne, Welland, Thorold, St. Catharines, and other points throughout the district. The gas is obtained in these wells, and in those of Port Colborne, from the white sandstone beds in the upper part of the Medina formation.

The record of drilling of "No. 1 Well" shows:— Log of well in Bertie Tp.

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 shales..........................	10 "	
Blue shales.........................	5 "	
White sandstone.....................	5 "	
Blue shale..........................	20 "	
White sandstone.....................	15 "	

The gas is from the lower white sandstone, at a depth of 836 feet from the surface.

I am indebted for the above information regarding these two gas fields to Mr. Eugene Coste, promoter and general manager of the two above-mentioned companies.

It is much to be regretted that ill-based rumors of large finds of gas throughout the Province have been received with confidence. Newspaper reports of immense finds have been but too common, and the discovery of the inaccuracy of such reports has done much to retard legitimate development. A case in point is the way in which a very small strike at Forest was reported. Several of our leading dailies contained accounts of the finding of a ten million cubic feet well at this point, and the public had to be disabused in their belief by the disagreeable intelligence that the gas flow was very insignificant. The facts of the case, as far as ascertained, go to show that a very small and short lived flow of gas was obtained there from the gravel and shales which lie beneath the thick deposit of Erie clay at this point. Newspaper canards.

Louisville.

Quebec.—In 1880 explorations for natural gas were begun in the neighborhood of Louisville (Riviere du Loup en haut), but it was not till 1885 that any borings were undertaken. In that year a company was formed by Mr. Poirier of St. Gregoire, and a boring made on lot No. 501, in the 12th concession of Beausejour, Nicolet county. The depth attained was 1,115 feet, veins of gas being struck at 316, 370, 580, 640, and 842 feet, all of these depths being probably included in the rocks of the Medina formation. The flow of gas encountered at 580 feet was the largest, and it has been estimated that the total flow from this well is in the neighborhood of 50,000 c. feet per diem.

St. Gregoire.

Combustible Gas Co.

During 1886 a company was incorporated under the Quebec statutes entituled "The Combustible Gas Co. of Quebec;" this company was presided over by Mr. Cyrille Duquet of Quebec. Exclusive privileges in boring for and utilization of natural gas in the province were vested in this company. Operations were at once begun by the sinking of a well at Maisonneuve, near Montreal. This well attained a depth of 1,500 feet, but, owing to the inflow of water, the gas, which was found in small quantities, was never utilized. Wells were then sunk by the company at Louiseville, mentioned above, where four wells were completed to depths ranging from 500 to 600 feet; owing to difficulty with water but little use has been made of these wells, though gas in paying quantities is reported from all of them.

Maisonneuve.

Many wells have been sunk in the neighborhood of Montreal, but except in those mentioned no gas was found. But little exploratory work has as yet been done elsewhere in the province. Dr. Selwyn, in his summary report to the Department of the Interior for the year 1887, speaks of the probable district of greatest gas production in that province as follows:—" An all-important consideration in connection with the probable occurrence of these reservoirs is that of the geological structure of the district, and while, for reasons in connection with this, 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, especially along, or in proximity to, the central part of the line indicated by Sir W. E. Logan as the course of the Deschambault Anticlinal."

North-West Territories.—Numerous borings have been made throughout the North-West Territories, and gas has been noted as occurring in more or less important quantities at several points. In only three wells, however, has it been found to be in economic quantity, namely in those situated at Cassills (8th Siding) and at Langevin Station, on the line of the Canadian Pacific Railway. At the latter place two wells are located; the first, sunk in 1883, attained a depth of 1,155 feet, and

Wells at Cassills and Langevin.

the second a depth of 1,426 feet. In the second well a strong flow of gas was obtained from between 1,000 and 1,100 feet, which has been utilized by the Canadian Pacific Railway in generating steam required for pumping and in the section-house. Of the gas found in these wells Dr. G. M. Dawson writes as follows: — Trans Royal Soc., Canada, Vol. iv, sec. iv, p. 96.—"The wells at this place did not yield any sufficient quantity of good water, though small flows were met with at several wells. They have, however, demonstrated the very important fact that a large supply of natural combustible gas exists in this district at depths of 900 feet and over in the sandy layers of the 'lower dark shales.' In consequence of the generally horizontal positions and widespread uniformity in character of the rocks, it is probable that a similar supply will be met with over a great area of this part of the North-West, and that it may become in the near future a factor of economic importance. . . . Mr. J. M. Egan, in a letter of late date (June 11th, 1886), informs me that the flow of gas from this well has continued since without noticeable decrease." The flow from these wells has never been measured, but it is estimated that 50,000 c. feet per diem was obtained from the deeper well; it is from this that the gas now being utilized is drawn.

At Cassills two wells were sunk, the first attaining a depth of 700 feet, while the second was carried to a point 1,000 feet below the surface. In the latter a flow of gas was obtained from a brown sand-rock at a depth of 820 feet, and it is understood that this supply is being drawn upon to supply the pumping engine at the section house at this point.

Approximate available flow of natural gas in Canada.

IN DECEMBER, 1889.

Ruthven, Essex County	10,000,000	c. ft. per diem
Welland County	15,050,000	" "
Collingwood and Delphi	9,000	" "
Small wells in Ontario	11,000	" "
Total, Ontario	25,070,000	" "
Quebec	55,000	" "
North-West Territories	75,000	" "
Total	25,200,000	" "

List of principal wells drilled in Ontario during recent years in exploration of natural gas.

LOCALITY.	Elevation above tide. feet.	Depth, feet.	Depth at which gas was struck, feet.	Result.
Essex County—				
Amherstburg.......	....	....	....	....
Marshfield..............	607	1,300	....	Oil
Essex Centre...........	647	1,200	....	....
Ontario Nat Gas and Fuel Co.'s wells:—				
Ruthven—"Coste No. 1."	652	1,031	1,017	Gas
Kingsville—"Coste No. 2"	608	1,031	....	....
Ruthven—"Coste No. 3."	664	1,103		
Kingsv'le—"Citizen's well"	608?	1,126	750	Gas?
Leamington......	624	1,030	965	Gas
Blytheswood............	?	1,200	....	....
Lambton County—				
Sarnia, "Peterson's Well"	637?	685	515	Gas
" "Dicken's Well"..	637?	665	515	Gas
" Well at Agricultural Co.'s Works....	625?	550	473	Gas
Brant County—				
Brantford, well at Waterous Engine Works...	707	1,118	....	Gas
Lot 16, con. 15, township of Brantford.........	672	2,160	1,950	Gas
Lincoln County—				
St. Catharines..........	297	2,200	2,185	Gas
Welland County—				
Thorold Nat. Gas Co.:—				
Thorald..............	517	2,430	2,394	Gas
Niagara Falls, South.....	547	784	230	Gas
Port Colborne Nat. Gas and Fuel Co:				
Port Colborne, "No.1 well"	586	1,500	764	Gas
" "No 2. " "	586	770	762	Gas
" "No. 3 " "	586	771	765	Gas
Provincial Nat. Gas and Fuel Co:				
Townships of Bertie and Humberstone. "No. 1 Well"....	618	846	836	Gas
"No. 2 " "....	abt. "	851	abt. 845	Gas
"No. 3 " "....	" "	836	" 830	Gas
"No. 4 " "....	" "	875	" 870	Gas
"No. 5 " "....	" "	842	" 835	Gas
"No. 5 " "....	" "	897	" 890	Gas
"No. 7 " "....	" "	854	" 845	Gas
Simcoe County—				
Beeton, "Lilley Well"...	723	1,400	346	Gas
Collingwood, "No. 1 Well"	600	553	150	Gas
" "No. 2 " "	600	542	160	Gas
" "No. 3 " "	600	464	175	Gas
" "No. 4 " "	590	351	150	Gas
Delphi (Field's crossing).	600	587	95	Gas
Thornbury........	....	....	....	....
York County—				
Mimico...................	300	1,060	425	Gas
Toronto	260	1,200	....	....
Ontario County—				
Whitby.	280	728	400	Gas

PETROLEUM.

By H. P. BRUMELL,

Assistant, Division Mineral Statistics and Mines.

In presenting the following short article on Petroleum, it is the intention to give merely a resumé of the work done in past years in exploration, etc., of petroleum, as well as the statistics of production, etc., for the year. It is to be regretted that, through lack of time, it has been found impossible to go into the question of the origin of oil, and its geological aspect in Canada; it is, however, the intention at no very distant date to take up the subject again and deal with it more thoroughly.

Canadian oil is a very heavy dark-brown petroleum of a gravity ranging from ·804 to ·808, though some writers state that the gravity at times reaches ·860. Owing to the amount of sulphur in its composition it is of a most obstinate character, requiring more thorough treatment in refining than any of the Pennsylvania or Ohio oils. Great ingenuity and study on the part of the Canadian refiners has, however, enabled them to overcome this feature; and now the illuminating oil produced in this country as put upon the market is perfectly sweet and free from the unpleasant odor so characteristic of this oil a few years ago. Gravity of oil. Sulphur in oil.

The contents of Canadian petroleum, as given by Mr. Norman Tate, are as follows:— Contents of oil.

Naphtha, sp. gr. ·735	12·5
Lamp oil, " " ·820	35·8
Lubricating oils	43·7
Paraffine	3·0
Coke	3·2
Loss	1·8
	100·0

Dr. Sheridan Muspratt quotes the same, as follows:—

Sp. gr. ·794	20·0
Sp. gr. ·837	50·0
Lubricating oil (rich in paraffine)	22·0
Tar	5·0
Coke	1·0
Loss	2·0
	100·0

The actual percentages of the various products of petroleum, accord- Percentage of product.

ing to the returns received from the refiners for the year 1889, are as follows:—

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

DISTRIBUTION.

Ontario.—The most important oil producing territory in Canada is and has been undoubtedly that of Lambton county in this province, as it is from this county that all the oil produced in the Dominion for refining has been obtained. The oil in this district is found in the Corniferous limestone lying immediately under the Hamilton formation, as is shewn by the following records:—

Wells at Oil Springs.

WELLS AT OIL SPRINGS.

(East side of field.)

Surface	60 feet.	
Limestone ("Upper lime")	35 "	Hamilton.
Shale ("Upper soapstone")	101 "	Hamilton.
Limestone ("Middle lime")	27 "	Hamilton.
Shale ("Lower soapstone")	17 "	Hamilton.
Limestone ("Lower lime")	130 "	
	370 "	

(West side of field.)

Surface	80 feet.	
Shale ("Upper soap")	116 "	Hamilton.
Limestone ("Middle lime")	27 "	Hamilton.
Shale ("Lower soap")	17 "	Hamilton.
Limestone ("Lower lime")	130 "	
	370 "	

Oil is found in both of these wells at 370 feet from the surface, and water at 252 feet. In both the wells above mentioned, the drill is supposed to have penetrated the Corniferous limestone to a depth of about 60 feet, the Hamilton formation being in the first well 250 feet, and in the second 230 feet in thickness.

Well at Petrolia.

WELL AT PETROLIA.

(Well sunk near Imperial Refinery.)

Surface	104 feet.		
Limestone ("Upper lime")	40	"	Hamilton.
Shale ("Upper soap")	130	"	
Limestone ("Middle lime")	15	"	
Shale ("Lower soap")	43	"	
Limestone, Hard white	68	"	
do. Soft "	40	"	Corniferous.
do. Grey "	25		

Oil is found at 465 feet.

The oil of Lambton county is obtained from two distinct "*pools*," known as the Oil Springs and the Petrolia fields. The above records are representative of all wells bored in the two fields respectively. The larger of the two—the Petrolia fields—with an approximate area of 26 square miles, extends W.N.W. about 9 miles, and E.S.E. about 4 miles from the village of Petrolia; while the Oil Springs field covers about 2 square miles, and includes the south-eastern part of the village of Oil Springs. Data are unfortunately wanting to show the production of these "pools" since their first development, though the output for the past few years has been in the neighborhood of 600,000 barrel per annum. Annual production.

Attention was first drawn to the district 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. Gum beds. The attention of Mr. J. H. Williams, of Hamilton, was drawn to the spot, and work in search of the oil then began in earnest. It was found that as wells were sunk deeper and deeper 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. The enterprise labored for some time under great difficulties; drilling was a very tedious operation, through lack of experience, the only appliance then in use being the old-fashioned "kicking-rig," operated by the weight of the human body.

The first flowing well was struck on the 19th of February, 1862, First flowing well. 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

"King wells." 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.

Dr. Winchell's description. Dr. Alex. Winchell, in his "Sketches of Creation," gives a very vivid description of the early workings in this district as follows: "Though western Pennsylvania has produced numerous flowing wells of wonderful capacity, there is no quarter of the world where the production has attained such prodigious dimensions as in 1862 upon Oil Creek in the township of Enniskillen, Ontario. The first flowing well was struck there January 11th, 1862, and before October not less than thirty-five wells had commeuced to drain a store house which provident nature had occupied untold thousands of years in filling for the uses of man. . . The price had fallen to ten cents per barrel. . . Three years later that oil would have brought ten dollars per barrel in gold. . . From detailed determinations I have ascertained that during the spring and summer of 1862 no less than five millions of barrels of oil floated off upon the water of Black Creek."

Flowing wells. The following list of wells in Enniskillen township, and their capacity, is taken from the same volume, Appendix, Note viii :—

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 " 11	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
163	Campbell & Forsyth	" 18 " II	1,000
163	Wilkes	" 18 " II	2,000
164	Bradley	" 18 " II	3,000
167	Webster & Shepley	" 18 " II	6,000

Depth in feet.	Situation.		Daily flow barrels.
170	Leavenworth	Lot 18 Con 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

Oil has been encountered in many other parts of Ontario, particularly throughout the territory underlain by the Hamilton and Corniferous formations. Small quantities were obtained in the neighborhood of Tilsonburg, in the township of Dereham, Oxford county, as well as in the township of Euphemia in Lambton county. Outside of the afore mentioned localities the drill has been busy throughout Ontario, with, however, but slight success, small quantities only being struck at Cape Smith on Manitoulin Island, at Comber and Marshfield in Essex county, at St. Mary's in Perth county, etc. Other explorations.

Quebec.—A small amount of exploratory work has been done in the Gaspé peninsula, where oil has for some years been known to exist. It has been noticed on the St. John River about half a mile above Douglastown, where it is seen to ooze from the sand and mud of the beach. Another locality is about two miles east of Gaspé Basin, where the oil is found floating on a small pool of water in the centre of a marsh of limited extent, the marshy ground on all sides being thoroughly saturated with semi-fluid petroleum. Various other localities have been noted in the neighborhood, one at Tar Point being particularly noticeable from its peculiarity. At this place the rocks are cut by a greenstone dyke, the cavities in which are lined with chalcedony and filled with fluid and semi-fluid petroleum. This dyke traverses rocks of the Oriskany formation, to which the sandstones—the oil-bearing rocks of this district—have been referred. Douglastown. Gaspé Basin. Tar Point.

New Brunswick.—But little work has been done in this province in search of oil; the operations up to the present time having been eminently unsuccessful. Springs of water associated with small quantities of oil have been observed at several points in the southern part of the province, notably at Upper Hillsboro', Beleveau, Memramcook and Dover. Several borings were made, principally in the neighborhood of Memramcook, without any greater success than the continuance of the "show" of oil. No record is to be obtained of these workings; Localities.

it is said, however, that a depth of 2,000 feet was attained in some of the more recent borings.

Nova Scotia.—Oil has, for a number of years, been known to occur in Nova Scotia, but it was not till about 1864 that efforts to prove the quantity were made. About that time the Pioneer Oil and Salt Co. sank two wells on the McIsaac farm, near Lake Ainslie in Cape Breton, where oil had for many years been seen to rise to the surface of the water. These wells reached a depth of about 600 feet with very poor results, nothing but "indications" being found. Since the above date several test holes were sunk, notably one near Baddeck, which attained a depth of about 500 feet. In this well no better results were obtained. Several companies have been formed to test the district, among others being the Pioneer Oil and Salt Co., The Victoria Oil Co., The Cape Breton Oil and Mining Co., The Inverness Oil and Land Co. and the American Oil Co.

Lake Ainslie.

Names of companies.

The facts which led to the formation of these companies and the work since performed by them are: that oil is frequently seen to rise through the waters of Lake Ainslie; that swamps in various parts of the district are frequently found to be covered with oil, and that many springs of water are found to be impregnated with petroleum.

Heretofore no benefit has accrued from the operations in this province in search of oil.

Manitoba.—During 1887 The Manitoba Oil Co. sank a well on the banks of the Vermillion River in search of petroleum, which it was anticipated would be found in the Devonian limestones that underly the Cretaceous rocks at that point. The well was sunk in 1887 to a depth of 300 feet (8 inch bore), and deepened in the following year to 743 feet. The Devonian limestone was encountered at 422 feet, but was found to be quite barren of oil or gas. No further efforts have been made to obtain oil in this province.

The North-West Territories.—In that region lying to the north of the territories of Alberta and Saskatchewan and drained by the Peace and Athabasca rivers, lies an immense and as yet practically unexplored oil region. Large areas in this district are found to be covered with a fine-grained sand-rock, which is thoroughly saturated with a semi-inspissated petroleum; where the country is cut by streams this fluid is seen to exude from these sands, where on exposure it becomes thickened, forming a mineral tar or maltha. No borings have as yet been made in search of the source of the oil, though it is believed to emanate from the Devonian limestones, which apparently everywhere underlie the sand rock above mentioned.

Chemical examination.

Examinations of this peculiar bituminous sand-rock were made by Mr. G. C. Hoffman, chemist to the Geological Survey, who, in the

Report of the Survey for the years 1880-81-82, pp. 34, describes the mineral as follows:—

"Bituminous sand-rock, from the Athabasca River about six miles below its confluence with the clear water, collected by Dr. R. Bell. This specimen was compact and homogeneous in appearance, and of a dull, dark brownish-black color. Specific gravity at 60° F. 2·040. At the temperature of 50° F. it is quite firm, barely, if at all, yielding to pressure, and does not soil the hand; at 70° F. it gives somewhat to the touch, and is slightly sticky; at 100° F. it becomes quite soft and eminently soils the fingers. It is scarcely acted on by alcohol in the cold, and but very slightly at a boiling temperature; but ether, oil of turpentine, kerosene, benzine (petroleum spirit), benzol (coal-tar naphtha) and bi-sulphide of carbon, more especially the last two named, readily dissolve the bituminous matter, with formation of dark brown colored solutions, and leaving a pure or almost pure siliceous residue in the form of sand, of which, apparently, the bitumen had constituted the sole binding medium.

"The composition of this specimen of the rock was found to be as follows:— Composition.

Bitumen	12·42
Water, mechanically included	5·85
Siliceous sand	81·73
	100·

"The sand consisted of colorless transparent quartz."

Mr. R. G. McConnell is now making investigations in this region, and it is confidently expected that during the next few years much will be made known that will lead to the development of this promising and extensive oil region. In the summary report of the department for 1889, this gentleman speaks of this district as follows:—

"Inspissated petroleum, lining cracks in calcareous nodules, was found along Peace River for some sixty miles below the Peace River landing. At Tar Islands, about thirty miles below the mouth of Smoky River, there is a saline spring which is kept in a constant state of ebullition by the escape of natural gas. Small quantities of tar line the sides of the spring and float on the surface of the water. This spring and a couple of others which are reported near by, are situated near the axis of a broad, flat anticlinal, one of the essential conditions of a successful oil field. Gas and oil in paying quantities are most frequently found in these great natural domes, and the only element of uncertainty in this district is the presence or absence of some porous formation to act as a reservoir. It is possible that the loose sands found along the Athabasca extend this far, or that some equivalent formation occupies their place, but as natural sections are wanting this can only be proved by artificial sections obtained by boring.

"Bituminous nodules were also observed along the north side of Lesser Slave Lake, and a tar spring is reported on this lake near the mouth of Martin River, but its situation is kept a secret by the Indian who professes to have discovered it."

Collingwood shales.

Oil Shales.—In the township of Collingwood, shales of the Utica formation appear at the surface; and on lot 23, con. 3, an attempt was in 1859 made to utilize them in the production of oil. A refinery containing twenty-four longitudinal cast-iron retorts was erected, the daily capacity of which was about 250 gallons of crude oil, which, on being distilled, afforded about 100 gallons of refined illuminating oil and 87 gallons of lubricating oil, leaving as residuum about 25 per cent of pitch and waste.

The yield of crude oil was supposed to be equivalent to 3 per cent of the shale retorted, and the cost of the crude oil about 14 cents per gallon.

The enterprise was, after many reverses and losses by fire, finally abandoned on the entrance into the market of the more cheaply produced petroleum of Lambton county. Many other localities are known in Canada where shales of a similar character may be found; one worthy of mention being in the northern part of the township of Bosanquet, Lambton county, where shales of Devonian age occur, which are said to contain 4·2 per cent. crude oil.

Bosanquet shales.

Storage and Carriage of Oil.

Tanking of oil by J. Kerr.

No better description of these very important factors in the oil business can be given than that from the pen of Mr. Jas. Kerr of Petrolia. In an article published in the Toronto *Mail* of December 1st, 1888, he states:—

" One of the necessities from the want of which the early oil operator suffered was tankage in which to store his oil pending the season of the year in which the bulk of it would be required, or to tide over a plethora of production till the requirements of the market could overtake it. Naturally the Canadian erected in the first place great wooden tanks, which increased in time to enormous proportions, some of them being as large as 24 feet in diameter and 29 feet deep, set on the ground and bound with iron hoops. Large iron tanks were introduced in 1865, two of which of about 3,000 barrels' capacity still remain a memento of that period. These, however, were found very expensive and subjected the oil stored in them to many sources of danger, and a vast improvement was found practicable, and of such a nature as no other part of the world has been known to supply.

"The Erie clay, before referred to, would almost appear to have been supplied for the express purpose of oil storage. This clay is of a solid, tenacious quality, free from seams or flaws, and easily removed. When properly constructed the tanks sunk therein prove to be cool, perfectly free from danger or loss from leakage or evaporation or destruction by fire, whether caused by lightning or otherwise. The tank is formed by excavating a circular hole about 30 feet in diameter to a depth of about 15 feet through the top soil (Saugeen clay), which is somewhat porous; a wooden crib is placed therein formed of double inch rings, five inches wide, outside of which boards are nailed, and clay from the strata below is solidly packed between the curbing and the wall, making a solid "puddling" above five inches thick. The sinking of the tank is then proceeded with to a depth of 50 or 60 feet; the entire wall is lined with segments made of inch pine about five inches wide, forming a perfectly tight tank holding from 8,000 to 10,000 barrels of oil, which, saturating the wood, renders it exceedingly durable. Timbers are projected across the top, supported by a bolt from the arch over it; joists are laid thereon, covered with plank and clay, and the contents rest in perfect safety till required.

"A large number of these tanks (of which about one million barrels' capacity exist in this locality) are owned by companies, who receive the oil from the producers at the wells and convey it through their pipe lines, some of which are nine miles in length, storing it and issuing certificates to the owners therefor."

Statistics.

During 1889 there were thirteen refineries in operation, nine of which are located in Petrolia, two in London, one in Sarnia and one in Hamilton, as follows:— List of refineries.

Imperial Oil Co	Petrolia
M. J. Woodward & Co	"
John McDonald	"
Petrolia Oil Co	"
Consumers' Oil Co	"
McMillan, Kittridge & Co	"
Producers' Oil Co	"
Jno. McMillan	"
Depper & McCort	"
Jno. R. Minhinnick	London
W. Spencer & Co	"
Sarnia Oil Co	Sarnia
Canadian Oil Co	Hamilton

Labor. These refineries employ about 260 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 **Wages.** refined oil. The wages paid for skilled labor in the production of refined oil is from $2.00 to $2.50 per day, while ordinary labor 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 refinery 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. As a rule a number of these wells so abandoned are, after a few months, again connected with the system of "jerkers" and pumped, as it has been found more economical to let some of the smaller producing wells rest for a short time. It is **Number of wells.** estimated that there are 3,500 wells now pumped, 2,500 of which are on the Petrolia field, and the remainder on the Oil Springs field, from which latter there is an approximate monthly production of 20,000 barrels.

Statistics. From returns received at this office from eleven refineries (those not to hand being the Sarnia Oil Co. and the Canadian Oil Co.) it is found that 25,372,653 gallons, or 724,933 bbls., were received at the refineries; deducting from this a decrease in stocks carried over by the tanking companies, amounting to 84,942 bbls., there is found to be an approximate production of crude oil during the year of 639,991 bbls., which, if calculated at the average price for the year of 95½ cents, gives a value of $612,101. These figures are of a necessity only approximate, as it has been found impossible to ascertain the stocks of crude oil carried over each year by the different refineries, only some of whom have given us this rather important information; it it thought, however, that the figures given above are very nearly correct, as the amount carried over as stock year by year varies but little.

Tanking companies. The tanking companies operating as such, are:—

Petrolia Crude Oil and Tanking Co	Petrolia
Producers' Tanking Co	"
Crown Warehousing Co	"

all of whom have kindly forwarded to this office returns of the year's business, which is shown as follows:—

Tankage.

Stocks 1st January, 1889	$298,714\frac{6}{35}$	bbls.
Quantity of oil received	$478,812\frac{31}{35}$	"
" " " delivered	$563,754\frac{32}{35}$	"
Stocks 1st January, 1890	$213,772\frac{32}{35}$	"
Decrease of stocks during year	$84,941\frac{9}{35}$	"

The returns of the several refineries before mentioned give the following results:—

PETROLEUM.

TABLE 1. Production.

PRODUCTION OF CANADIAN OIL REFINERIES.

Products.	1888.		1889	
	Quantity.	Value.	Quantity.	Value.
Illuminating oils...galls.	9,833,228	$1,059,614	*9,479,917	$1,084,829
Benzine and naphtha. "	492,886	29,354	409,135	34,861
Paraffine oils .... "	690,729	82,238	703,025	87,936
Gas oils............ "	3,107,306	68,477	2,917,346	65,954
Lubricating oils and tar............. "	3,284,273	132,601	2,191,881	96,407
Paraffine wax........lbs.	585,651	29,175	561,820	44,197
Totals...........	....	$1,401,459	....	$1,414,184

*The proportion of illuminating oil produced to total manufactures of petroleum during the year is 38.7 : 100.

PETROLEUM.

TABLE 2.

Consumption.

CONSUMPTION OF CRUDE OIL AND CHEMICALS.

Article.	1888.	1889.
Crude Petroleum...galls.	22,947,369	25,066,275
Sulphuric Acid......lbs.	4,082,076	3,638,704
Soda................ "	317,436	380,487
Litharge .... "	520,793	477,969
Sulphur .... "	104,479	76,325

On consulting the above table there is found to be a very considerable amount of sulphuric acid used. In former years this acid was for the most part imported, but it is a gratifying fact that during the past two years all the acid used in the refining of oil has been of Canadian manufacture and from Canadian pyrites. The principal acid makers in Canada at the present time are Messrs. G. H. Nichols & Co., who have erected large works at their mines at Capelton, Que., from whence they ship the acid in tank cars direct to the refineries. Considerable quantities of spent acid—"sludge"—were, during past years, shipped to Detroit and other points in the United States, where it was utilized in the manufacture of fertilizers in connection with bone and other phosphates.

Sulphuric acid of Canadian manufacture.

"Sludge."

Another by-product consists of the lead refuse obtained in the process of refining. During 1887 Mr. William Wilson erected in Petrolia a small smelting plant for the utilization of this product, but owing to the small amount of material available the business never attained very large proportions.

Inspection returns.

The following figures are taken from the books of the Inland Revenue Department, and show the number of packages inspected during 1889 as well as the number of gallons inspected for each year since 1881.

During 1889 there were inspected:—

220,958 packages at 10 cents inspection fee.
4 " " 5 " " "
38,640 " " 2½ " " "

Assuming that the packages contain 42, 10 and 5 gallons each respectively, there is found to be approximately:—

9,280,236 gallons in packages of 42 gallons each.
40 " " " " 10 " "
192,200 " " " " 5 " "
or a total inspection of 9,472,476 gallons.

This amount computed at the average proportion of 38 per cent. refined oil in the crude would represent a consumption of 24,664,144 gallons or 704,690 barrels of crude oil.

The amount of imported oils inspected during 1889 was approximately 1,817,291 gallons, an increase over 1888 of 28,247 gallons, and over 1887 of 305,858 gallons.

PETROLEUM.

TABLE 3.

CANADIAN PETROLEUM AND NAPHTHA INSPECTED, AND CORRESPONDING QUANTITIES OF CRUDE OIL.

Year.	Refined Oils Inspected.	Crude Equivalent Calculated.	Ratio of Crude to Refined.
1881	5,380,081	10,760,162	100 : 50
1882	5,111,893	11,359,762	100 : 45
1883	6,204,544	13,787,875	100 : 45
1884	6,730,068	16,825,170	100 : 40
1885	5,853,290	14,633,225	100 : 40
1886	6,469,667	17,025,439	100 : 38
1887	7,905,666	20,804,384	100 : 38
1888	9,246,176	24,332,042	100 : 38
1889	9,472,476	24,664,144	100 : 38

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. Prices on Oil Exchange.

PETROLEUM.

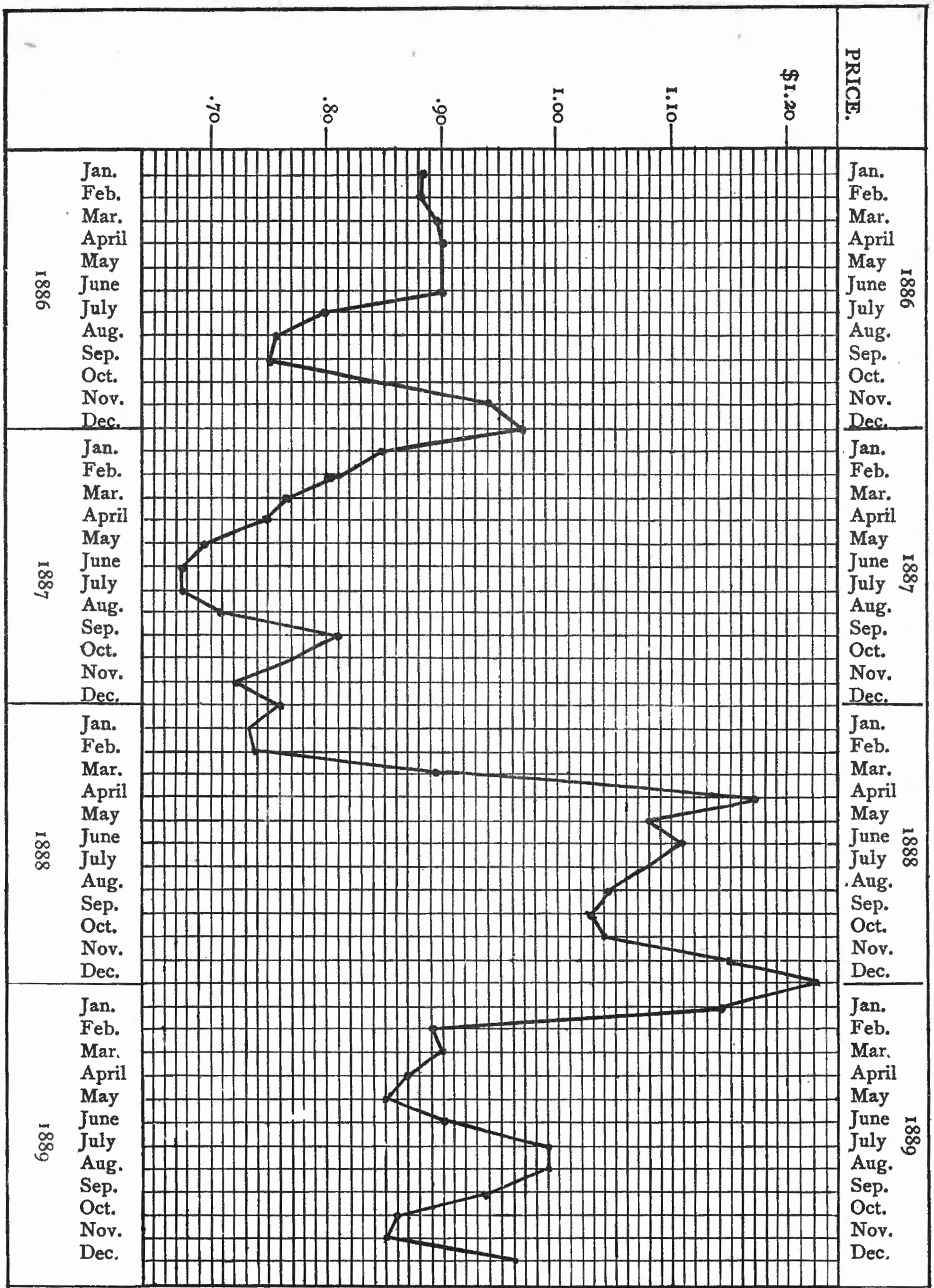
TABLE 4.

PETROLIA OIL EXCHANGE.

CRUDE PETROLEUM BUSINESS FOR THE YEAR 1889.

Month.	Opening price.	Highest price.	Lowest price.	Closing price.	Average closing price.	Average price.	Sales (Barrels.)
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	
January	1.21	1.21	1.00½	1.00½	1.13	1.13	32,666
February....	.87	.92	.83	.92	.89	.96	51,267
March	.93½	.94	.80	.80	.90	.89	15,947
April.	.83	.90	.83	.88	.87	.88	16,143
May	.85½	.86	.83½	.85½	.85	.85	27,120
June	.85¾	.94¼	.85¼	.94¼	.90	.91	41,063
July..	.96	1.00	.96	1.00	.99	1.01	35,538
August	.99¾	.99¾	.97	.99	.99	.99	24,238
September ..	.99	.99	.89½	.89½	.94	.96	32,791
October	.89½	.89½	.80	.82	.86	.86	35,626
November...	.80½	.92	.80	.90¾	.85	.88	34,112
December ...	.88½	1.05	.87	1.01	.96	1.01	54,421
Year 1889...	1.21	1.21	.80	1.01	.92¾	.95½	400,932
" 1888...	.75½	1.23½	.71	1.23	1.02⅜	1.03¾	516,007
" 1887...	.92	.92	.66	.76	.78	.78	406,203

Plate VII.



PETROLEUM.

TABLE A.

RANGE OF PRICE (AVERAGE CLOSING PRICE) OF CRUDE OIL.
DURING 1886, 1887, 1888 and 1889

The following tables of exports and imports of oil are compiled from information obtained from the Customs Department and explain themselves.

PETROLEUM.

TABLE 5.

EXPORTS OF CANADIAN CRUDE AND REFINED PETROLEUM FROM 1873 TO 1889. Exports.

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
Totals	13,322,135	$2,453,046

PETROLEUM.

TABLE 6.

Imports.

IMPORTS OF CRUDE AND REFINED PETROLEUM DURING THE YEARS 1888 AND 1889.

Province.	1888.		1889.	
	Gallons.	Value.	Gallons.	Value.
Ontario	1,709,142	$168,770	1,742,949	$175,238
Quebec.	918,760	84,864	848,294	76,913
Nova Scotia.............	763,510	62,375	812,380	75,815
New Brunswick.........	776,920	64,668	923,006	83,159
Prince Edward Island....	215,899	15,761	167,324	14,147
Manitoba.	254,976	35,557	177,922	20,695
British Columbia........	213,359	49,775	268,171	60,028
Total................	4,852,566	$481,770	4,940,046	$505,995

The following figures give the total yearly imports of crude and refined petroleum since 1885.

1885....................	3,810,116 gallons..................	$412,137
1886....................	4,179,851 "	469,231
1887....................	4,465,044 "	429,612
1888..	4,852,566 "	481,770
1889....................	4,940,046 "	505,995

The amounts of imported oils inspected during the same years are :—

1885	1,211,152 gallons
1886	1,584,422 "
1887	1,511,433 "
1888	1,789,044 "
1889	1,817,291 "

Subtracting these amounts from the total imports as shown in preceding table, there will be found to have been an importation of other oils, principally crude and lubricating, as follows:—

1885	2,599,064 gallons
1886	2,595,429 "
1887	2,953,611 "
1888	3,063,522 "
1889	3,122,755 "

On adding the amounts of domestic refined oil inspected, to those imported and inspected, there is found to have been an annual consumption of illuminating oil as follows :— Market for illuminating oils.

1885	7,064,442	gallons
1886	8,054,089	"
1887	9,417,099	"
1888	11,035,220	"
1889	11,289,767	"

Note.—Throughout this article the gallon used is the imperial gallon.

PETROLEUM.

TABLE 7.

IMPORTS OF PARAFFINE WAX.

Paraffine wax.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario	27,303	$2,274	35,271	$2,666
Quebec	26,477	2,627	30,902	2,755
Nova Scotia	2,051	213	16,701	790
New Brunswick	1,329	131	2,315	198
Prince Edward Island	....	....	1	1
Manitoba	76	10	10	4
British Columbia	632	41	77	10
Total	57,868	$5,296	85,277	$6,424

PHOSPHATE AND MANUFACTURED FERTILISERS.

PHOSPHATE.

Production.

There were altogether 30,988 tons of phosphate (apatite) mined and sold in the Dominion during 1889, having a value of $316,662. This shows an encouraging increase over 1888 of 8,503 tons and $74,377.

The two producing districts contributed to the above total as follows :—

	Tons.	No. of Producers.	Force Employed.
Quebec District.............	27,552	5	438
Ontario "	3,436	4	50

The number of producers and of men employed, as given above, represents only the chief operators and the men directly employed by them at their mines. In the Ontario district, however, the grand total of production is largely contributed to also from the results of the desultory mining operations of farmers on their own lots throughout the district.

Exports.

Details of the export trade in this mineral are given in the following tables A and Nos. 1 and 2.

Table A represents the grand totals of the material exported year by year since 1878, whilst table 1 gives the items going to make up these grand totals as credited to each province in the books of the Customs Department. It will be evident, however, that these do not necessarily represent the produce of the several districts, as much phosphate is shipped to Montreal from the Ontario district before being entered for export, and is thus credited to Quebec.

PHOSPHATE.

TABLE 1.

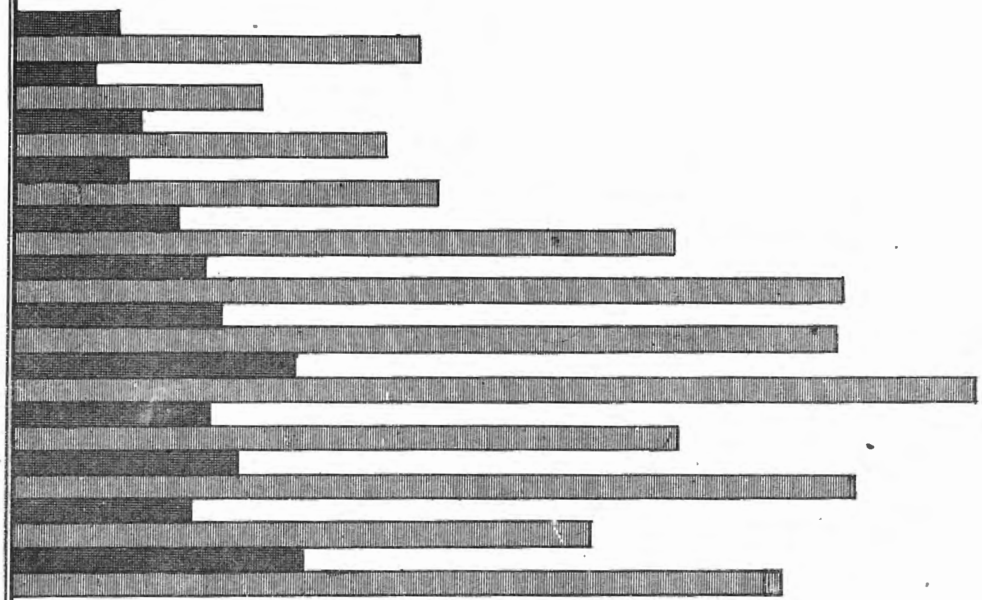
EXPORTS OF PHOSPHATE.

Year.	Ontario.		Quebec.	
	Tons.	Value.	Tons.	Value.
1878	824	$12,278	9,919	$195,831
1879	1,842	20,565	6,604	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
Totals....	15,878	$188,245	208,241	$3,706,600

Plate VIII.

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



The data from which the following table, No. 2, has been compiled are taken from "The Mining and Mineral Statistics of Great Britain and Ireland."

PHOSPHATE.

TABLE 2.

IMPORTS INTO GREAT BRITAIN OF CANADIAN PHOSPHATE COMPARED WITH TOTAL IMPORTS INTO THAT COUNTRY.

Year.	Canadian Apatite.		Total Phosphates.		Per cent. of Canadian Apatite to total quantity.
	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 "
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 "

The mining for this mineral was confined, as in the past, to two districts, viz., that of Ottawa County in the province of Quebec and in the Eastern Ontario district. In the former, the chief operations were carried on as previously in the township of Portland and the adjacent parts of the surrounding townships of Templeton, Buckingham and Bowman at the following mines :—The Dominion Phosphate Co.'s North Star Mine ; the Phosphate of Lime Co.'s Mine at High Rock ; the Star Hill and Crown Hill Mines of the Canadian Phosphate Co. ; the Emerald Mine of the Ottawa Phosphate Mining Co. and the Blackburn Mine in Templeton, all of which contributed to the grand total. Besides these, a varying amount of development work was carried on at various points, accompanied by the extraction of phosphate, often in considerable amounts, chiefly at the following points, viz., at the Central Lake and Stewart's Mines, N.W., from the Star Hill Mine and at the Little Rapids Mine and adjacent workings of the London Company on lots 8 in range I. and 7 in range II. of Portland East as well as at a number of other places. Quebec.

In the Ontario district, as already stated, a large proportion of the output is due to the operations of farmers throughout the district spasmodically opening up their properties, but outside of these the Ontario.

ERRATA.

Page 95 s, Table 2, "Percent of Canadian Apatite to Total Quantity" *should read* Ratio of Value of Canadian Apatite to Total Value of Imported Phosphates.

chief operations were carried on the Foxton, Otty Lake and Bobs Lake Mines, and at the mines operated by Messrs. Wilson & Greene in the township of North Burgess.

Prices and Market.

There are always good sales for these high class phosphates in the English and Continental markets, and the prices ruled fairly high for the season, with a greatly improved tendency for the following year. These as kindly furnished us by a dealer in this article are as follows :—

PRICES OF CANADIAN PHOSPHATE F.O.B. IN MONTREAL FOR THE SEASON 1889.

85 per cent........	$19.00 per ton.	70 to 75 per cent...	$10.50 per ton.
80 to 85 per cent...	17.00 "	65 to 70 per cent...	8.00 "
75 to 80 per cent...	13.00 "	60 to 65 per cent...	6.00 "

These prices ruled during the whole of the last shipping season.

MANUFACTURED FERTILISERS.

This industry is yet only in its infancy in Canada, there being only three works manufacturing fertilisers, and that only on a very limited scale. One of these is in New Brunswick, one in the Eastern Townships of Quebec and one in Ontario. Productino.

By direct returns received at this office, there were manufactured 775 tons of chemical fertilisers in whose composition superphosphate largely entered. This amount is returned as worth $26,606. These figures, of course, include none of the large amounts of gypsum which are mined as previously mentioned and used as land dressing.

As entered in the books of the Customs Department the exports of this material are as follows :— Exports.

Ontario..................	$1,401
Quebec..................	10
	$1,411

As set forth in the below given table, No. 1, there is a slight increase in the home consumption of fertilisers and materials entering into their composition.

MANUFACTURED FERTILISERS.

TABLE 1.

IMPORTS.

Articles.	1888.		1889.	
	Quantity.	Value.	Quantity.	Value.
Fertilisers...	....	$16,621	....	$12,729
Ground Gypsum..............lbs.	90,702	344	117,240	285
Bones (crude and dust)........ "	134,000	861	128,900	1,226
Potash, German mineral....... "	11,627	234	8,623	234
" muriate & bichromate of. "	540,307	21,990	615,691	28,883
Kainite .... "	247,080	2,405	269,719	1,867
Sulphate of Ammonia .... "	68,156	2,363	109,943	2,482
Totals..........................	....	$44,818	....	$47,706

PYRITES AND SULPHURIC ACID.

Pyrites.

There were shipped from Canada during 1889 72,225 tons of pyrites available for acid making, which, taking at the average price of $4.50 per ton, gives a value of $307,292. The figures for 1888 were 63,479 tons and $285,656, so that there is an increase for 1889 of 8,746 tons and $21,636.

This production is all due to three mines in the Eastern Townships district, Province of Quebec.

Sulphuric Acid.

The figures for 1888 are 10,998,713 lbs., with a value of $152,592. This shews an increase over last year of 2,270,493 lbs. and $31,077.

Pyrites was used in the manufacture of nearly all this acid, except for a certain amount of imported brimstone which was used for this purpose.

Exports and Imports.

The Customs Department having only commenced to take note of the exports of sulphuric acid on 1st July last, they can only be given for the half year from that date to the end of December. For that period the declared amount came to 62,293 lbs., worth $1,152, all from Ontario.

The imports are shown in tables 1 and 2:—

PYRITES AND SULPHURIC ACID.

TABLE 1.

IMPORTS OF SULPHURIC ACID.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario	105,825	$1,661	52,050	$708
Quebec	3,699	100	2,509	58
Nova Scotia	60,334	602	50,395	545
New Brunswick	107,868	1,125	44,630	504
Manitoba	33,123	392	18,804	217
British Columbia	20,709	555	31,917	822
Totals	331,558	$4,435	200,305	$2,854

PYRITES AND SULPHURIC ACID.

TABLE 2.

IMPORTS : BRIMSTONE OR CRUDE SULPHUR.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario......	1,139,743	$17,022	2,304,066	$19,632
Quebec................	880,660	9,399	869,526	11,412
Nova Scotia............	413,461	5,443	725,404	8,619
New Brunswick.........	66,063	1,091	40,713	621
Prince Edward Island....	1,608	35	......	......
Manitoba..............	2,220	55	1,537	39
British Columbia	44,125	434	15,149	354
Totals............	2,547,880	$33,479	3,956,395	$40,677

SALT.

Production. The direct returns received at this office shew a total production of this article of 32,832 tons, valued at $129,547, exclusive of the value of the packages.

As one or two of the returns omit the value of the packages used, our information on this point is not quite complete, but a close estimate of these missing items give the following as nearly correct figures :—195,000 barrels, valued at about $40,000, whilst there was a large quantity of bags of various sizes used with an aggregate value of about $4,000.

The production for the past four years is as follows :—

	Tons.	Value.
1886	62,359	$227,195
1887	60,173	166,394
1888	59,070	185,460
1889	32,832	128,547

The Grand Trunk Railway Co. has again kindly furnished figures of shipments of Salt over their system in Western Ontario, which would necessarily handle nearly all the produce of the salt district. These are as follows :—

1883	35,961	tons.
1884	34,850	"
1885	39,600	"
1886	41,577	"
1887	36,311	"
1888	37,120	"
1889 Including shipments over Can. Pac. Ry.	33,589	"

Ontario. There were 13 operators during this year, employing some 210 hands in all.

The Ontario district, which produces nearly all the salt, still seems to suffer from competition with English salt. Some grades of this come in duty free for fisheries, thus monopolising the Atlantic seaboard market, whilst all grades come in with freight rates largely in their favor, enabling this commodity to compete even in Ontario.

In view of the depressed state of the industry nearly all the makers were working during the year under a combine to restrict output to the needs of the available market.

N. W. T. Mr. Tyrell during his explorations for the Survey in the neighborhood of Lake Winnipegosis noted the occurrence of a brine spring, near Swan Lake, in that vicinity.

New Brunswick. Returns were received from one producer in this province who, however, makes only table and dairy salt.

Mr. R. Chalmers, in his preliminary report on his work in the southern part of the province, makes some interesting notes on the salt springs of this district as follows :—

" Brine springs are found at Sussex, at Salina, on Salt Springs Creek, and at Bennett's Brook, near Peticodiac. Five or six hundred bushels of salt per annum are manufactured at Sussex. This is all consumed locally, and used chiefly for table and dairy purposes. Several springs occur near the site of these salt works. A boring 125 feet deep was recently sunk at one of these springs—13 feet of it through surface deposits and 112 feet in rock. The object was to find the salt rock, but nothing of the kind was met with. The strength of the brine, I was informed, increased slightly till the solid rock was reached ; beyond that it did not perceptibly change. At Salina an attempt was made some years ago to manufacture salt from the brine of the surface springs there, but was discontinued. Possibly a series of borings might result in improving the quality of the brine, but none have yet been made. At Bennett's Brook nothing has been done to utilize the springs there, to my knowledge. In all these places the brine contains a considerable percentage of sulphate of lime or gypsum. There appears to be less, however, in that of the Sussex springs than at Salina or Bennett's Brook. The salt manufactured at the Sussex works is said to be of a superior quality."

SALT.

TABLE 1.

EXPORTS.

Province.	1888.		1889.	
	Bushels.	Value.	Bushels.	Value.
Ontario	14,968	$3,921	8,350	$2,342
Quebec	133	36	75	34
New Brunswick..........	......	......	132	14
Prince Edward Island....	150	30	......	......
Totals..............	15,251	$3,987	8,557	$2,390

SALT.

TABLE 2.

IMPORTS OF SALT (DUTY FREE) FOR FISHERIES.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario..................	2,092,290	$ 5,028	1,097,709	$ 2,949
Quebec..................	66,780,742	69,293	63,407,401	73,542
Nova Scotia..............	89,970,848	101,322	61,962,730	94,700
New Brunswick..........	38,859,120	50,379	33,787,804	65,219
Prince Edward Island....	1,062,520	2,614	3,395,040	5,581
Manitoba...............	458,200	2,138	192,072	757
British Columbia........	3,605,600	5,647	1,291,547	13,584
Totals...............	202,829,320	$236,421	165,134,303	$256,332

SALT.

TABLE 3.

IMPORTS: COARSE SALT PAYING DUTY.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario..................	937,600	$3,397	2,883,684	$8,895
Quebec..................	478,844	1,198	199,000	792
New Brunswick..........	......	......	5,600	12
British Columbia........	190,000	834	74,900	367
Totals...............	1,606,444	$5,429	3,163,184	$10,066

SALT.

TABLE 4.

IMPORTS: FINE SALT, PAYING DUTY.

Province.	1888.		1889.	
	Pounds.	Value.	Pounds.	Value.
Ontario..................	376,713	$ 1,539	1,053,926	$ 4,105
Quebec...................	5,676,807	15,012	6,523,220	19,904
Nova Scotia..............	309,608	2,195	310.061	1,554
New Brunswick............	1,366,736	4,283	1,722,947	7,393
Prince Edward Island.....	17,268	84	13,849	69
Manitoba.................	3,384	25	464,503	1,418
British Columbia.........	1,178,838	5,397	807,418	5,223
Totals...............	8,929,354	$28,535	10,895,924	$39,666

SILVER.

Production.

The total production of this metal during 1889 amounted to 383,318 ozs, worth $343,848.

The different provinces contributed to the grand total as follows :—

British Columbia	53,192	ozs.	valued	at	$ 47,873
Ontario	181,609	"	"	"	162,309
Quebec	148,517	"	"	"	133,666
Total	383,318	"	"	"	$343,848

The value of the silver produced in 1888, according to the report for last year, was $395,377, showing a falling off in production for 1889 of $51,529 As, however, in the absence of direct returns from Ontario, for 1888, the export returns had to be taken, this comparison may not be quite correct.

British Columbia.

The produce of silver in this province for 1888 was $37,925, an increase of $9,948 for 1889.

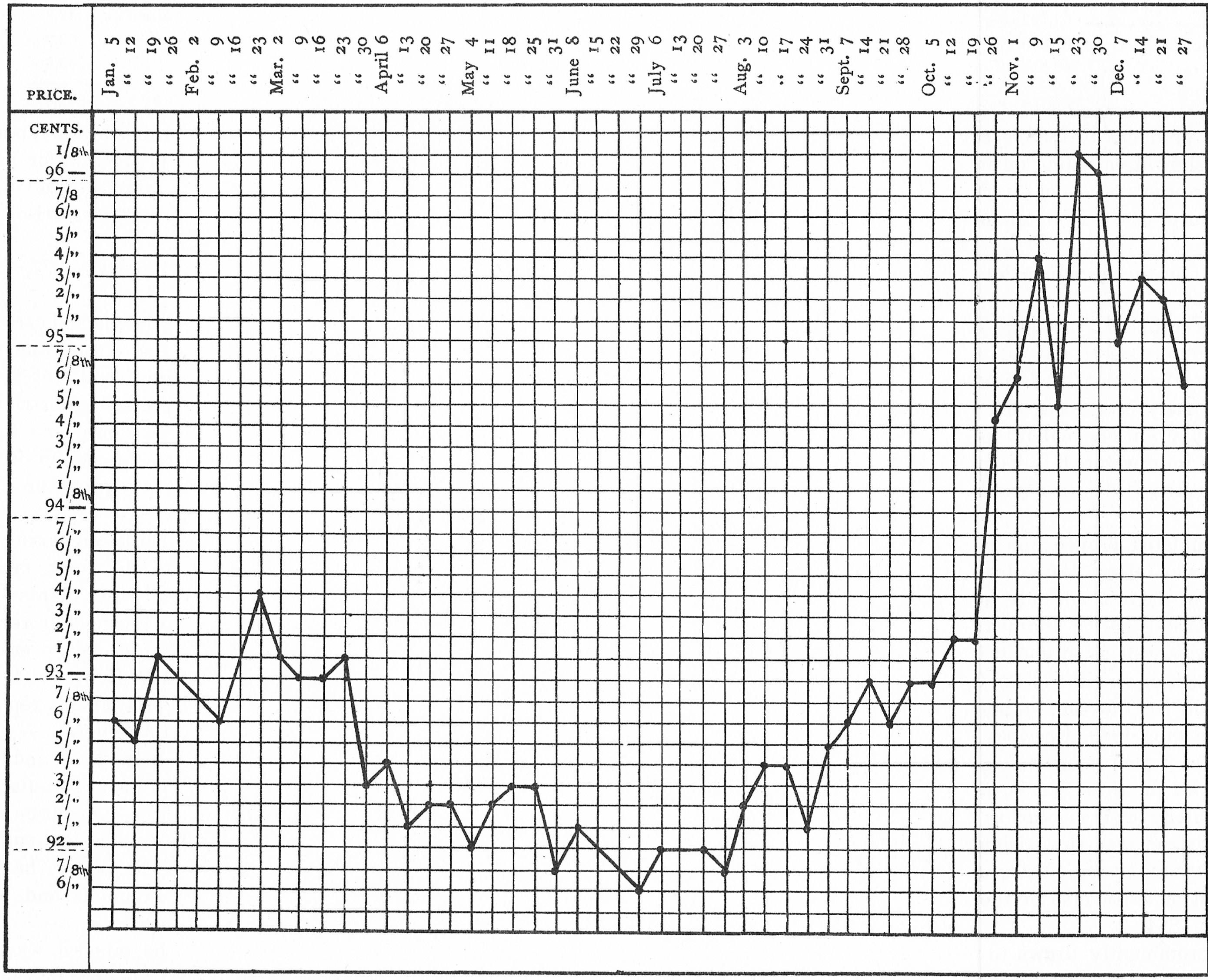
As previously, this was shipped in the shape of galena and carbonate lead ores running high in silver. It all came from the West Kootenay mining district, from the Toad Mountain and Hot Springs sub-divisions. This extremely interesting and promising district still continues to attract much attention, and it appears probable that it only awaits the advent of improvement in its present communications with the outside world to step to the front rank as a producer of rich argentiferous lead ores.

As soon as the contemplated branch line is built, connecting with the Canadian Pacific Railway about 120 miles to the north, facilities will be had for shipment of the ores not only to all other points on the continent, but a nearer market will be afforded at the smelter recently completed at Revelstoke, as well as at one it is intended to erect at Golden, a little further east on the line of the C. P. Ry.

Speaking of this district, Dr. Dawson, in his preliminary report on his work for the Survey during 1889, describes it as follows :—

" Much prospecting has been going on in both East and West Kootanie for the past two or three years, and a large number of promising discoveries—chiefly of silver-bearing ores—have been made. The West Kootanie sub-district was that visited by me last summer, and in it no previous observations by officers of the Survey had been made, with the exception of a traverse of the Columbia and Arrow Lakes by Mr. Bowman in 1884.

" Attention was first prominently drawn to the mineral wealth of the West Kootanie region when the discovery of rich ore by the Hall Brothers on a mountain, which has since been known as Toad



SILVER
TABLE A.
PRICES CURRENT
1889

Mountain, became known in 1887. Many prospectors soon flocked to the vicinity, and a large number of claims have since been taken up, not only on and near Toad Mountain, but also at Hot Springs or Ainsworth, on the west side of Kootanie Lake, at Hendryx on the opposite side, and at many outlying localities. At Nelson and Ainsworth town sites have been laid out, and the first steps toward the establishment of permanent mining centres have been taken.

" Speaking generally of the district, I may say that the result of my examination has been to convince me that the importance of the mineral discoveries made has not been exaggerated, while their number and the area over which they are distributed is such as to guarantee a large and continuous output of good ore so soon as adequate means are provided for the transport of the product to market.

" The majority of the ores met with are to be classed as silver ores, and in the vicinity of Hot Springs and Hendryx these are for the most part argentiferous galenas, which, in a number of instances near Hot Springs, are decomposed to a considerable depth, forming so-called 'carbonate-ores.' These possess a special value owing to the ease with which they are worked and their importance in the process of smelting the unaltered galenas. The aggregate quantity of such 'carbonate ores' to be found in the deposits already proved must be great, but all will no doubt pass in depth into sulphide ores.

" At Hot Springs or Ainsworth a truly remarkable number of metalliferous veins has already been brought to light within a very limited area, and additional discoveries are still being made from time to time even within this area. Near the lake shore, the country-rock is a coarse mica-schist which is overlain further back by green and grey schists, and these in turn are followed by limestones and black argillaceous schists, a mass of granite bounding the whole at a distance of two to three miles inland. In evident relation to this change in the country-rock is the circumstance that the ores improve almost uniformly in respect to contents of silver in crossing the series of veins in a westward direction from the lake and rising higher above the lake-level. Some of the deposits associated with the limestones hold more or less native silver in a filiform condition, and very high assays are frequently obtained from these. It is not yet possible to quote assays of the ores of this vicinity made from specimens collected by myself, but it is safe to say that from several of the claims, considerable quantities of ore can already be obtained by ordinary hand picking, which yield from 50 to over 100 ounces of silver to the ton, in addition to a high percentage of lead.

" At Hendryx, the only considerable developments made are those of the New Haven Mining and Smelting Company. The principal feature at this place is a lode of very great size, consisting largely of galena, but classing in respect to silver as a low-grade ore. So soon as efficient means are provided for handling and smelting this ore and shipping the product, a very large output may be counted on.

"The Toad Mountain ores differ from the foregoing in containing a large amount of copper and less galena. The Hall Brothers' property, known as the 'Silver King Mine,' from the name of the claim on which most work has been done, is so far the leading one here, and has turned out a considerable quantity of ore which has approached or surpassed $300 to the ton in total value as sold at the smelter. Other claims are, however, being opened out, some of which present a very favorable appearance.

"No large quantity of ore has yet been shipped from the deposits of the vicinity of Kootanie Lake and Toad Mountain, but small shipments of hand-picked rich ores have been made from time to time during the two past summers, representing a total value of $75,000. The ore has been carried down to the lake shore on horses and mules, taken by steamer to Bonner's Ferry in Northern Idaho, thence over thirty miles by waggon to the nearest point on the Northern Pacific Railway, and then, as a rule, to Montana, where it has been sold and smelted. The cost per ton of transporting the ores to smelter by this route has been not less than $30, and when to this is added the cost of mining and cobbing the ore, it is evident that very high grade ore alone can thus be utilized, while even in the case of deposits capable of yielding a considerable proportion of such high grade material, the greater part of the ore extracted, embracing the lower grades and requiring concentration, must at present be put to one side."

Besides these districts in the West Kootenay division, the report of the Minister of Mines of the province contains mention of similar discoveries in other divisions, notably in East Kootenay where, as also in the other divisions, the local commissioner reports that the miners who formerly worked altogether for placer gold are turning their attention more and more to prospecting for veins leading to a corresponding increase of discoveries.

Ontario.

Work continues to be actively prosecuted in the Thunder Bay district, chiefly in the Rabbit Mountain and Silver Mountain subdivisions, west of Port Arthur.

Returns were received from five operators, four of whom had made shipments during the year and gave employment at the mines themselves to some 270 men. Besides these, however, there would be all the force working for the mines in other ways than in mining proper.

Outside of the work at the producing mines considerable attention has been paid to prospecting and preliminary testing of veins already found.

The customs entries of exports of silver ore had to be taken last year in the absence of direct returns, and if these be taken as correct as given, viz., $208,064, there is a falling off for this year of $46,755.

The silver produce of this province is, as formerly, arrived at by calculating from the known percentage of the metal contained in the shipments of copper ores from the Capelton mines. This amounted in 1888 to $149,388, which shows on comparison with the figures for this year a decrease of $15,722. Quebec.

Dr. Selwyn, in his summary of the operations of the Geological Survey for the season 1889, points out some interesting facts with regard to possible occurrences of other areas of these Cambrian silver-bearing rocks, similar to those of the Port Arthur district, in the direction of Labrador, which place he visited during the summer. He says :— Labrador.

" Mr. Packard also describes the remarkable columnar basaltic, trap rocks of Castle and Henley Islands in Chateau Bay, but I think erroneously assigns them to the Laurentian. From their attitude and appearance, they are, I think, more probably of Cambrian age, and equivalent to the Animikie of Thunder Bay, Lake Superior, Lake Nipigon. and the islands on the Eastern shores of Hudson's Bay. No such rocks are, so far as I am aware, associated anywhere with the Laurentian system. If this proves to be correct, we may expect to find areas in East Main and Labrador of both the Archæan (Huronian) and the Cambrian (Animikie) metaliferous-bearing zones of Lake Superior. The white quartzites of Marble Island, described by Dr. Bell as Huronian, seem to correspond closely with those described by Mr. Packard at Dominio Harbor and Cape Webuc, while the columnar basalts of Castle and Henley Islands, Chateau Bay, are almost identical with those of Castle Peninsula, Richmond Gulf, the Outer and Inner Barns of Lake Nipigon, and the better known trap formation of Thunder Cape, Pie Island and McKay's Mountain, on Lake Superior.

The appended graphic table A will give a clear idea of the ruling prices for this product during the year, as quoted in the *Engineering & Mining Journal*, of New York. Prices.

Table No. 1 gives the exports of silver ores, as returned to the Customs Department for the past four years :— Exports.

Silver.

Table 1.

Exports of Silver ore.

Province.	1886.	1887.	1888.	1889.
Ontario....	$16,505	$184,763	$208,064	$203,871
Quebec....	8,000	450	5	2,500
Nova Scotia.......	......	......	......	50
Manitoba....	1,452	3,741	......	5
British Columbia..	......	17,331	10,939	5,737
Totals........	$25,957	$206,284	$219,008	$212,163

STRUCTURAL MATERIALS.

Granite.—The production of granite during 1889 amounted to 10,197 tons, worth $79,624. As compared with last year, this shows a decrease of 11,155 tons and $67,681. **Granite.**

The output is that of ten quarries, employing 347 men.

Marble.—There appears to have been but little of this article produced during the year, the returns to this office showing only 83 tons, valued at $980. **Marble.**

The following tables, Nos. 1 and 2, show the imports of marble and granite :—

STRUCTURAL MATERIALS.

TABLE 1.

IMPORTS OF MARBLE.

Province.	1887.	1888.	1889.
Ontario	$39,673	$51,284	$49,432
Quebec......	22,840	26,817	32,549
Nova Scotia..............	9,580	11,744	9,949
New Brunswick.........	6,682	8,081	9,682
Prince Edward Island.....	1,997	3,074	2,424
Manitoba	110	492	414
British Columbia........	2,076	3,550	4,649
Totals............	$82,958	$105,042	$109,099

STRUCTURAL MATERIALS.

TABLE 2.

IMPORTS OF MANUFACTURES OF STONE OR GRANITE, N. E. S.

Province.	1887.	1888.	1889.
Ontario..................	$15,253	$40,502	$60,478
Quebec	3,286	14,340	10,663
Nova Scotia............	491	1,343	1,637
New Brunswick.........	465	1,397	2,567
Prince Edward Island...	117	264	150
Manitoba	1,059	397	248
British Columbia........	940	722	2,347
Totals.............	$21,611	$58,965	$78,090

Slate.

Slate.—The production of this material for 1889 was 6,935 tons, having a value of $119,160. This showed a slight increase over the returns for last year of 1,621 tons and $28,471 in value.

This product represents roofing slates, various articles, such as troughs, tanks, etc., fashioned with machinery out of the solid slate, and also school slates to a large extent.

The data relating to the exports and imports of this material will be found in the following tables, No. 3 and 4:—

STRUCTURAL MATERIALS.

TABLE 3.

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

STRUCTURAL MATERIALS.

TABLE 4.

IMPORTS OF SLATE.

Province.	1887.	1888.	1889.
Ontario	$17,299	$30,704	$19,678
Quebec	2,211	2,025	2,502
Nova Scotia	927	694	342
New Brunswick	3,909	2,379	1,961
Prince Edward Island	88	172	149
Manitoba	191	149	29
British Columbia	589	2,382	432
Totals	$25,214	$38,505	$25,093

Flagstones.

Flagstones.—Returns were received covering a production of 14,000 square feet, valued at $1,400.

Building Stones.

Building Stones.—Table No. 5 represents the amount and value of these materials produced during 1889, as returned to this office. It can, of course, only purport to represent the operations of the chief producers, as it would be next to impossible to get at the amount further produced by spasmodic opening up of small quarries all the length of the Dominion for local uses. It is, however, believed that by adding one-fourth to the figures as returned, a close approximation to the actual figures will be obtained, which can therefore be taken as 426,000 cubic yards, and $1,140,000.

The exports and imports are given in tables Nos. 6, 7 and 8:—

STRUCTURAL MATERIALS.

TABLE 5.

PRODUCTION OF BUILDING STONE.

Province.	Number of returns.	Cubic yards.	Value.
Ontario..................	59	166,081	$443,192
Quebec	22	165,647	430,262
New Brunswick.........	6	4,869	29,466
Prince Edward Island....	3	2,550	6,375
Manitoba................	1	790	1,446
North-West Territories...	1	1,400	2,950
Totals...............	92	341,337	$913,691

STRUCTURAL MATERIALS.

TABLE 6.

EXPORTS OF STONE AND MARBLE, WROUGHT AND UNWROUGHT.

Province.	1888.		1889.	
	Wrought.	Unwrought.	Wrought.	Unwrought.
Ontario	$ 1,660	$23,284	$ 3,422	$ 271
Quebec	490	90	......	391
Nova Scotia	505	17,496	2,714	1,060
New Brunswick	19,442	15,135	15,226	26,482
British Columbia	17	......	12	......
Totals	$22,114	$56,005	$21,374	$28,204

STRUCTURAL MATERIALS.

TABLE 7.

IMPORTS OF DRESSED FREESTONE AND OTHER BUILDING STONES.

Province.	1887.	1888.	1889.
Ontario	$3,189	$1,268	$ 837
Quebec	74	8,200	1,242
Nova Scotia	....	252	10
New Brunswick	....	....	6
Prince Edward Island	2	....	....
British Columbia	148	....	....
Totals	$3,413	$9,720	$2,095

STRUCTURAL MATERIALS.

TABLE 8.

IMPORTS OF ROUGH FREESTONE, SANDSTONE AND BUILDING STONE.

Province.	1887.	1888.	1889.
Ontario................	$47,610	$68,196	$84,615
Quebec	22,014	25,330	40,185
Nova Scotia............	254	546	15
New Brunswick..........	......	......	187
Manitoba	......	......	594
British Columbia.......	......	......	517
Totals.............	$69,878	$94,072	$126,113

Lime.

Lime.—The foregoing remarks about the bnilding stones, apply equally to the lime, viz., that the following table, No. 9, can be taken as representing only the production of the chief operators. Wherever there are beds of limestone, or even a plentiful supply of drift carried limestone boulders throughout the country, small kilns will be found erected by the local farmers, etc., for burning lime as their occasional erection of buildings requires, which undoubtedly totals up to a considerable sum. It is believed, however, that the returns represent about four-fifths of the total amounts, which may, therefore, be taken at 3,600,000 bushels and worth $450,000.

STRUCTURAL MATERIALS.

TABLE 9.

PRODUCTION OF LIME.

Province.	Number of returns.	Bushels.	Value.
Ontario	73	1,622,892	$136,814
Quebec	14	187,220	36,831
New Brunswick..........	11	1,005,685	162,157
Prince Edward Island....	2	19,992	5,200
Manitoba	5	52,460	6,646
British Columbia........	1	60,000	15,200
Totals...............	106	2,948,249	$362,848

Cement.—The returns this year, which may be taken as representing the whole production, show a very encouraging increase. They show a total of 90,474 barrels produced, valued at $69,790, an increase over 1888 of 39,806 barrels and $34,197. Cement.

The exports of lime and cement are shown in the following tables, Nos. 10, 11, 12, 13 and 14:—

STRUCTURAL MATERIALS.

TABLE 10.

EXPORTS OF LIME AND CEMENT.

Province.	1887.	1888.	1889.
Ontario	$4,269	$12,262	$ 12,877
Quebec..................	83	398	71
Nova Scotia..............	142	278	11,017
New Brunswick	77,518	97,318	135,222
Prince Edward Island.....	4	......	2
Manitoba	241	......	......
British Columbia.........	4	......	2,060
Totals...............	$82,261	$110,256	$161,249

ERRATA.

Page 115 s, Table 9, $136,814 *should read* $198,734

STRUCTURAL MATERIALS.

TABLE 11.

IMPORTS OF LIME.

Province.	1888.		1889.	
	Barrels.	Value.	Barrels.	Value.
Ontario	6,616	$4,016	6,642	$3,959
Quebec	3,148	2,223	2,808	2,013
Nova Scotia	399	366	336	288
New Brunswick	104	105	36	47
Manitoba	450	394	603	528
British Columbia	1,251	1,251	1,000	1,000
Totals	11,968	$8,355	11,425	$7,835

STRUCTURAL MATERIALS.

TABLE 12.

IMPORTS OF HYDRAULIC CEMENT.

Province.	1888.		1889.	
	Barrels.	Value.	Barrels.	Value.
Ontario	3,102	$3,360	3,782	$4,683
Quebec	1,051	2,038	153	384
Nova Scotia	506	785	9	14
New Brunswick	1,208	1,553	235	252
Manitoba	......	.....	1,316	1,910
British Columbia	22	74	1,155	2,834
Totals	5,889	$7,810	6,650	$10,077

STRUCTURAL MATERIALS.

TABLE 13.

IMPORTS OF CEMENT IN BULK OR BAGS.

Province.	1888.		1889.	
	Bushels.	Value.	Bushels.	Value.
Ontario	3,220	$824	14,410	$2,879
Quebec	......	......	5	2
Nova Scotia	27,066	9,434	......	......
British Columbia........	......	......	2	1
Totals............	30,286	$10,258	14,417	$2,882

STRUCTURAL MATERIALS.

TABLE 14.

IMPORTS OF PORTLAND CEMENT.

Province.	1888.		1889.	
	Barrels.	Value.	Barrels.	Value.
Ontario	10,896	$15,570	27,491	$ 26,939
Quebec.................	79,045	109,736	120,555	174,007
Nova Scotia.............	12,174	20,104	12,239	19,098
New Brunswick.........	3,899	5,977	9,551	16,896
Prince Edward Island....	703	1,249	277	527
British Columbia........	4,358	8,247	2,305	5,667
Totals.............	111,075	$160,883	172,418	$243,134

Bricks and Tiles.

Bricks and Tiles.—Tables 15 and 16 give in a summarized form the production of bricks and tiles for each province of the Dominion, as compiled from returns received at this office. It is estimated to represent about four-fifths of the total production for bricks, and probably two-thirds of the production of tiles. This would bring the totals for bricks up to about 250,000 M., worth $1,600,000, and for tiles of about 16,000 M. worth $202,000.

The imports of bricks, tiles, earthenware, clays, etc., will be found in tables 17 to 22 inclusive :—

STRUCTURAL MATERIALS.

TABLE 15.

PRODUCTION OF BRICKS.

Province.	Number of returns.	Thousands.	Value.
Ontario.................	218	149,220	$889,476
Quebec	27	29,959	203,590
New Brunswick..........	10	11,800	91,975
Prince Edward Island....	6	720	6,480
Manitoba	2	1,800	15,636
North-West Territories...	4	885	9,210
British Columbia........	5	6,177	57,517
Totals...............	272	200,561	$1,273,884

STRUCTURAL MATERIALS.

TABLE 16.

PRODUCTION OF TILES.

Province.	Number of returns.	Thousands.	Value.
Ontario.................	84	10,394	$132,560
Quebec	1	17	255
New Brunswick..........	2	115	1,450
Totals.................	87	10,526	$134,265

STRUCTURAL MATERIALS.

TABLE 17.

IMPORTS OF BUILDING BRICK.

Province.	1888.	1889.
Ontario..................	$1,619	$8,247
Quebec.................	22,137	827
Nova Scotia.............	95	414
New Brunswick..........	329	82
Manitoba................	14	1.834
Prince Edward Island	....	55
Totals...............	$24,194	$11,459

STRUCTURAL MATERIALS.

TABLE 18.

IMPORTS OF DRAIN TILES AND SEWER PIPES.

Province.	1888.	1889.
Ontario.................	$65,675	$43,241
Quebec.................	27,095	27,463
Nova Scotia..............	252	437
New Brunswick..........	789	2,390
Manitoba................	629	1,778
British Columbia.........	4,793	6,818
Totals.............	$99,233	$82,127

STRUCTURAL MATERIALS.

TABLE 19.

IMPORTS OF FIRE BRICKS, AND MANUFACTURES OF FIRE CLAY, N.E.S.

Province.	1887.	1888.	1889.
Ontario	$21,221	$38,343	$11,336
Quebec	31,240	35,033	3,926
Nova Scotia	687	11,372	635
New Brunswick	7,778	950	677
Prince Edward Island	263	248	5
Manitoba	178	484	543
British Columbia	962	3,881	1,380
Totals	$62,329	$90,311	$18,502

STRUCTURAL MATERIALS.

TABLE 20.

IMPORTS OF FIRE CLAY.

Province.	1887.	1888.	1889.
Ontario	$ 7,285	$ 8,797	$6,562
Quebec	17,861	12,884	7,898
Nova Scotia	1,106	1,144	1,000
New Brunswick	312	968	1,018
Prince Edward Island	36	37	13
Manitoba	120	160	46
British Columbia	724	739	924
Totals	$27,444	$24,929	$17,461

STRUCTURAL MATERIALS.

TABLE 21.

IMPORTS OF CLAYS, ALL OTHER N. E. S.

Province.	1887.	1888.	1889.
Ontario	$5,502	$3,224	$2,663
Quebec..................	473	3,562	3,220
Nova Scotia..............	......	26,051	131
New Brunswick..........	233	......	402
British Columbia.........	3	13	......
Totals................	$6,211	$32,850	$6,416

Miscellaneous Clay Products.—The returns relating to this subject received at this office give a total value of $239,385. This consists mostly of sewer pipes and pottery ware. Miscellaneous Clay Products.

Sand and Gravel.—No returns were received for these two products. Tables Nos. 23 and 24 show the exports and imports. Sand and gravel

STRUCTURAL MATERIALS.

TABLE 22.

IMPORTS OF EARTHENWARE.

Articles.	1888.	1889.
Brown and colored Earthen and Stoneware and Rockingham ware..................................	$ 36,224	$ 36,806
Decorated, printed or sponged, and all Earthenware, N. E. S..	167,860	233,215
Demijohns or jugs, churns and crocks...............	5,905	5,350
Totals..................................	$209,989	$275,371

STRUCTURAL MATERIALS.

TABLE 23.

EXPORTS OF SAND AND GRAVEL.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario....	260,759	$38,043	282,774	$51,830
Nova Scotia.............	170	355	172	690
New Brunswick.........	......	......	80	80
British Columbia........	......	......	18	47
Totals............	260,929	$38,398	283,044	$52,647

STRUCTURAL MATERIALS.

TABLE 24.

IMPORTS OF SAND AND GRAVEL.

Province.	1888.		1889.	
	Tons.	Value.	Tons.	Value.
Ontario	9,194	$13,536	10,133	$14,033
Quebec................	14,556	12,937	12,200	12,976
Nova Scotia.............	1,459	3,815	999	5,014
New Brunswick.........	1,371	1,795	1,039	1,565
Manitoba...............	25	81	34	121
British Columbia........	21	73	4	57
Totals............	26,626	$32,237	24,409	$33,766

NICKEL.

The value of the Nickel produced during 1889 will be found, on reference to page 5 s, to have been included in the last item in the table giving the summary of the mineral production of Canada in 1889.

Whilst this amount was thus credited in the total value of the products of the mining and allied industries of the Dominion, the details were confidential, and therefore cannot be published.

The product was altogether the result of the operations of the Canadian Copper Company, in exploiting the famous deposits of sulphuretted copper and nickel ores at Sudbury, Ontario, and was shipped to the United States in the form of matte.

Two other companies were in operation at this place working similar deposits, but their work for 1889 was altogether confined to opening up their mines and erecting plant, so that they had no shipments to report.

Further details regarding the operations of these mines are given under the heading of Copper on page 30 s.

INDEX.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

ANNOTATED LIST

OF THE

MINERALS OCCURRING IN CANADA.

BY

G. CHRISTIAN HOFFMANN, F. Inst, Chem., F.R.S.C.,
Chemist and Mineralogist to the Survey.

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(*Reprinted from the Transactions of the Royal Society of Canada, volume* vii, *section* iii, 1889.)*

The following alphabetically arranged list of minerals embraces all such as have, up to date (July 31st, 1890), been identified, with any degree of certainty, as occurring in Canada. It includes species, varieties and synonyms—the names of species being printed in black-faced type. Doubtful species; such as have been shown on reëxamination not to be good species; those requiring further investigation; and one or two, the occurrence of which in Canada has not been placed beyond all doubt, are enclosed in brackets—the note to each of these particular minerals explaining for which of the foregoing reasons it has been thus distinguished. It would have been foreign to the present intention to have enumerated all the localities of occurrence of each particular mineral. Hence it is only in some few instances—those of the more rarely occurring,—that this has been done. In the case of those of more frequent occurrence, the principal localities where they are found are, not infrequently, for the most part given; whilst in instances of very general occurrence, mention is sometimes merely made of those places where the mineral has been met with in its most interesting form. In the preparation of this list the writer has freely availed himself of the writings of Dr. T. Sterry Hunt, Professor E. J. Chapman and the late Professor H. How; but more especially of those of Dr. Hunt, whose extended and important contributions to the mineralogy of Canada may indeed be said to form the basis upon which the present work has been constructed.

* The notes which there appear under "Addenda" have here been incorporated with the others.

ABBREVIATIONS.

AM. JOURN. SCI.—American Journal of Science and Arts.

ANN. REP. GEOL. CAN.—Annual Reports of the Geological and Natural History Survey of Canada (commencing 1885). Montreal.

CAN. JOURN.—Canadian Journal of Industry, Science and Art. Toronto.

CAN. NAT.—Canadian Naturalist and Quarterly Journal of Science. Montreal.

CAN. REC. SCI.—Canadian Record of Science. Montreal.

DANA, MIN.—A System of Mineralogy; by J. D. Dana, aided by G. J. Brush. 5th ed. New York, 1871—with three appendices, bringing the work up to 1882.

ED. N. PHIL. JOUR.—Edinburgh New Philosophical Journal. Edinburgh.

GEOL. CAN.—Geology of Canada (Report of progress from its commencement to 1863.) Montreal, 1863.

JOURN. CHEM. SOC.—Journal of the Chemical Society, London.

MIN. N. S —Mineralogy of Nova Scotia; by H. How. Halifax, 1869.

PHIL MAG.—The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science. London.

REP. GEOL. CAN.—Reports of Progress of the Geological Survey of Canada (years 1863-1884, inc.=14 vols.). Montreal.

TRANS. ROY. SOC. CAN.—Proceedings and Transactions of the Royal Society of Canada. Montreal.

TRANS. N. S. INST.—Proceedings and Transactions of the Nova Scotian Institute of Natural Science. Halifax.

TSCH. MIN. MITTH.—Tschermak Mineralogische Mittheilungen. Vienna.

VAR.—Variety of.

SYN.—Synonym of.

ANAL.—Analysis.

LIST OF MINERALS.

Acadialite, [1] .... *var.* Chabazite.
Acmite, [2] .... ——
Actinolite, [3] .... *var.* Amphibole.
Agalmatolite, [4] .... *var.* Pinite.
Agate, [5] .... *var.* Quartz.
Alabaster, [6] .... *var.* Gypsum.
Albertite, [7] .... near Asphaltum.

Albite, [8]	——
Allanite, [9]	——
Almandite, [10]	*var.* Garnet.
Alum. Native,	*syn.* Kalinite.
" Feather,	*syn.* Halotrichite.
" Iron,	*syn.* Halotrichite.
" Magnesium,	*syn.* Pickeringite.
Alunite, [11]	——
Alunogen, [12]	——
Amazon-stone, [13]	*var.* Microcline.
Amethyst, [14]	*var.* Quartz.
Amianthus	*syn.* Asbestus.
Ammonium chloride	= Sal-ammoniac.
Amphibole, [15]	——
Analcite, [16]	——
Anatase	*syn.* Octahedrite.
Andalusite, [17]	——
Andesite, [18]	——
Andradite, [19]	*var.* Garnet.
Anhydrite, [20]	——
[Animikite], [21]	——
Ankerite, [22]	——
Anorthite, [23]	——
Anthracite, [24]	*var.* Mineral coal.
Anthraxolite, [25]	near Asphaltum?
Antimonite	*syn.* Stibnite.
Antimony, Native, [26]	——
" blende	*syn.* Kermesite.
" bloom	*syn.* Valentinite.
" glance	*syn.* Stibnite.
" Grey,	*syn.* Stibnite.
" oxide	= Senarmontite, Valentinite.
" oxy-sulphide	= Kermesite.
" Red,	*syn.* Kermesite.
" sulphide	= Stibnite.
Apatite, [27]	——
Aphrodite, [28]	——
Apophyllite, [29]	——
Argentite, [30]	——
Arquerite, [31]	——
Arragonite, [32]	——
Arsenic, Native, [33]	——

Arsenical copper	*syn.* Domeykite.
" nickel	*syn.* Niccolite.
" pyrites	*syn.* Arsenopyrite.
Arsenide of platinum	= Sperrylite.
Arsenopyrite, [34]	——
Asbestus, [35]	*var.* Amphibole and Pyroxene.
Asphaltum, [36]	——
Augite, [37]	*var.* Pyroxene.
Axinite, [38]	——
Azurite, [39]	——
Barite, [40]	——
Barium carbonate	= Witherite.
" sulphate	= Barite.
Barytes	*syn.* Barite.
Berthierite, [41]	——
Beryl, [42]	——
Biotite, [43]	——
Bismuth, Native, [44]	——
" carbonate	= Bismutite.
" glance	*syn.* Bismuthinite.
" sulphide	= Bismuthinite.
Bismuthinite, [45]	——
Bismutite, [46]	——
Bitter-spar	*var.* Dolomite.
Bitumen	*syn.* Asphaltum.
Bituminous coal, [47]	*var.* Mineral coal.
Black copper	*syn.* Melaconite.
Black lead	*syn.* Graphite.
Blende	*syn.* Sphalerite.
Blood-stone	*syn.* Heliotrope.
Blue iron earth	*syn.* Vivianite.
Blue malachite	*syn.* Azurite.
Bog iron-ore, [48]	*var.* Limonite.
Bog manganese	*var.* Wad.
Bornite, [49]	——
Bournonite, [277]	——
Brown hematite	*syn.* Limonite.
[Bytownite], [50]	——
Cacholong, [51]	*var.* Opal.
[Cacoclasite], [52]	——
Cacoxenite, [53]	——
Cairngorm stone, [231]	*var.* Quartz.

Calcareous spar .... *syn.* Calcite.
" tufa, [54] .... *var.* Travertine.
Calcite, [55] .... ——
" Fœtid, [56] .... *var.* Calcite.
Calcium carbonate............................ = Calcite.
" fluoride............................ = Fluorite.
" phosphate............................ Apatite.
" silicate............................ Wollastonite.
" sulphate............................ = Anhydrite, Gypsum.
Cancrinite, [57] .... ——
Cannel coal, [58] .... *var.* Mineral coal.
Capilliary pyrites............................ *syn.* Millerite.
Carnelian, [59] .... *var.* Chalcedony.
Cassiterite, [60] .... ——
Celestite, [61] .... ——
Centrallassite, [62] .... ——
Cerussite, [63] .... ——
Chabazite, [64] .... ——
Chalcedony, [65] .... *var.* Quartz.
Chalcocite, [66] .... ——
Chalcopyrite, [67] .... ——
Chert............................ *syn.* Hornstone.
Chiastolite, [68] .... *var.* Andalusite.
Chlorite, [69] .... (Penninite).
Chloritoid, [70] .... ——
Chondrodite, [71] .... ——
Chromic iron............................ *syn.* Chromite.
Chromiferous garnet, [72] .... *var.* Garnet.
" mica, [165] .... *var.* Mica.
Chromite, [73] .... ——
Chrysocolla, [74] .... ——
Chrysolite, [75] .... ——
Chrysotile, [76] .... *var.* Serpentine.
Cinnabar, [77] .... ——
Cinnamon stone............................ *syn.* Essonite.
Clay iron-stone, [78] .... *var.* Siderite.
Clintonite .... *syn.* Seybertite.
Coal, bituminous............................ *var.* Mineral coal.
Cobalt, arsenate............................ = Erythrite.
" arsenide............................ = Smaltite.
" bloom............................ *syn.* Erythrite.
Coccolite, [79] .... *var.* Pyroxene.
[**Cookeite**], [80] .... ——

Copper, Native, [81]		——
" arsenide	=	Domeykite.
" Black	*syn.*	Melaconite.
" carbonate	=	Azurite, Malachite.
" Grey	*syn.*	Tetrahedrite.
" oxide	=	Cuprite, Melaconite.
" silicate	=	Chrysocolla.
" sulphide	=	Chalcocite, Covellite.
" Vitreous	*syn.*	Chalcocite.
Copper glance	*syn.*	Chalcocite.
Copper nickel	*syn.*	Niccolite.
Copper ore, Purple	*syn.*	Bornite.
" Red	*syn.*	Cuprite.
" Yellow	*syn.*	Chalcopyrite.
Copper pyrites	*syn.*	Chalcopyrite.
Coracite, [82]	*var.*	Uraninite.
Corundum, [83]		——
Covellite, [84]		——
Cryptomorphite, [85]		——
Cuprite, [86]		——
Cyanite, [87]		——
Dawsonite, [88]		——
Diallage, [89]	*var.*	Pyroxene.
Diopside, [90]	*var.*	Pyroxene.
Disthene	*syn.*	Cyanite.
Dog-tooth-spar, [91]	*var.*	Calcite.
Dolomite, [92]		——
Domeykite, [93]		——
Dysyntribite	*syn.*	Gieseckite.
Elaeolite, [94]	*var.*	Nephelite.
Epidote, [95]		——
Epistilbite, [96]		——
Epsomite, [97]		——
Epsom salt	*syn.*	Epsomite.
Erubescite	*syn.*	Bornite.
Erythrite, [98]		——
Essonite, [99]	*var.*	Grossularite.
Fahlunite, [100]		——
[Fassaite], [101]	*syn.*	Augite.
Feather alum	*syn.*	Halotrichite.
Felspar, Albite		——
" Andesite		——
" Anorthite		——

Felspar, Labradorite	——
" Microcline	——
" Oligoclase	——
" Orthoclase	——
Fluorite, [102]	——
Fluor-spar	*syn.* Fluorite.
Fœtid calcite, [56]	*var.* Calcite.
Freibergite, [103]	*var.* Tetrahedrite.
Galena	*syn.* Galenite.
Galenite, [104]	——
Garnet, [105]	——
" Almandite	——
" Andradite	——
" Chromiferous	——
" Grossularite	——
" Spessartite	——
Genthite, [106]	——
Gieseckite, [107]	*var.* Pinite.
Glauber Salt	*syn.* Mirabilite.
Glauconite, [108]	——
Gmelinite, [109]	——
Gold, [110]	——
Göthite, [111]	——
Graphic tellurium	*syn.* Sylvanite.
Graphite, [112]	——
Green malachite	*syn.* Malachite.
Green vitrol	*syn.* Melanterite.
Grey antimony	*syn.* Stibnite.
Grey copper	*syn.* Tetrahedrite.
Grossularite, [113]	*var.* Garnet.
Gypsum, [114]	——
Gyrolite, [115]	——
Halite, [116]	——
Halotrichite, [117]	——
Heavy-spar	*syn.* Barite.
Heliotrope, [118]	*var.* Quartz.
Hematite, [119]	——
" Brown	*syn.* Limonite.
Heulandite, [120]	——
Hornblende, [121]	*var.* Amphibole.
Hornstone, [122]	*var.* Quartz.
Howlite, [123]	——
Humboldtine, [124]	——

[Huntilite], [21]	——
Huronite, [125]	——
Hyacinth, [126]	*var.* Zircon.
Hyalite, [278]	*var.* Opal.
Hypersthene, [127]	——
Iceland-spar, [128]	*var.* Calcite.
Idocrase........................	*syn.* Vesuvianite.
Ilmenite, [129]	*var.* Menaccanite.
[**Ilvaite**], [130]	——
Infusorial earth, [131]	= Earthy tripolite.
Iridosmine, [132]	——
Iron alum........................	*syn.* Halotrichite.
Iron, Meteoric........................	——
" carbonate........................	= Siderite.
" chromate........................	= Chromite.
" ochre, [133]	*var.* Hematite, Limonite.
" oxalate........................	= Humboldtine.
" oxides........................	= Göthite, Hematite, Limonite, Magnetite, Martite.
" phosphate........................	= Vivianite.
" silicate........................	= Ilvaite.
" Spathic........................	*syn.* Siderite.
" sulphate........................	= Melanterite.
" sulphide........................	= Pyrite, Pyrrhotite, Marcasite.
" tungstate........................	= Wolframite.
Iron ore. Magnetic........................	*syn.* Magnetite.
" Micaceous........................	*var.* Hematite.
" Specular........................	*var.* Hematite.
" Titanic........................	*syn.* Menaccanite.
Iron pyrites........................	*syn.* Pyrite.
" Magnetic........................	*syn.* Pyrrhotite.
" White........................	*syn.* Marcasite.
Iron sand, [134]	——
Ironstone, Clay........................	*var.* Siderite.
Iserite, [135]	*var.* Menaccanite.
Jade........................	*syn.* Nephrite.
[Jamesonite], [136]	——
Jasper, [137]	*var.* Quartz.
Kalinite, [138]	——
Kämmererite, [139]	*var.* Penninite.
Kaolinite, [140]	——

Kermesite, [141]		—
Labradorite, [142]		—
Laumontite, [143]		—
Lazulite, [144]		—
Lead, Native, [145]		—
" carbonate	=	Cerussite.
" sulphide	=	Galenite.
Ledererite	*syn.*	Gmelinite.
Lederite	*syn.*	Titanite.
Lepidomelane, [146]		—
Lignite, [147]	*var.*	Mineral coal.
Limonite, [148]		—
Loganite, [149]	*var.*	Penninite.
[Louisite], [150]		—
[Macfarlinite], [21]		—
Macle	*syn.*	Chiastolite.
Magnesite, [151]		—
Magnesium alum	*syn.*	Pickeringite.
Magnesium carbonate	=	Magnesite.
" silicate	=	Aphrodite, Chondrodite, Serpentine, Talc.
" sulphate	=	Epsomite.
Magnetic iron ore		Magnetite.
Magnetic pyrites	*syn.*	Pyrrhotite.
Magnetite, [152]		—
Malachite, [153]		—
Malacolite, [154]	*var.*	Pyroxene.
Maltha	*syn.*	Pittasphalt.
Manganese-spar	*syn.*	Rhodochrosite.
Manganese, Bog	*var.*	Wad.
" oxide	=	Manganite, Psilomelane, Pyrolusite.
Manganite, [155]		—
Manganosiderite	*syn.*	Rhodochrosite.
Marble	*var.*	Calcite.
Marcasite, [156]		—
Martite, [157]	*var.*	Hematite.
Melaconite, [158]		—
Melanterite, [159]		—
Menaccanite, [276]		—
Meneghinite, [160]		—
Mercury sulphide	=	Cinnabar.
Mesole, [161]	*var.*	Thomsonite.

Mesolite, [162]	——
Meteoric iron, [163]	*var.* iron.
Micaceous iron ore, [164]	*var.* Hematite.
Mica, Biotite	——
" Chromiferous, [165]	——
" Lepidomelane	——
" Muscovite	——
" Phlogopite	——
" Rose-colored, [177]	——
Michel-Lévyte, [279]	= Barite.
Microcline, [166]	——
Millerite, [167]	——
Mineral Coal, [168]	——
" oil	*syn.* Petroleum.
" pitch	*syn.* Asphaltum.
" resin, [169]	——
" tar, [170]	*syn.* Pittasphalt.
Mirabilite, [171]	——
Mispickel	*syn.* Arsenopyrite.
Molybdenite, [172]	——
Molybdenum oxide	= Molybdite.
" sulphide	= Molybdenite.
Molybdic ochre	*syn.* Molybdite.
Molybdite, [173]	——
Monazite, [174]	——
Mordenite, [175]	——
Morenosite, [176]	——
Mountain cork, [35]	*var.* Asbestus.
" leather, [35]	*var.* Asbestus.
Muscovite, [177]	——
Nail-head-spar, [178]	*var.* Calcite.
Naphtha	*syn.* Petroleum.
Natroborocalcite	*syn.* Ulexite.
Natrolite, [179]	——
Nephelite, [180]	——
Nephrite, [181]	*var.* Amphibole.
Niccolite, [182]	——
Nickel, Arsenical	*syn.* Niccolite.
" arsenide	= Niccolite.
" silicate	= Genthite.
" sulphate	= Morenosite.
" sulphide	= Millerite, Polydymite.

Nickel, vitriol	*syn.* Morenosite.
Nickel-Gymnite	*syn.* Genthite.
Nitre, [183]	——
Obsidian, [184]	——
Octahedrite, [185]	——
Oligoclase, [186]	——
Olivine	*syn.* Chrysolite.
[Ontariolite], [187]	——
Opal, [188]	——
Orthoclase, [189]	——
Osmiridium	*syn.* Iridosmine.
Oxalite	*syn.* Humboldtine.
Pargasite, [190]	*var.* Amphibole.
Paulite, [127]	*syn.* Hypersthene.
Pearl-spar, [191]	*var.* Dolomite.
Pectolite, [192]	——
Peridot	*syn.* Chrysolite.
Peristerite, [193]	*var.* Albite.
Perthite, [194]	——
Petalite, [195]	——
Petroleum, [196]	——
Phlogopite, [197]	——
Pickeringite, [198]	——
Picrolite, [199]	*var.* Serpentine.
Pitchblende	*syn.* Uraninite.
Pitchstone, [200]	——
Pittasphalt, [170]	——
Platinum, Native, [201]	——
" arsenide	= Sperrylite.
Plumbago	*syn.* Graphite.
Polydymite, [202]	——
Potassium alum	*syn.* Kalinite.
" nitrate	= Nitre.
Prase, [280]	*var.* Quartz.
Prehnite, [203]	——
Pseudomorphous quartz, [204]	——
Psilomelane, [205]	——
Purple copper-ore	*syn.* Bornite.
Pyrallolite, [206]	*var.* Talc.
Pyrite, [207]	——
Pyrites, Arsenical	*syn.* Arsenopyrite.
" Capilliary	*syn.* Millerite.
" Copper	*syn.* Chalcopyrite.

Pyrites, Iron .... *syn.* Pyrite.
" Magnetic .... *syn.* Pyrrhotite.
" White iron .... *syn.* Marcasite.
Pyrolusite, [208] .... ——
Pyroxene, [209] .... ——
Pyrrhotite, [210] .... ——
Quartz,
" *var.* Agate .... ——
" Amethyst .... ——
" Cairngorm stone .... ——
" Carnelian .... ——
" Chalcedony .... ——
" Heliotrope .... ——
" Hornstone .... ——
" Jasper .... ——
" Prase .... ——
" Pseudomorphous .... ——
" Rock crystal .... ——
" Rose .... ——
" Smoky .... ——
Raphilite .... *syn.* Tremolite.
Red antimony .... *syn.* Kermesite.
" copper ore .... *syn.* Cuprite.
" hematite .... *syn.* Hematite.
Rensellaerite .... *syn.* Pyrallolite.
Retinalite, [211] .... *var.* Serpentine.
Rhodochrome .... *syn.* Kämmererite.
Rhodochrosite, [212] .... ——
Ripidolite, [213] .... ——
Rock crystal, [214] .... *var.* Quartz.
Rock salt .... *syn.* Halite.
Rose quartz, [215] .... *var.* Quartz.
Rutile, [216] .... ——
Sagenite, [217] .... *var.* Rutile.
Sahlite, [218] .... *var.* Pyroxene.
Sal-ammoniac, [219] .... ——
Salt, Common .... *syn.* Halite.
Samarskite, [220] .... ——
Saponite, [221] .... ——
Scapolite .... *syn.* Wernerite.
Schorl .... *syn.* Tourmaline.
Selenite, [222] .... *var.* Gypsum.
Senarmontite, [223] .... ——

Serpentine, [224]		——
Seybertite, [225]		——
Siderite, [226]		——
Sideroplesite, [227]	*var.*	Siderite.
Silicified wood, [228]	*var.*	Quartz.
Silicoborocalcite	*syn.*	Howlite.
Silver glance	*syn.*	Argentite.
Silver, Native, [229]		——
" antimonide	=	[Animikite].
" arsenide	=	[Huntilite].
" sulphide	=	Argentite.
Smaltite, [230]		——
Smoky quartz, [231]	*var.*	Quartz.
Soapstone, [232]	*var.*	Talc.
Sodalite, [233]		——
Sodium chloride	=	Halite.
" sulphate	=	Mirabilite.
Spathic iron	*syn.*	Siderite,
Specular iron, [234]	*var.*	Hematite.
Sperrylite, [235]		——
Spessartite, [236]	*var.*	Garnet.
Sphaerostilbite, [237]	*var.*	Stilbite.
Sphalerite, [238]		——
Sphene	*syn.*	Titanite.
Spinel, [239]		——
Spodumene, [240]		——
Staurolite, [241]		——
Steatite, [242]	*var.*	Talc.
Steeleite, [243]	*var.*	Mordenite.
Stellarite, [244]		——
Stibnite, [245]		——
Stilbite, [246]		——
Strontianite, [247]		——
Strontium carbonate	=	Strontianite.
" sulphate	=	Celestite.
Sulphatite, [248]		——
Sulphur, Native, [249]		——
Sulphuric acid	=	Sulphatite.
Sylvanite, [250]		——
Tubular-spar	*syn.*	Wollastonite.
Tachylite, [251]		——
Talc, [252]		——
Tellurium. Graphic	*syn.*	Sylvanite.

Tennantite, 253		——
Tenorite	*syn.*	Melaconite.
Tetrahedrite, 254		——
Thomsonite, 255		——
Titanite, 256		——
Titanium oxide	=	Octahedrite, Rutile.
Tin oxide	=	Cassiterite.
Tinstone	*syn.*	Cassiterite.
Tourmaline, 257		——
Travertine, 258	*var.*	Calcite.
Tremolite, 259	*var.*	Amphibole.
Tripolite, 131	*var.*	Opal.
Turgite, 260		——
Ulexite, 261		——
Uraconite, 262		——
Uralite, 263	*var.*	Amphibole.
Uraninite, 264		——
Uranium oxide	=	Uraninite.
" sulphate	=	Uraconite.
Uranochre	*syn.*	Uraconite.
Valentinite, 265		——
Vesuvianite, 266		——
Vitreous copper	*syn.*	Chalcocite.
" silver	*syn.*	Argentite.
Vivianite, 267		——
Wad, 268		——
Wernerite, 269		——
Wheel-ore	*syn.*	Bournonite.
White antimony	*syn.*	Valentinite.
" iron pyrites	*syn.*	Marcasite.
" lead ore	*syn.*	Cerussite.
Wilsonite, 270	*var.*	Pinite.
[Winkworthite], 271		——
Witherite, 272		——
Wolframite, 273		——
Wollastonite, 274		——
Yellow copper ore	*syn.*	Chalcopyrite.
Zinc blende	*syn.*	Sphalerite.
" sulphide	=	Sphalerite.
Zircon, 275		——

Remarks on Foregoing List.

1. Acadialite—The flesh-red, brownish-red, and yellowish-red varieties of chabazite (which have been named Acadialite) are found at Partridge Island, Swan Creek and Two Islands (Cumberland Co.), in the province of Nova Scotia.

2. Acmite—Forms an important constituent of some of the nephelene-seyenites of Montreal (Hochelaga Co.) and Belœil (Rouville Co.), in the province of Quebec. Anal., B. J. Harrington, Trans. Roy. Soc. Can., vol. i, sec. iii, p. 81, 1882 and 1883.

3. Actinolite—A bed of actinolite, mingled with an asbestiform serpentine and talc, occurs in the township of Bolton (Brome Co.), and a finely fibrous variety, without admixture, constitutes a bed in St. Francis (Beauce Co.), province of Quebec.

4. Agalmatolite—Of a greenish-white to olive-green color occurs in layers in an indurated clay-slate at St. Nicholas (Lévis Co.); of a honey-yellow color, forming a thin bed in clay-slate in the parish of St. Francis (Beauce Co.), and of an amber-yellow, with chloritic slates, on Lake Memphramagog (Stanstead Co.), province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, pp. 484, 485.

5. Agate—Many beautiful varieties are found in the trap regions of Nova Scotia: as on the shore extending from Sandy Cove to the head of St. Mary's Bay (Digby Co.); near Cape Blomidon, in large blocks (King's Co.), and fine moss agates are met with near Cape Split and at Scot's Bay (King's Co.), also at Two Islands (Cumberland Co.). Agates are found in abundance in the amygdaloids of Lake Superior, and sometimes of considerable size and beauty. They abound in rolled masses on the beaches of Michipicoten and St. Ignace Islands, at Thunder Bay and elsewhere along the shore of this lake—province of Ontario.

6. Alabaster—Considerable masses of a very beautiful snow-white gypsum or alabaster are met with in the gypsum quarries of Hillsborough (Albert Co.), in the province of New Brunswick.

7. Albertite—This beautiful mineral has, so far, only been met with in King's, Albert and Westmoreland counties—the most important locality being in the parish of Hillsborough (Albert Co.)—in the province of New Brunswick. It is not found in beds, but in

true cutting veins, which, although at times coincident with the bedding, are as often oblique or at right angles to it. The chief deposits, those of the Albert mines (in Hillsborough), occur in highly bituminous and oil-bearing shales situated near or at the base of the Lower Carboniferous; but, at points not widely separated, veins of the mineral are found penetrating, for short distances, the underlying metamorphic rocks—supposed to be of Huronian age—and the overlying and little disturbed beds of the Millstone grit. The maximum thickness of the vein as first found near the surface was twenty-two feet, that of the smaller veins only a few inches, while the veinlets were often not thicker than a sheet of paper. It is estimated that since its first discovery (by John Duffy in 1849) some 200,000 tons of this material have been raised at the Albert mines. The deposit has, however, now become practically exhausted, and the mine in consequence abandoned. (From information communicated by Professor L. W. Bailey, of the University of New Brunswick.)

8. Albite—Large cleavable masses of white albite, with quartz and mica, constitute a granite found at the Lake of Three Mountains, on the River Rouge, in the township of Clyde (Ottawa Co.), and a faintly greyish-white almost white albite, exhibiting a fine bluish opalescence, occurs in large fragments in a coarse pegmatite vein—composed of quartz, muscovite, microcline, with occasionally black tourmaline, garnet, etc.—cutting a greyish garnetiferous gneiss in the township of Villeneuve, also in Ottawa county, province of Quebec. See also note to "Peristerite."

9. Allanite—Small crystals of this mineral were found, by Dr. T. S. Hunt, in a felspathic rock near Bay St. Paul (Charlevoix Co.), and in a rock composed of labradorite and hypersthene from Lake St. John (Chicoutimi Co.), province of Quebec. Also occurs (Professor E. J. Chapman, Can. Journ., new series, vol. ix, p. 103, 1864), in the form of a narrow vein in granitoid strata at Hollow Lake, the head waters of the South Muskoka, in the province of Ontario.

10. Almandite—The red garnet from the Stickeen and Skeena Rivers, as also many of the other red varieties alluded to under "Garnet," will, most probably, be found to be referable to this variety.

11. Alunite—A massive, fine granular, light reddish colored alunite, has been met with—associated with a greyish translucent quartz

and specular iron—at New Ireland Road, parish of Alma (Albert Co.), in the province of New Brunswick.

12. ALUNOGEN—Has been found, in the form of a crust of from 5 to 5½ cm. thick, on an old heap of shale at the Scotia mine, Springhill coal-field, Cumberland Co., province of Nova Scotia. Anal., F. D. Adams, Rep. Geol. Can., 1878-79, p. 8 H.

13. AMAZON-STONE—Occurs abundantly, and of good color, in the township of Sebastopol (Renfrew Co.), in the province of Ontario. It has also been found in the pegmatite vein, referred to under "Albite," in the township of Villeneuve, and is again met with in the townships of Wakefield and Hull (Ottawa Co.), province of Quebec.

14. AMETHYST—Often of great beauty, is found at many places on the shores of Cumberland, King's, Annapolis and Digby counties, Nova Scotia. The best localities are:—Cape Sharp and Partridge Island (Cumberland Co.), Cape Blomidon (King's Co.), and Digby Neck (Digby Co.). Fine specimens occur in veins around Thunder Bay—more especially at Amethyst Harbor, and at the mouth of McKenzie's River—and at other points on the north shore of Lake Superior, province of Ontario.

15. AMPHIBOLE—See under "Actinolite," "Asbestus," "Hornblende," "Nephrite," "Pargasite," "Tremolite."

16. ANALCITE—Fine specimens of this mineral are found at Cape d'Or, Swan Creek, and Two Islands (Cumberland Co.), also at Cape Blomidon (King's Co.), in the province of Nova Scotia. It has been observed, in association with natrolite, in some of the dykes cutting the Trenton limestone at the reservoir extension, Montreal (Hochelaga Co.), province of Quebec. Also occurs in the amygdaloidal traps of the north shore of Lake Superior, province of Ontario. Anal., B. J. Harrington, Rep. Geol. Can., 1877-78, p. 45 G.

17. ANDALUSITE—Occurs in pale flesh-red colored crystals in a fine grained micaceous schist at Moore's Mills (Charlotte Co.), province of New Brunswick. Also found, in somewhat micaceous argillites, on Lake St. Francis (Beauce Co.), in the province of Quebec. See also note to "Chiastolite."

18. ANDESITE—Occurs in large striated cleavable masses of a reddish color, with hypersthene and ilmenite, constituting a rock at

Château Richer (Montmorency Co.), province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 478.

19. ANDRADITE—Is found in pale yellowish, honey-yellow, and brownish-yellow colored crystals, imbedded in chalcopyrite; and in yellowish-green colored masses, in association with white fibrous tremolite and dolomite, at the Malaspina copper-mine, north-east side of Texada Island, province of British Columbia.

20. ANHYDRITE—Is met with in considerable quantities, constituting beds, in the gypsum deposits of Nova Scotia and New Brunswick.

21. ANIMIKITE — HUNTILITE — MACFARLINITE. The minerals thus designated occur at the Silver Islet mine, Lake Superior, province of Ontario. The two first named were described by Dr. H. Wurtz (Eng. Min. Journ., xxvii, pp. 55 and 124, 1879), the last by T. Macfarlane (Can. Nat., 2 ser., vol. iv, p. 463, 1870), the results of whose investigations of the foregoing are given in the Trans. Amer. Inst. Min. Eng., viii, 236, 1880. [The true nature of the individual minerals present in the Silver Islet ores is still to be determined, but there is probably present a silver arsenide (Huntilite), and perhaps also a silver antimonide (animikite) allied to dyscrasite—Dana, Min., App. iii, p. 71, 1882.]

22. ANKERITE—This is one of the most plentiful and characteristic of the minerals filling the numerous fissure veins occurring at the base of the southern slope of the Cobequid Mountains, Londonderry, Colchester Co., Nova Scotia. Analyses, H. Louis, Trans. N. S. Inst., vol. v, p. 49, 1879-82.

23. ANORTHITE—This felspar is one of the component minerals of the coarsely crystalline intrusive diorite of Yamaska Mountain (Yamaska Co.), in the province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 479.

24. ANTHRACITE—Of the Carboniferous system is not known to occur in Canada; there are, however, deposits of this mineral, of Cretaceous age, on the Queen Charlotte Islands—the best known locality being at Cowgitz, on Skidegate channel, at the southern end of Graham Island — province of British Columbia. For reference to analyses, see under "Mineral Coal."

25. ANTHRAXOLITE—This name has been given, by Professor E. J. Chapman, but simply as a convenient term for present use, to the

black combustible coal-like matter which is not unfrequently met with in the provinces of Quebec and Ontario. He describes it as follows:—Black, lustrous, resembling anthracite in general characters, but very brittle. Hardness equals 2·25 — 2·50; specific gravity, 1·35 — 1·55. Generally decrepitates when heated. Before the blowpipe, a small fragment loses its lustre, but exhibits no further change. Composition, essentially carbon, with from 3 — 25 per cent. of volatile matter, including a small amount of moisture, and ash varying from 0 — 11 per cent. Exhibits under the microscope no trace of organic structure. Dr. T. S. Hunt, in speaking of this material, says, "It can scarcely be doubted but that it has resulted from the slow alteration of liquid bitumen in the fissures of the strata." This would explain the great variability in the percentage of volatile matter (exclusive of moisture) which is observed in specimens from different localities, the amount of alteration having in some instances proceeded further than in others. It never occurs in true beds like coal, but is found either lining fissures or filling veins and fissures, sometimes several inches in diameter, in the limestones, shales and sandstones, and even in the trap rocks which traverse these. Sometimes it occurs in buttons or drops, forming botyroidal masses. It has been met with in many places in the province of Quebec, viz., on the Island of Orleans, at Quebec and Sillery (Quebec Co.), Point Lévis, and St. Nicholas (Lévis Co.), Lotbinière (Lotbinière Co.), Drummondville (Drummond Co.), Acton (Bagot Co.), in the vicinity of Chatte River in Gaspé, and elsewhere. In the province of Ontario it has been observed filling fissures in the chert beds among the Upper Copper-bearing rocks of Lake Superior. Analyses, T. S. Hunt, Geol. Can., 1863, pp. 524-526.

26. Antimony, Native—Occurs in some quantity and in good specimens at the antimony mine in the parish of Prince William (about twenty-five miles from Fredericton), York county, province of New Brunswick. In a lamellar or, more rarely, finely granular form, occurs, in association with stibnite, valentinite, senarmontite and kermesite, accompanied by quartz and a little brown-spar, in veins in argillite in the township of South Ham, Wolfe county, province of Quebec.

27. Apatite—The variety fluor-apatite is very common in the Laurentian rocks of Canada, where it occurs both in the form of veins and of large irregular shaped deposits or lenticular masses. The most important deposits are in the townships of Buckingham,

Templeton, Portland and Wakefield (Ottawa Co.), in the province of Quebec—but extensive deposits also occur in the townships of North and South Burgess and North Elmsley, in the province of Ontario. This mineral also occurs in connection with crystalline limestone—being found, in the form of olive-green terminated crystals, with rounded angles, together with grains of purple fluorite, and crystals of black spinel, imbedded in a yellowish crystalline limestone, in the township of Ross (Renfrew Co., Ont.); and crystals of blue apatite and quartz are imbedded in a coarsely cleavable, sky-blue calcite at the Calumet Falls in the township of Litchfield (Pontiac Co., Que.). Small hexagonal prisms, sometimes an inch in length and one or two lines in diameter, transparent, of a pink or purple color, with surfaces often dull, and angles rounded, occur, in association with crystals of augite, in an intrusive mass of fine grained, grey dolerite at St. Roch, on the Achigan River, L'Assomption Co., Que. Anal., T. S. Hunt, Rep. Geol. Can., 1863-66, p. 203. On the composition of Canadian apatites, G. C. Hoffmann, Rep. Geol. Can., 1877-78, pp. 1-14 H.

28. Aphrodite—Is found filling fissures in the massive pyrallolite of the township of Grenville (Argenteuil Co.), in the province of Quebec. Anal., T. S. Hunt, Geol. Can., 1863, p. 473.

29. Apophyllite—Green and white crystals, aggregated in plates or in square prisms, occur at Two Islands and Cape d'Or (Cumberland Co.), Blomidon (King's Co.), and Margaretville (Annapolis Co.), in the province of Nova Scotia. Also, in foliated masses or plates, often of a red color, in association with calcite, on Prince's Location, Spar Island, Lake Superior, province of Ontario.

30. Argentite—Occurs, with native silver, chalcocite, sphalerite, etc., in a vein of calcite at Prince's mine; with native silver, in a vein of barite, celestite and calcite, on Jarvis Island; with native silver, sphalerite, and a little galenite and pyrite, in a vein of barite and calcite on McKellar's Island; and with sphalerite, pyrite, niccolite, etc., in a veinstone consisting of calc-spar, bitter-spar and quartz, on Silver Islet, Lake Superior. With native silver, in a gangue of calcite, at the Duncan mine—also at the Rabbit Mountain, Porcupine, Beaver and other mines in the district of Thunder Bay (Lake Superior), province of Ontario.

31. Arquerite—Is found with alluvial gold upon Vital and Silver Creeks, Omenica district, province of British Columbia. Anal., H. G. Hanks, Dana, Min., App. iii, p. 4, 1882.

32. ARRAGONITE—Is met with, in the form of acicular crystals, varying in size from microscopic minuteness to an inch or more in length, lining fissures or cavities in the ankerite or implanted upon barite or calcite, in the ankerite deposits of Londonderry (Colchester Co.), province of Nova Scotia. Has been observed forming stalactites and delicate fibrous masses in a calcareous rock in the township of Tring (Beauce Co.), province of Quebec—and sparingly amongst the Lake Superior traps, province of Ontario.

33. ARSENIC. NATIVE,—Is found, in veins, seven miles up Watson Creek, west side of Fraser River, twenty-five miles above Lytton, province of British Columbia. Ann. Rep. Geol. Can., vol. ii, p. 9 T, 1886.

34. ARSENOPYRITE—Is of exceedingly common occurrence in the gold-bearing quartz bands of Nova Scotia. Is found according to Dr. Hunt, well crystallized, with galena, in a quartz vein on the Chaudière in St. Francis (Beauce Co.) ; and still more abundantly in small crystals, in association with galena, in a large vein of quartz on Moulton Hill, near Lennoxville (Sherbrooke Co.), province of Quebec. Occurs in large quantities in quartzose veins in the township of Marmora (Hastings Co.), and it is also met with in the township of Tudor, in the same county, province of Ontario.

35. ASBESTUS—A more or less delicately fibrous variety of hornblende has been met with in the townships of Templeton and Buckingham (Ottawa Co.), province of Quebec. In the latter township, mountain cork was found in quantity and in masses of considerable size at the Emerald phosphate mine. Mountain leather has also been met with in this township as well as the Beaver mine in the township of O'Connor, District of Thunder Bay, in the province of Ontario. The fibrous variety of serpentine, which constitutes a large proportion of what is known in commerce as asbestus, occurs in quantity in the Eastern Townships of the province of Quebec.—See under " Chrysotile."

36. ASPHALTUM—Occurs in the vicinity of Oil Creek, in the southern part of the township of Enniskillen (Lambton Co.), province of Ontario, where it forms two layers, of a viscid consistency, known as gum-beds, occupying areas of about an acre, each, in extent, and having a thickness varying from a few inches to two feet. Another bed of bitumen, of from two to four inches in thickness, is met with at Petrolia, in the northern part of the same township. The

material of this bed, which is more solid than that of those just referred to, and mixed with a good deal of earthy matter, is readily separable into thin layers, which are soft and flexible. Very extensive deposits of a bituminous sand-rock occur for great distances along the banks of the lower Athabasca River, North-west Territory; these are described in Rep. Geol. Can., 1882-84, part CC., and the results of the examination of the material appear in Rep. Geol. Can., 1880-82, p. 3 H.

37. Augite—Well defined crystals of black augite are found imbedded in the dolerites of Montreal (Hochelaga Co.), Rougemont (Rouville Co.), and Montarville (Chambly Co.) Mountains, in the province of Quebec. Anal., T. S. Hunt, Geol. Can., 1863, p. 468.

38. Axinite—Is said by Dr. Bigsby to have been found, in fine crystals, lining a cavity in a boulder of primitive rock at Hawkesbury (Prescott Co.), in the province of Ontario. It has been found *in situ* by Dr. R. Bell, in small veins in trap, on the east coast of Hudson Bay, about one mile and a-half south of the mouth of Little Whale River. Here it occurs, of a purplish-brown color, in association with epidote, imbedded in a matrix of calcite with a little quartz.

39. Azurite—Has, so far, not been met with in characteristic specimens, but merely as an incrustation on copper-ores, or in the form of stains and small earthy masses in copper-holding rock. Among the many localities where it has been observed, may be mentioned :—The Prince of Wales mine, Upton (Bagot Co.), and at the Black River mine—in a drusy calcite, with sulphurets of copper, in the form of small crystals—St. Flavien (Lotbinière Co.), province of Quebec. With green carbonate of copper at Batchewanung Bay and Prince's mine, Lake Superior, province of Ontario.

40. Barite—Occurs, sometimes in very beautiful crystalline masses, in numerous irregular veins or pockets in the slates of the East River of the Five Islands (Colchester Co.), Nova Scotia. In a vein cutting Laurentian limestone, in the township of Hull (Ottawa Co.), province of Quebec—and the following localities in the province of Ontario, viz., the townships of Bathurst and North Burgess (Lanark Co.), McNab (Renfrew Co.), Dummer and Galway (Peterborough Co.), and Summerville (Victoria Co.), also —constituting large veins, on Jarvis, McKellar's and Pie Islands, Lake Superior. Red crystals associated with purple fluorite are

found on Iron Island, Lake Nipissing ; and isolated pale reddish-yellow crystals have been found by Professor Chapman (Can. Journ., Nov., 1885) in veins, in the township of Neebing, near Fort William, Thunder Bay, Lake Superior, and subsequently in other mineral veins in that region.

41. BERTHIERITE—Is mentioned (Dana, Minn., p. 86) as occurring near Fredericton, province of New Brunswick. Professor Bailey thinks the locality referred to would most probably be the antimony mine in the parish of Prince William, about twenty-five miles from Fredericton (York Co., N.B.).

42. BERYL—Crystals of this mineral, having a diameter of three inches and more, and a length of from twelve to fifteen inches have been met with, by Abbé J. C. K. Laflamme, in the township of Jonquière (Chicoutimi Co.), and it has also been found in the township of Brassard (Berthier Co.), province of Quebec.

43. BIOTITE—A dark bottle-green mica from Moore's slide (Roche-Fendue channel) on the Ottawa River, has been referred to this species.

44. BISMUTH. NATIVE,—Was recognized by Professor Chapman in some rolled pieces of quartz from near Echo Lake, on the north-west shore of Lake Huron ; and agreeably with the observations of Dr. Hunt, it also occurs, in traces, in a veinstone in the township of Tudor (Hastings Co.), province of Ontario.

45. BISMUTHINITE—Has been met with, in small lamellar and sub-fibrous masses, in a quartz vein at Hill's mine, in the rear of Tudor township, Hastings county, province of Ontario.

46. BISMUTITE—Has been recognized, by Dr. Hunt, as occurring in a quartz vein at Hill's mine, in the rear of the township of Tudor, Hastings county, province of Ontario.

47. BITUMINOUS COAL—Of the Carboniferous formation occurs in the provinces of New Brunswick and Nova Scotia. In the former, though covering a large surface area, more than two-thirds of the entire extent of the province, the Carboniferous or coal-bearing rocks have afforded as yet but little promise of large or valuable deposits, and with the exception of the beds at Grand Lake in Queen's county, which are about two feet in thickness, no stratum of bituminous coal, sufficiently large or pure to be profitably worked, has as yet been discovered. In the province of Nova

Scotia there are three important coal basins, viz., those of Cape Breton, Pictou and Cumberland counties—the first mentioned occupying an area of at least 190 square miles, with a thickness of not less than 7,000 feet of the Carboniferous strata; the second occupies an area of only some 22 square miles, but several of the coal seams are of extraordinary thickness; the area of the Cumberland field is likewise small, but includes several good seams. Coal is not found in the provinces of Quebec and Ontario; the black combustible coal-like matter referred to under "Anthraxolite," is however met with in small quantity at various localities in both these provinces. In the North-west Territory in the Rocky Mountains, and in the adjacent foot-hills, there are extensive deposits of a bituminous coal which, although of Cretaceous age, is in all respects—physical character and chemical composition—undistinguishable from coal of the Carboniferous, and the same may be said of the coal of the extensive and important deposits, also of Cretaceous age, which exist in various parts of British Columbia. For reference to analyses, see under "Mineral coal."

48. Bog Iron-ore—Occurs in great abundance at numerous localities in the provinces of Quebec and Ontario. In the former, the most important sites are in the Three Rivers district, or between the Rivers St. Maurice, Batiscan and St. Anne. Other deposits occur in the townships of Stanbridge, Farnham, Simpson, Ascot, Ireland, Eardley, Hull, Templeton—the seigniories of Vaudreuil, Lotbinière Lauzon, St. Vallier, and elsewhere. In Ontario it is met with, in greater or less quantity, in the townships of Charlotteville, Middleton, and Windham (Norfolk Co.), Cambden (Kent Co.), Bastard (Leeds Co.), etc. Analyses, T. S. Hunt, Geol. Can., 1863, p. 510.

49. Bornite—Occurs, most commonly associated with chalcopyrite and chalcocite, in the townships of Cleveland and Melbourne (Richmond Co.), Acton (Bagot Co.), Leeds and Halifax (Megantic Co.), Sutton (Brome Co.), and elsewhere in this section of the province of Quebec. It has been found at the West Canada mines on Lake Huron, also at some points on Lake Superior, in the province of Ontario—and near the head of Salmon Arm of Jarvis Inlet, and between that inlet and Howe Sound, province of British Columbia.

50. Bytownite—The name given by Dr. Thompson to a greenish white felspathic mineral found in a boulder, near Bytown (now the city of Ottawa), in the province of Ontario,—and which has

since been shown by Zirkel (Tsch. Min. Mitth., 1871, 61) to be a mixture. An analysis of a portion of the specimen upon which Dr. Thompson founded the species, is given by Dr. T. S. Hunt in the Geol. Can., 1863, p. 479.

51. CACHOLONG—Beautiful specimens of this mineral are obtainable on the coast between Capes Split and Blomidon (King's Co.), in the province of Nova Scotia.

52. CACOCLASITE—The cacoclasite of Professor H. C. Lewis (the Naturalist's Leisure Hour and Monthly Bulletin, A. E. Foote, No. 87, Exposition extra, 1885), has quite recently been submitted to a careful reëxamination by Dr. F. A. Genth, and shown not to be a good species. Am. Journ. Sci., 3 ser., vol. xxxviii, p. 200, 1889.

53. CACOXENITE—Has been observed by Dr. Harrington as occurring in the form of beautiful little yellow tufts on the walls of cavities in calcite at the pyrite deposit near Brockville, in Elizabethtown, province of Ontario.

54. CALCAREOUS TUFA—See note to "Travertine."

55. CALCITE—Is found in large rhombohedral, also modified crystals, at Partridge Island (Cumberland Co.), and on the coast between Capes Split and Blomidon (King's Co.), and a very fine apple-green calcite is found at McKenzie's River (Inverness Co.), province of Nova Scotia. A coarsely cleavable sky-blue calcite occurs at the Calumet Falls in Litchfield (Pontiac Co.), also in the township of Wakefield (Ottawa Co.), and a yellow, cleavable calcite, also a fibrous variety, in the township of Templeton (Ottawa Co.), province of Quebec. A salmon-red, cleavable calcite in the township of Sebastopol, Renfrew county, in the province of Ontario. Crystalline limestone, suitable for employment as marble, for architectural purposes, occurs in most, and is very abundant in some, of the provinces of the Dominion. White, red, grey, brown, and black (and various shades of these colors) varieties are met with, respectively, at:—St. Armand (Mississquoi Co.), Caughnawaga (Laprairie Co.), Dudswell (Wolfe Co.), Point Claire (Jacques Cartier Co.), St. Dominique (Bagot Co.), St. Joseph (Beauce Co.), etc., in the province of Quebec—and Arnprior (Renfrew Co.), Cornwall (Stormont Co.), L'Orignal (Prescott Co.), Pakenham (Lanark Co.), and elsewhere in the province of Ontario. See also notes to "Dog-tooth-spar," "Foetid calcite," "Iceland-spar,"

"Nail-head-spar," "Travertine." For a list of minerals of the Laurentian limestones, see Report "On the Laurentian limestones of North America," by Dr. T. S. Hunt, Rep. Geol. Can., 1863-66, p. 181, et seq.

56. Foetid Calcite—A milk-white, cleavable, foetid calcite, forms a large bed in the township of Grenville, and is also met with in the adjoining township of Chatham (Argenteuil Co.), province of Quebec.

57. Cancrinite—Occurs in the nepheline-syenites of Montreal (Hochelaga Co.), and Belœil (Rouville Co.), province of Quebec. Anal., B. J. Harrington, Trans. Roy. Soc. Can., vol. i, sec. iii, p. 81, 1882 and 1883.

58. Cannel Coal—Occurs at Little Glace Bay, Cape Breton, province of Nova Scotia. Anal., H. How, Phil. Mag., 4 ser., vol. xxxvii, p. 268, 1869.

59. Carnelian—Is found at Blomidon (King's Co.); at Trout Cove (Digby Co.), and the north shore of Granville (Annapolis Co.), province of Nova Scotia.

60. Cassiterite—Small quantities of this mineral, in the form of minute grains, were found to be associated with the Sperrylite obtained at the Vermillion mine, in the township of Denison, District of Algoma, province of Ontario (H. L. Wells, Am. Jour. Sci., 3 ser., vol. xxxvii, p. 68, 1889). Very small quantities of this mineral, in the form of minute crystals, have also been found by Dr. Genth (priv. com.) in some tailings from the Battery lead, Malaga gold mining district, Queen's county, province of Nova Scotia.

61. Celestite — Occurs:—in white translucent crystalline foliated masses, which are sometimes radiated, and often several inches in diameter, in the Black River or Trenton limestone of Kingston (Frontenac Co.); in large crystallized masses, semi-transparent and of a bluish or occasionally, in parts, pale reddish color, in a vein cutting Laurentian limestone in the township of Lansdowne (Leeds Co.); in radiating fibrous masses, constituting a vein in the Laurentian strata of Bagot (Renfrew Co.); a red variety, in cavities in dolomite, at the forks of the Credit, township of Caledon (Peel Co.). Other localities in this province (Ontario) are:—Owen Sound, Drummond and Grand Manitoulin Islands (Lake Huron), etc.

62. CENTRALLASSITE—Is found in trap of Triassic age near Black Rock (King's Co.), in the province of Nova Scotia. Anal., H. How, Ed. N. Phil. Journ., new series, vol. x, p. 84, 1859: Phil. Mag., 5 ser., vol. i, p. 128, 1876.

63. CERUSSITE—Has hitherto been met with only in small earthy masses and incrustations, associated with the galenite of certain localities in British Columbia.

64. CHABAZITE—Is found in large and very perfect crystals at Swan Creek (Cumberland Co.), Mink Cove and Sandy Cove, Digby Neck, and Williams Brook (Digby Co.), and Pinnacle Island (Colchester Co.), in the province of Nova Scotia. See also note to "Acadialite."

65. CHALCEDONY—Is found in many parts of the trap district of Nova Scotia, where, according to Dr. How, an almost unique blue chalcedony is found on the coast between Capes Split and Blomidon (King's Co.), and a very fine milk-white chalcedony near Trout Cove, Digby Neck (Digby Co.). It occurs—of an olive-green color, in small veins on Belanger's Island, lying off the entrance to Richmond Gulf, eastern coast of Hudson Bay; in thin bands or veins, with jasper, on the River Ouelle (Kamouraska Co.), in the province of Quebec. In veins in the amygdaloidal traps of Lake Superior, province of Ontario; and elsewhere in Canada.

66. CHALCOCITE—Is found, most frequently in association with chalcopyrite, or chalcopyrite and bornite, in the townships of Leeds and Halifax (Megantic Co.), Brome, Sutton (Brome Co.), Shefford, Stukeley (Shefford Co.), Melbourne, Cleveland, Brompton (Richmond Co.), Acton (Bagot Co.), and Tingwick (Arthabaska Co.), in the province of Quebec—at the Canada West mines on Lake Huron, and Prince's location, Lake Superior, in the province of Ontario.

67. CHALCOPYRITE—Is widely distributed throughout many of the Eastern Townships of the province of Quebec. In some of them it is occasionally met with unaccompanied by other ores of copper, but it is more frequently associated with chalcocite or bornite, or both. The more important localities lie in the townships of Bolton, Brome, Sutton (Brome Co.), Leeds, Halifax (Megantic Co.), Stukeley (Shefford Co.), Ascot (Sherbrooke Co.), Acton (Bagot Co.), Cleveland, Melbourne (Richmond Co.), Chester

(Arthabaska Co.), and Ham (Wolfe Co.). Other noteworthy localities are—the township of McKim, and adjoining townships, in the District of Nipissing; the West Canada mines, Lake Huron, and Point-aux-Mines and other places on Lake Superior, in the province of Ontario.

68. Chiastolite—Occurs in a fine grained micaceous schist at Moore's Mills, Charlotte county, province of New Brunswick; and in the somewhat micaceous argillites on Lake St. Francis in Beauce county, province of Quebec.

69. Chlorite (Penninite)—Occurs, most frequently, in admixture with other minerals, forming beds of chloritic slates as in Bolton (Brome Co.), Shefford (Shefford Co.), Ascot (Sherbrooke Co.), Cleveland and Melbourne (Richmond Co.), and other Eastern Townships of the province of Quebec. In some of these townships, however, as for instance those of Potton and Bolton (Brome Co.), and Broughton (Beauce Co.), beds of pure compact chlorite are met with, and occasionally, as in Cleveland (Richmond Co.), the chloritic slates are traversed by thin, well defined veins, which are filled with pure scaly chlorite. Anal., T. S. Hunt, Geol. Can., 1863, p. 607.

70. Chloritoid—Is of common occurrence in the micaceous schists of the Eastern Townships, in which it is disseminated in small grains and crystalline plates, or small lamellar and spherical masses. It is thus found in the townships of Leeds (Megantic Co.), Brome and Sutton (Brome Co.), in the province of Quebec. Anal., T. S. Hunt, Geol. Can., 1863, p. 498.

71. Chondrodite—Is often met with in the crystalline limestones of the Laurentian series. It is found, in grains, in the limestones of St. Jérôme (Terrebonne Co.); in a magnesian limestone, in Aldfield (Pontiac Co.), province of Quebec—and, with small scales of graphite, in a white crystalline limestone near Newborough, in North Crosby, also in South Crosby (Leeds Co.), in the province of Ontario, and elsewhere in these provinces.

72. Chromiferous Garnet—A very beautiful emerald-green chromiferous garnet occurs, in granular masses and minute crystals, thickly disseminated through a vein of white cleavable calcite, on the east side of Brompton Lake, in the township of Orford (Sherbrooke Co.), and a very similar garnet is found, associated with apatite, pyroxene, calcite, orthoclase, tourmaline and idocrase, in

the township of Wakefield (Ottawa Co.), province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 497; B. J. Harrington, Can. Nat., 2 ser., vol. ix, p. 305, 1881.

73. CHROMITE—Is found in pockets, scattered through serpentine, at Mount Albert, Shickshock Range (Gaspé Co.), and in considerable quantity, in connection with serpentine and other magnesian rocks of the Quebec group, in the townships of Bolton (Brome Co.), Ham and Wolfstown (Wolfe Co.), and Leeds (Megantic Co.), in the province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 504.

74. CHRYSOCOLLA—Is found sparingly amongst some of the copper ores of Lake Superior, province of Ontario.

75. CHRYSOLITE—Occurs in the form of grains, and occasionally as ill-defined crystals, in a dark grey dolerite, near South Lake (Antigonish Co.), province of Nova Scotia. In well-defined green crystals, and olive or amber-colored imperfect crystals, and small honey-yellow grains, in the eruptive rocks of Rougemont (Rouville Co.), Montarville (Chambly Co.), and Montreal (Hochelaga Co.); in red angular masses in a dyke at St. Anne's (Jacques Cartier Co.), and of a pale yellowish to greyish-green color, forming rock masses at Mount Albert, Shickshock Range (Gaspé Co.), in the province of Quebec. Olivine has also been detected in several of the eruptive rocks of British Columbia. Analyses, T. S. Hunt, Geol. Can., 1863, p. 464: B. J. Harrington, Rep. Geol. Can., 1877-78, p. 39 G.

76. CHRYSOTILE—Often constitutes seams, sometimes nearly seven inches thick, in the serpentine of the Eastern Townships of the province of Quebec: the more important localities comprising—the townships of Thetford and Coleraine (Megantic Co.), Shipton and Melbourne (Richmond Co.), Ham (Wolfe Co.), Broughton (Beauce Co.), and Bolton in Brome county. Anal., E. G. Smith, Am. Journ. Sci., 3 ser., vol. xxix, p. 32, 1885.

77. CINNABAR—Occurs, *in situ*, sparsely disseminated through a fine crystalline granular limestone, at the Ebenezer mine, Hector (Kicking Horse) Pass, Rocky Mountains, British Columbia.

78. CLAY IRONSTONE—Is found everywhere in the Coal Measures of Pictou county, Nova Scotia, in irregular beds from five to forty inches thick. Occurs in layers and nodules, in connection with

a small seam of coal at Gaspé, province of Quebec. Is widely distributed in the North-west Territory, in some localities in considerable abundance, in the form of nodules and nodular sheets. Analyses, G. C. Hoffmann, Rep. Geol. Can., 1880-82, p. 8—12 H.

79. COCCOLITE—A greenish-grey granular pyroxene or coccolite, occurs in the township of Portland, and the same mineral, of a pale green color, is met with in the, in part, adjoining township of Buckingham (Ottawa Co.), province of Quebec.

80. COOKEITE—A micaceous mineral having all the blow-pipe characters of, and which may prove to be identical with, Cookeite was found sparsely disseminated through a specimen of galenite from Otter Tail Creek, province of British Columbia. Ann. Rep. Geol. Can., vol. ii, p. 10 T., 1886 [where, however, the locality is erroneously given—read as above].

81. COPPER. NATIVE,—Is found, in the form of grains and irregular shaped masses, occasionally several pounds in weight, in veins and fissures traversing the trap at Cape d'Or and Spencer's Island (Cumberland Co.), Five Islands (Colchester Co.), Margaretville (Annapolis Co.), Briar Island (Digby Co.), and many other places in this section of Nova Scotia. More abundantly, however, in the province of Ontario, occurring in fine particles, filaments, grains or masses, the latter sometimes more than one hundred pounds in weight, in amygdaloidal traps and greenstones, in veins and fissures traversing these, and in sandstones associated with the same, in many localities on the north and east shore of Lake Superior, some of the more important of which are—Battle Island, the Islands of St. Ignace and Michipicoten, also at Mamainse and Cape Gargantua.

82. CORACITE—Is said to form a vein about two inches in width, at the junction of the trap and syenite, at Mamainse, east side of Lake Superior, province of Ontario.

83. CORUNDUM—Has been found in small light blue crystals imbedded in crystalline Laurentian limestone, also in rose-red to sapphire-blue grains, disseminated through a rock made up of felspar, quartz, calcite, mica and sphene, in the township of Burgess (Lanark Co.), province of Ontario.

84. COVELLITE—Occurs in nodular form, with nodules of more or less altered chalcocite, at New Annan (Colchester Co.), province of Nova Scotia. Anal., H. Louis, Trans. N. S. Inst., vol. iv, p. 427, 1878.

85. CRYPTOMORPHITE—Is found, in conjunction with ulexite, Howlite, mirabilite, halite, Arragonite, calcite and selenite, in gypsum deposits at the Clifton quarry, Windsor (Hants Co.), province of Nova Scotia. Anal., H. How, Am. Jour. Sci., 2 ser., vol. xxxii, p. 9, 1861.

86. CUPRITE—Has been found, in association with a little native copper and blue and green carbonate, in quartz, at Spencer's Island (Cumberland Co.);—the collector, Mr. C. W. Willimott, informing me that it occurs, *in situ*, at Bennett's Brook, one mile east of Horse-shoe Cove, and at intermediate points between that and Cape d'Or, one mile west of Horse-shoe Cove (Cumberland Co.), Nova Scotia. Also occurs, but in small quantity only, in some of the copper deposits of the Eastern Townships of the province of Quebec, as at Acton (Bagot Co.), where it has been observed in the form of cinnabar-red stains upon blackish shales.

87. CYANITE—Occurs in the form of radiated columnar aggregates of a pure blue, light bluish-grey, and greenish-grey color, imbedded in a granular quartz, on the North Thompson River, British Columbia. Anal., G. C. Hoffman, Rep. Geol. Can., 1878-79, p. 1 H.

88. DAWSONITE—Occurs in the joints of a white felspathic dyke, cutting the Trenton limestone, near the western end of McGill College, Montreal, (Hochelaga Co.), province of Quebec. Anal., B. J. Harrington, Can. Nat., 2 ser., vol. vii, page 305, 1875 ; see also vol. x, p. 84, 1883.

89. DIALLAGE (HYDROUS)—Small masses of a pearly, translucent, celandine-green diallage, occur in a rock in the township of Orford (Sherbrooke Co.), and a coarsely cleavable, bronze-colored variety of diallage, forming a rock, is met with in the township of Ham (Wolfe Co.), province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 469.

90. DIOPSIDE—See note to "Malacolite."

91. DOG-TOOTH-SPAR—Large scalenohedrons of calcite have been found at the Bruce and Wellington mines on Lake Huron, also at the Silver Islet and Duncan (formerly Shuniah) mines (at the last named, Professor Chapman observed, in a *vug*, a bunch of crystals, many of which measured upwards of eighteen inches in length), Thunder Bay, Lake Superior, province of Ontario. Good specimens of dog-tooth-spar are also found at Teny Cape (Hants Co.), Black Rock (King's Co.), Partridge Island and Two Islands (Cumberland Co.), etc., in the province of Nova Scotia.

92. DOLOMITE—In the form of rock-masses, is of very common occurrence in Canada. Besides forming great beds among the Laurentian limestones, dolomites make up the chief part of the so-called Calciferous formation, and are developed on a great scale in its geological equivalent, the Quebec group. The so-called limestones of the whole of the Middle and Upper Silurian series in Ontario are, with a few exceptions, dolomites, including the Clinton, Niagara, Guelph, and Onondaga formations. See also note to "Pearl-spar."

93. DOMEYKITE—Has been found, in admixture with niccolite, in a vein cutting a bed of amygdaloid on Michipicoten Island, Lake Superior, province of Ontario. Analyses, T. S. Hunt, Geol. Can., 1863, p. 506.

94. ELAEOLITE—Is mentioned, by Dr. Hunt, as occurring in orange-red grains, with black hornblende, in a white felspathic rock, which is found in boulders on Pic Island in Lake Superior, province of Ontario.

95. EPIDOTE—Characterizes large portions of the metamorphic rocks of the province of Quebec, in many parts of which occur beds which are entirely made up of quartz and epidote; sometimes in distinct grains, at other times forming a homogeneous, generally pale green, very tough and sonorous rock. Characteristic specimens of this rock are met with in the township of Melbourne (Richmond Co.), but beds of the same occur in numerous localities in this section of the province. This mineral has been met with in the crystalline form, in a concretionary epidotic rock, at St. Joseph (Beauce Co.), province of Quebec; also in some of the amygdaloidal traps and greenstones of Lake Superior—as at Mamainse, where crystals of the same are found implanted upon mesolite—in the province of Ontario.

96. EPISTILBITE—Is found with stilbite on ledges of trap at Margaretville, about seven miles east of Port George, Annapolis county, province of Nova Scotia. Analyses, H. How, Am. Journ. Sci., 2 ser., vol. xxvi, p. 33, 1858.

97. EPSOMITE—Occurs at the Clifton gypsum quarry, Windsor, Hants county, province of Nova Scotia. As an efflorescence on the black shales of the Utica formation near Montreal (Hochelaga Co), and upon the black shales of Quebec (Quebec Co.), province of Quebec. As an efflorescence on a serpentine rock near the

iron-ore bed of Crow Lake in Marmora (Hastings Co.), and as a crystalline incrustation upon sheltered surfaces of the dolomites at various points along their outcrop from Niagara Falls to Lake Huron, and near Niagara is said to be found, with gypsum, in geodes in the rock—province of Ontario. Also occurs, in association with Mirabilite, as an incrustation upon the cliffs of shale at Fort St. John, Peace River, British Columbia. Anal., G. C. Hoffmann, Rep. Geol. Can., 1875-76, p. 421.

98. ERYTHRITE—Is found as a rose-red incrustation on calcareous spar, at Prince's mine on Lake Superior, province of Ontario.

99. ESSONITE—Occurs in small crystals, with crystals of idocrase, pyroxene and zircon, in calcite at Grenville (Argenteuil Co.), and both massive and crystallized, in the townships of Portland and Wakefield (Ottawa Co.), in the province of Quebec.

100. FAHLUNITE—Is mentioned, by Professor How, as occurring in granite on the road between Windsor and Chester, Hants county, province of Nova Scotia.

101. FASSAITE—A black, occasionally blackish-green, pyroxene from the township of Templeton (Ottawa Co.), province of Quebec, would seem, from its chemical composition and other characters to be referable to this variety. Anal., B. J. Harrington, Rep. Geol. Can., 1877-78, p. 17 G.

102. FLUORITE—Occurs, in green octahedral crystals, with barite, lining fissures in porphyry, on an island three miles east of Gravelly Point; in green cubes, associated with quartz and calcite, at Prince's mine; of a purple color, filling veins in syenite, on the main land opposite Pic Island, and also, with calcite in amygdaloid three miles east of Cape Gargantua; in cubes two or more inches in diameter, associated with large crystals of amethyst, in *vugs* in the large irregular veins in the syenite at the mouth of McKenzie's River, Thunder Bay; in veins near Black Bay and Terrace Bay; on Fluor Island in Neepigon Bay, and elsewhere on Lake Superior, province of Ontario.

103. FREIBERGITE—An argentiferous tetrahedrite, associated with some galenite and sphalerite, in a gangue of quartz, is found at Cherry Creek, thirty-three miles east of the head of Okanagon Lake, province of British Columbia.

104. GALENITE—Is very widely distributed throughout Canada; both in interstratified masses, veins, and small crystalline aggregations, etc., scattered through rocks of various kinds. Some of the most noteworthy localities of its occurrence are situate—in the counties of Carleton, Lanark, Leeds, Frontenac, Hastings, and Peterborough, and on the north shore of Lake Superior, as at Prince's Mine, Thunder Cape, and Point des Mines, etc., in the province of Ontario. Extensive deposits of galenite exist in the Illecillewaet district,—at Mount Stephen (Tunnel Mountain), and at Hot Springs and Hendryx Camps, Kootanie Lake, etc., in the province of British Columbia. Fine specimens consisting of more or less perfect octahedra, the axes of some which were five centimetres in length, have been found, in *vugs*, at the Silver Islet mine, Lake Superior.

105. GARNET—Is very frequently met with, and in nearly all parts of the Dominion. The following comprise some of the many localities of its occurrence. In the province of Quebec: small beds of granular red garnet occur at St. Jérôme (Terrebonne Co.), in Rawdon (Montcalm Co.), and at the north-east side of Bay St. Paul (Charlevoix Co.): white lime-alumina garnet, mixed with serpentine, is met with at Orford (Sherbrooke Co.), and an apparently homogeneous rock composed in great part of a similar variety, occurs at St. Francis (Beauce Co.): red and yellowish-red varieties are met with in the townships of Chatham and Grenville (Argenteuil Co.): a rose-red iron-alumina garnet is found disseminated in small masses through gneiss on the Rouge River and vicinity in the township of Clyde, and dark red garnet in the townships of Villeneuve and Templeton, and large and handsome crystals of colorless, light brownish, pale olive-green, and brownish-yellow garnet in the township of Wakefield, Ottawa county. Magnificent crystals of red garnet occur, imbedded in micaceous schist, on the Skeena and Stickeen Rivers, and a massive brownish-red manganesian lime-iron garnet is found near Foster's Bar, Fraser River—in the province of British Columbia. Analyses, T. S. Hunt, Geol. Can., 1863, 496. See further under "Almandite," "Andradite," "Chromiferous garnet," "Essonite," "Grossularite," "Spessartite."

106. GENTHITE—A mineral apparently identical with Genthite has been met with in a vein on Michipicoten Island, Lake Superior, province of Ontario. Analyses, T. S. Hunt, Geol. Can., 1863, pp. 506, 507.

107. GIESECKITE—Dysyntribite occurs at Arisaig pier and Frenchman's Barn in Antigonish county, province of Nova Scotia.

108. GLAUCONITE—Occurs in a sandstone of the Lauzon formation, near Point Lévis (Lévis Co.), and on the Island of Orleans, in the province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 487.

109. GMELINITE—Has been found at Cape Blomidon (King's Co.), and Two Islands and Five Islands (Colchester Co.), in the province of Nova Scotia. Analyses, A. A. Hayes, Am. Journ. Sci., vol. xxv, p. 78, 1834; O. C. Marsh, ib., 2 ser., vol. xliv, p. 362, 1867; A. B. Howe, ib., 3 ser., vol. xii, p. 270, 1876.

110. GOLD—The most important auriferous regions of Canada are situated in the provinces of British Columbia, Quebec, and Nova Scotia; the first on the Pacific coast, the last forming the extreme eastern portion of the Dominion. Gold is, however, also found in some of the rivers of the North-west Territory—in the Lake of the Woods and Lake Superior region, and in the district north of Lake Ontario, in the province of Ontario,—and is reported to have been found in a few localities in the province of New Brunswick. In British Columbia mining has been almost entirely confined to the placer deposits. In the vicinity of the Lake of the Woods and of Lake Superior gold occurs in veins associated with silver and other ores. In the townships of Madoc and Marmora (province of Ontario), in aurifeorous mispickel. In the province of Quebec the placer deposits of the Chaudière region and of the township of Ditton are the only ones in which much work has as yet been attempted. The gold of Nova Scotia is found in quartz, the alluvial gold so far discovered being quite inconsiderable in quantity.

111. GÖTHITE—Is mentioned by Dr. Harrington, as occurring, in association with black oxide of manganese and calcite, in veins cutting the Lower Carboniferous limestones at Black Rock, near the mouth of the Shubenacadie, province of Nova Scotia.

112. GRAPHITE—This mineral is met with in most of the stratified rocks of the Laurentian system; not only the limestones, but the gneiss, pyroxenite, quartzite and pyrallolite beds sometimes hold disseminated graphite. It is also met with in the iron ores of the series, as in the township of Hull (Ottawa Co.), in the province of Quebec. Apart from its being met with in a disseminated

form, it occurs in beds or seams from a few inches to two or three feet in thickness. These are often interrupted giving rise to lenticular masses, which are sometimes nearly pure and at other times mingled with carbonate of lime, pyroxene, and other foreign minerals. The most important deposits are in the townships of Buckingham and Lochaber (Ottawa Co.), and Grenville (Argenteuil Co.), province of Quebec; but it is also found in the townships of Burgess (Lanark Co.), Loughborough and Bedford (Frontenac Co.), province of Ontario, and, in small quantity, in other localities in these provinces. It is also met with, in a disseminated form, at French Vale and Glendale, in the province of Nova Scotia; in the vicinity of St. John, province of New Brunswick; and at Alkow Harbor, Dean's Canal, in the province of British Columbia. Localities and general mode of occurrence, T. S. Hunt, Geol. Can., 1863, pp. 529, 793, and Rep. Geol. Can., 1863-66, pp. 218-223. Analyses, etc., of Canadian Graphite, G. C. Hoffmann, Rep. Geol. Can., 1876-77, pp. 489-510; analyses of disseminated graphite from Nova Scotia and New Brunswick, G. C. Hoffmann, Rep. Geol. Can., 1878-79, p. 2; ib., 1879-80, p. 1 H.

113. Grossularite—Handsome specimens of a white lime-alumina garnet are found in the township of Wakefield (Ottawa Co.), province of Quebec (G. F. Kunz, Anal., C. Bullman, Am. Journ. Sci., 3 ser., vol. xxvii, p. 306, 1884). The white lime-alumina garnet from Orford (Sherbrooke Co., P. Que.), referred to under "Garnet," is also referable to this variety.

114. Gypsum—Occurs in connection with the Lower Carboniferous limestones, in enormous deposits in the province of Nova Scotia. It is largely quarried at Windsor, Newport, Walton, Wentworth, Shubenacadie, and a number of other places. It is a very abundant mineral in the province of New Brunswick, the deposits being both numerous and extensive. They occur in all parts of the Lower Carboniferous district, in King's, Albert, Westmorland, and Victoria counties. Rock masses of granular and compact gypsum, more or less mixed with dolomite, characterize the Onondaga formation of western Ontario, and occur largely in the valley of the Grand River, more especially in the townships of Dumfries, Brantford, Oneida, Seneca, and Cayuga, etc.—It is also met with in the province of Manitoba. See also notes to "Alabaster," "Selenite."

115. Gyrolite—Is found on apophyllite in trap, about twenty-five miles south-west of Cape Blomidon, between Margaretville and Port George, Annapolis county, province of Nova Scotia. Anal., H. How, Ed. N. Phil. Journ., new series, vol. xiv, p. 117, 1861.

116. Halite—An important deposit of rock salt is known to exist along the eastern shore of Lake Huron, embracing the counties of Bruce, Huron and Lambton, in the province of Ontario. It was first met with at Goderich, in 1866, at a depth of 964 feet; in the year following at Clinton, at a depth of 1,180 feet, and in the succeeding year at Kincardine, at a depth of about 900 feet; subsequently at Seaforth at 1,035 feet, and again at Kingstone's Mills in Warwick, at 1,200 feet. A boring made in Goderich in 1876, and which was carried to a depth of 1,517 feet, has shown the existence of no less than six beds of rock salt, one of which is close upon 31 feet, and another very nearly 35 feet in thickness. For geological details, records of borings, and analyses of brines and salt, see following reports by Dr. T. Sterry Hunt—" On Brine-springs and Salt," Rep. Geol. Can., 1863-66, pp. 263-272. " On the Goderich Salt Region," ib., 1866-69, pp. 211-242, and a second report on the Goderich salt region, ib., 1876-77, pp. 221-243.

117. Halotrichite—Has been found in some heaps of shale and slack coal, at the Glace Bay coal mines, in Cape Breton county, province of Nova Scotia. Anal., E. Gilpin, Trans. N. S. Inst., vol. vi, p. 175, 1883-86.

118. Heliotrope—Reported by Professor How, as having been found by Dr. Gesner in small nodules or fragments of rock on the beach of Chute's Cove (Annapolis Co.), has been found, *in situ*, by C. W. Willimott, at Two Islands (Cumberland Co.), province of Nova Scotia.

119. Hematite—Important deposits of red hematite are met with at several localities in Pictou and other counties in Nova Scotia. It occurs, in association with specular iron ore, among the Huronian strata of the Quaco hills, and more abundantly in those of West Beach and Black River, St. John county, province of New Brunswick. Forms an extensive bed in the township of McNab (Renfrew Co.), and is further found in the townships of Dalhousie and Beckwith (Lanark Co.), Palmerston (Frontenac Co.), Madoc (Hastings Co.), Leeds (Leeds Co.), etc.—at Gros Cap, north side

of Michipicoten Harbor, and other localities in the Lakes Superior and Huron region, province of Ontario. See also notes to "Micaceous iron ore," "Specular iron ore," "Martite." Mineral associations of hematite, B. J. Harrington, Rep. Geol. Can., 1873-74, p. 212. Analyses, by various analysts, ib., pp. 223-226, and subsequent Reports.

120. Heulandite—Fine specimens of this mineral are met with at Isle Haute, Partridge Island, and Two Islands (Cumberland Co.), also at Black Rock, Hall's Harbor, Long Point, and Cape Blomidon (King's Co.), in the province of Nova Scotia.

121. Hornblende—Black crystallized hornblende enters abundantly into the diorites of Yamaska Mountain (Yamaska Co.), and Mount Johnson (Iberville Co.), and occurs sparingly in the trachytes of Brome (Brome Co.), and Shefford (Shefford Co.) Mountains: beds of black hornblende, holding garnets, are associated with the serpentines of Mount Albert in the Shickshock Mountains (Gaspé Co.), and black or greenish hornblende is very commonly disseminated through the felspathic rocks of the Laurentian series, giving rise to syenite and syenitic gneiss: also forming beds of hornblendic rock, as at Lake St. John (Chicoutimi Co.), province of Quebec. Black or dark green hornblende, in cleavable masses, is found associated with the magnetite of Bathurst and South Sherbrooke townships (Lanark Co.), province of Ontario. Anal., B. J. Harrington, Rep. Geol. Can., 1873-74, p. 201.

122. Hornstone or Chert—Occurs, in veins traversing syenite in the township of Grenville (Argenteuil Co.), in the province Quebec; in great abundance, in nodular masses and thin layers, in the Corniferous formation, and occasionally, in a similar form, in the limestones of the Trenton and Niagara groups; also, in layers, in the lower beds of the silver-bearing rocks of Thunder Bay (the lower division of the Upper Copper-bearing rocks of Logan), Lake Superior, province of Ontario.

123. Howlite—Occurs, in the form of nodules which are generally about the size of filberts or pigeon's eggs, and occasionally, but rarely, as much as two inches in diameter, imbedded in anhydrite and gypsum at Brookville, and in gypsum at Winkworth, Newport Station, Noel, etc., in Hants county, province of Nova Scotia. Analyses, H. How, Phil. Mag, 4 ser., vol. xxxv, p. 32, 1868.

124. HUMBOLDTINE—Has been observed as a sulphur-yellow incrustation upon the black schists at Kettle Point in the township of Bosanquet, Lambton county, province of Ontario.

125. HURONITE—The Huronite of Dr. Thompson—an impure or altered form of anorthite—is found, *in situ*, near Sudbury (District of Nipissing, province of Ontario), where it occurs in rounded or somewhat angular masses, in a dark green dyke of diabase. Anal., B. J. Harrington, Trans. Roy. Soc. Can., vol. iv, sec. iii, p. 82, 1886.

126. HYACINTH—Cherry-red, transparent crystals of zircon, are mentioned by Dr. Hunt as occurring in the crystalline limestone of the township of Grenville, Argenteuil county, province of Quebec.

127. HYPERSTHENE—Occurs, in broad lamellar masses, with andesite and ilmenite, constituting a rock at Château Richer (Montmorency Co.), and in the parish of St. Urbain, near Bay St. Paul (Charlevoix Co.), in the province of Quebec. Also (Paulit) at Paul Island, Nain, coast of Labrador. Anal., T. S. Hunt, Geol. Can., 1863, p. 468.

128. ICELAND-SPAR—Fine cleavable and transparent masses of calcite occur at Harrison's location on St. Ignace Island, Lake Superior, and in the township of Galway (Peterborough Co.), province of Ontario.

129. ILMENITE—Occurs in vast beds or masses in anorthosite rock in the parish of St. Urbain, at Bay St. Paul (Charlevoix Co.), and in a similar rock in Château Richer (Montmorency Co.), and in Rawdon (Montcalm Co). Large deposits, associated with labradorite rocks, have also been observed near the mouth of Rapid River (Bay of Seven Islands), on the Saguenay River, on the shores of Lake Kenogami, and it has also been met with in several other localities in the province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 501, and Rep. Geol. Can, 1866-69, p. 260.

130. ILVAITE—A substance which, from its composition and physical characters, was regarded as a variety of lievrite, was found in the form of a boulder, in the vicinity of Ottawa (formerly Bytown), Carleton county, province of Ontario. Description and analysis, T. S. Hunt, Geol. Can., 1863, p. 465.

131. INFUSORIAL EARTH—Is found occupying the bottoms of lakes in several of the counties of the maritime provinces. The deposits are not unfrequently of considerable depth, and the earth remarkably pure. Some of the more important localities are—Fountain Lake, Amherst (Cumberland Co.), Folly Lake (Colchester Co.), and Merigonish (Pictou Co.), in the province of Nova Scotia, and Fitzgerald Lake, about seven or eight miles from St. John (St. John Co.), Pollet Lake, Mechanic Settlement and Pleasant Lake, about six miles to the south-west (King's Co.), in the province of New Brunswick. Anal., G. C. Hoffmann, Rep. Geol. Can., 1878-79, p. 4 H.

132. IRIDOSMINE—Occurs, as first observed by Dr. T. S. Hunt, in the form of small hard steel-grey plates, associated with the native platinum found in the gold washings of the Rivière du Loup, Beauce county, province of Quebec.

133. IRON-OCHRE—Extensive deposits of iron-ochre (*var.* limonite) are met with in numerous localities in the province of Quebec. A remarkable deposit of this material is found in St. Anne (Montmorency Co.), and very large beds of the same occur in Cap de la Madeleine (Champlain Co.), and in Pointe du Lac (St. Maurice Co). Amongst other places, where deposits of more or less importance occur, may be mentioned the counties of Bonaventure, Joliette, Laval and Vaudreuil. In the province of Ontario, beds of ochre are met with in Walsingham (Norfolk Co.), Esquesing (Halton Co.), Sydenham (Grey Co.), Nottawasaga (Simcoe Co.), and other townships. Chemical examination of iron-ochres, T. S. Hunt Geol. Can., 1863, p, 512.

134. IRON SAND—Occurs at St. Mary's Bay, Digby county, province of Nova Scotia. Considerable deposits of the same are met with at Moisie, Portneuf, Bersimis, Mingan, and Natashquan, in Saguenay county, and at Batiscan, in Champlain county, and elsewhere in the province of Quebec. It is also found on the shores and islands of Lakes Superior, Huron, Erie, Ontario, and many of the smaller lakes in the province of Ontario. Mode of occurrence, examination, and analyses, T. S. Hunt, Rep. Geol. Can., 1866-69, pp. 261-269.

135. ISERITE—Constitutes a certain portion of the black magnetic sands met with at St. Mary's Bay, Digby county, province of Nova Scotia, on the north shore and Gulf of the St. Lawrence,

province of Quebec, and on the shores and islands of Lakes Superior, Huron, Erie and Ontario, etc., in the province of Ontario.

136. JAMESONITE—Is stated to occur near Fredericton, New Brunswick. Professor Bailey (of the University of New Brunswick) informs me that should such be the case, it would most probably be at the antimony mine in the parish of Prince William (about twenty-five miles from Fredericton), York county, province of New Brunswick.

137. JASPER—A red and purple striped, and red and yellow striped jasper, is abundant at St. Mary's Bay (Digby Co.), and a red variety is found on Briar Island, in the same county, on Partridge Island (Cumberland Co.), Long Island, and at Woodworth's Cove (King's Co.), in the province of Nova Scotia. A blood-red jasper, often finely clouded, occurs near Sherbrooke (Sherbrooke Co.), a small bed of dark green and reddish-brown jasper, traversed by small veins of white chalcedony, at River Ouelle (Kamouraska Co.), and a dark-red jasper in the township of Hull (Ottawa Co.), province of Quebec. This mineral also enters largely into the composition of the beautiful jasper conglomerate —consisting of pebbles of red and reddish-brown jasper and smoky quartz, thickly imbedded in a white quartzite—which constitutes great beds on the north shore of Lake Huron, province of Ontario.

138. KALINITE—Is mentioned by Professor Chapman as occurring in considerable abundance on the exposed faces of some high bluffs of argillaceous shale on Slate River, a tributary of the Kaministiquia, about twelve miles west of Fort William, Lake Superior, province of Ontario.

139. KÄMMERERITE—Is mentioned by Dr. Hunt as occurring, with chromite, in serpentine in the townships of Bolton (Brome Co.), and Melbourne (Richmond Co.), in the province of Quebec.

140. KAOLINITE—Is met with in masses, sometimes half an inch thick, in fissures in a sandstone of the Sillery formation, just below the Chaudière Falls (Lévis Co.). The masses have a greenish or yellowish-white color and are composed of minute soft scales, very unctuous and slightly coherent (Anal., T. S. Hunt, Geol. Can., 1863, 495). This mineral has also been found in the form of minute pearly scales of a yellowish-white color, unctuous and plastic, lining cavities in a rock in the township of Acton (Bagot

Co.), likewise in the province of Quebec. Anal., G. C. Hoffmann, Rep. Geol. Can., 1874-75, p. 314.

141. KERMESITE—Occurs, in small crystalline tufts, with native antimony, stibnite, valentinite and senarmontite, in veins traversing argillite in the township of South Ham, Wolfe county, province of Quebec.

142. LABRADORITE—Fine examples of this felspar occur in St. Jérôme, Morin—bluish, opalescent, cleavable,—Abercrombie, and Mille Isles (Terrebonne Co.), also at Rawdon—as a bluish-white granular homogeneous rock—(Montcalm Co.), and Château Richer—as a pale bluish or greenish-grey rock, with red spots—(Montmorency Co.), in the province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 478; G. C. Hoffmann, Rep. Geol. Can., 1874-75, p. 316.

143. LAUMONTITE—Is very abundant at Port George, where occasionally veins of three inches thickness are seen intersecting the sides of the cliff, and is also found at Margaretville, where it occurs colored green by copper, Annapolis county, province of Nova Scotia. Anal., H. How, Am. Journ. Sci., 2 ser., vol. xxvi, p. 30, 1858.

144. LAZULITE—Has been found—massive, of a deep azure-blue color, in narrow veins traversing a greyish-white, in parts milk-white, subtranslucent quartz—three-quarters of a mile east of the mouth of the Churchill River, District of Keewatin. Anal., G. C. Hoffmann, Rep. Geol. Can., 1878-79, p. 2 H.

145. LEAD, NATIVE,—Was observed by Professor Chapman to occur, in the form of thin strings, in a colorless quartz from the vicinity of Dog Lake of the Kaministiquia, Thunder Bay, Lake Superior, province of Ontario.

146. LEPIDOMELANE—Was recognized by Mr. R. A. A. Johnston in a sample of ore from the township of Marmora, Hastings county, province of Ontario. The material consisted of a fine granular arsenopyrite, through which was distributed a somewhat large amount of lepidomelane and a little white sub-translucent quartz.

147. LIGNITE—Of varying composition, but for the most part of very superior quality, of Cretaceous and Laramie age, is found over very extensive areas throughout the North-west Territories; there

are also extensive Tertiary deposits, supposed to be of Miocene age, both on the coast and interior of British Columbia, which in many places contain lignites. For reference to analyses, see under "Mineral Coal."

148. LIMONITE—Important deposits of this mineral are met with in Pictou and Colchester counties, province of Nova Scotia. As there met with it occurs in the form of lustrous botryoidal or mammillary and stalactitic masses, which exhibit a fibrous structure when broken; also compact and lustreless, and at other times earthy. Analyses, B. J. Harrington and G. C. Hoffmann, Rep. Geol. Can., 1873-74, pp. 231-234.—See also notes to "Bog-Iron-ore," "Iron-ochre."

149. LOGANITE—Occurs, in the form of short thick oblique rhombic prisms of a clove or chocolate-brown color, in association with serpentine, phlogopite and apatite, in a white crystalline limestone at the Calumet Falls, Pontiac county, province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 490.

150. LOUISITE—Honeyman, with analysis, Trans. N. S. Inst., vol. v, p. 15, 1879-82. [Needs further examination; free silica is very probably present—Dana, Min., App. 3, p. 70, 1882].

151. MAGNESITE—Has, so far, only been met with in rock masses, forming, in association with serpentine, dolomite and steatite, beds in the townships of Sutton and Bolton, Brome county, province of Quebec.

152. MAGNETITE—Is found, often beautifully crystallized, in veins in the Triassic trap of King's and Annapolis counties, in the province of Nova Scotia. Occurs massive, or disseminated in crystals in dolomite and chloritic slate (sometimes constituting fifty-six per cent. of the mass) in the metamorphic strata of the Eastern Townships of Sutton, Bolton, Ascot, Leeds and Orford; in the Laurentian, in the township of Hull, etc.,—also, in the form of black sand (see note to iron-sand), on the north shore of the Gulf of St. Lawrence,—in the province of Quebec. Forms deposits, frequently of very great extent, among the Laurentian rocks, in the counties of Frontenac, Hastings, Haliburton, Lanark, Leeds, Peterborough, Renfrew, etc., and is also met with in certain localities on Lakes Superior and Huron, province of Ontario. Further west, important deposits occur in crystalline rocks, supposed to be of Carboniferous age, in the vicinity of Gillies Bay, south side of Texada

Island, province of British Columbia. Crystals pseudomorph after pyrite, E. B. Kenrick, Ann. Rep. Geol. Can., vol. iii, p. 58 T, 1887. Mineral associations of magnetite, B. J. Harrington, Rep. Geol. Can., 1873-74, p. 194. Analyses, by various analysts, ib., pp. 208-211.

153. MALACHITE—Has, so far, not been met with in characteristic specimens, but merely as an incrustation on copper ores or in the form of stains and small earthy masses in copper-holding rocks. Of the numerous localities where it has been observed may be mentioned—Spanish River, where some of the quartz veins carrying chalcocite are stained throughout with green carbonate of copper; with galenite in a lode which crosses a long narrow island near the shore at Thunder Cape, Lake Superior, province of Ontario. In the form of little fibrous masses, with sulphurets of copper, in a drusy calcite at the Black River mine, St. Flavien, Lotbinière county, province of Quebec.

154. MALACOLITE (DIOPSIDE)—Large twin-crystals of white pyroxene, associated with cinnamon-colored garnets, are found in druses in a pale greenish pyroxene rock in the township of Orford (Sherbrooke Co.), and slender, pale greyish-green colored crystals, sometimes six inches in length, occur imbedded in limestone at the Calumet Falls (Pontiac Co.), province of Quebec. Crystals of pale greyish-green pyroxene—often replaced on their acute lateral edges, and occasionally several inches in diameter—associated with crystals of dark green pargasite, and black tourmaline, are found at the High Falls and at the Ragged Chute in the township of Blythfield, Renfrew county, province of Ontario. Analyses, T. S. Hunt, Geol. Can., 1863, pp. 467, 468.

155. MANGANITE—Is frequently found associated with pyrolusite at Teny Cape (Hants Co.), and elsewhere—often crystallized on that ore. It is abundant at Walton and Cheverie, and is met with at Douglas and Rawdon, in Hants county, province of Nova Scotia. Also occurs on Amherst Island, Magdalen Islands, province of Quebec.

156. MARCASITE—Has been obtained, by Professor Chapman, from the walls of a vein holding galenite and chalcopyrite, in the township of Neebing, a few miles east of the Kaministiquia River, northwest shore of Lake Superior, province of Ontario.

157. MARTITE—Has been met with in the Triassic trap of North Mountain, Digby county, province of Nova Scotia, and was also observed by Professor Chapman in a gneissoid boulder from Bass Lake, a few miles north of Orillia, Simcoe county, province of Ontario.

158. MELACONITE—Is recorded by Professor Chapman as occurring, but in traces only, in some of the copper deposits of the Eastern Townships of the province of Quebec.

159. MELANTERITE—Has been found in some heaps of shale and slack coal at the Glace Bay coal mines, in Cape Breton county, province of Nova Scotia. Also occurs, in small quantities, in many of the ores from the mineral veins of Lake Superior, Lake Huron, and the Hastings region, province of Ontario.

160. MENEGHINITE—Is found, apparently in a veinstone of quartz and dolomite, in the vicinity of Marble Lake, in the township of Barrie, Frontenac county, province of Ontario. Anal., B. J. Harrington, Trans. Roy. Soc. Can., vol. i, sec. iii, p. 79, 1882 and 1883.

161. MESOLE—Occurs, in association with mesolite, in trap rock in the neighborhood of Port George, Annapolis county, province of Nova Scotia. Anal., H. How, Ed. N. Phil. Journ., new series, vol. viii, p. 207, 1858.

162. MESOLITE—Is found at Port George, and is also said to be very abundant in the North Mountains, Annapolis county, province of Nova Scotia. Analyses, H. How. Am. Journ. Sci., 2 ser., vol. xxvi, p. 32, 1858.

163. METEORIC IRON—A specimen of meteoric iron, weighing 370 pounds, was found, in 1854, on the surface of the ground, in the township of Madoc, Hastings county, province of Ontario. Its shape is rudely rectangular and flattened on one side. The surface is irregularly pitted, and coated with a film of dark oxide. The iron is malleable, and highly crystalline in texture. A polished surface when etched by an acid exhibits the so-called Widmannstädt's figures. It contains 6·35 per cent. of nickel; small amounts of the phosphide of iron and nickel (Schreibersite) are disseminated through it, and in making a section of it, rounded masses of magnetic sulphide of iron (troilite?) were met with. Results of its examination by Dr. T. S. Hunt, Geol. Can., 1863, p. 508.

164. MICACEOUS IRON-ORE—Is found in veins in the Cobequid Hills of Londonderry (Colchester Co.); constitutes an important deposit on the west side of the East River (Pictou Co.); is met with on Salmon River, at Melrose, Manchester, and Roman's Valley in Guysborough county, and at St. Peters, Richmond county, province of Nova Scotia. Mingled with variable amounts of quartz and chlorite, it constitutes beds of a schistose rock in the townships of St. Armand (Missisquoi Co.), Brome and Sutton (Brome Co.); occurs in small beds in the township of Bristol (Pontiac Co.), and is also met with in the townships of Templeton and Hull (Ottawa Co.), and elsewhere in the province of Quebec. Forms small beds in Potsdam sandstone in the townships of Bastard (Leeds Co.), and Ramsay (Lanark Co.), in the province of Ontario.

165. CHROMIFEROUS MICA—Is found in several localities in the Eastern Townships of the province of Quebec. Minute scales of it occur in the magnesite of Sutton (Brome Co.), and it has also been observed, in larger plates and imperfect crystals, in a dolomite from Bolton, in the same county.

166. MICROCLINE—Is found in large cleavable masses, in association with quartz, muscovite, albite, etc., constituting a coarse pegmatite vein in the township of Villeneuve, Ottawa county, province of Quebec.

167. MILLERITE—Is met with in small grains and prismatic crystals, together with minute grains and crystals of a bright green chromiferous garnet, disseminated through a white cleavable calcite, in a vein on the east side of Brompton Lake, in the township of Orford (Sherbrooke Co.), province of Quebec.

168. MINERAL COAL—See under "Anthracite," "Bituminous coal," "Cannel coal," "Lignite."
Analyses, E. Hartley, Rep. Geol. Can., 1866-69, pp. 365-447—T. S. Hunt, ib., 1871-72, p. 98—B. J. Harrington, ib., 1872-73, pp. 76-81; ib., 1873-74, p. 63; ib., 1876-77, pp. 466-470—G. C. Hoffmann, ib., 1873-74, pp. 90-93 and 188-191; ib., 1875-76, p. 423; ib., 1879-80, pp. 8-14 H; ib., 1882-84, pp. 1-44 M; Ann. Rep. Geol. Can., 1885, pp. 1-11 M; ib., 1887-88, pp. 5-20 T.

169. MINERAL RESIN—Is not unfrequently very freely disseminated through some of the coals and lignites of the North-west Territory,

in the form of small flattened grains and nodules of a yellow, yellowish-brown or brown color. The nodules do not, generally speaking, exceed a-quarter of an inch in diameter, but occasionally some of much larger dimensions are met with. One from a coal seam on the Middle Fork of the Old Man River, Rocky Mountains (North-west Territory), was found to be a little over an inch and a-half in diameter, and three-quarters of an inch thick.

170. MINERAL TAR—Is often seen exuding from the deposits of bituminous sand rock occurring along the banks of the Athabasca River (see note to "Asphaltum"), and in numerous places on the ground at the foot of either bank, or on terraces lower than their summits, this tar collects in pools, or flows in sluggish streams to lower levels. It also occurs at several localities on the shores of the western part of Great Slave Lake; at one or two places on Peace River, and elsewhere in this part of the North-west Territory.

171. MIRABILITE—Occurs at the Clifton gypsum quarry, Windsor, Hants county, province of Nova Scotia; and, associated with epsomite, as an incrustation upon the cliffs of shale at Fort St. John, Peace River, province of British Columbia. Anal., G. C. Hoffmann, Rep. Geol. Can., 1875-76, p. 421.

172. MOLYBDENITE—Is somewhat widely distributed, being found, although in most instances only in small quantities, in nearly all the provinces of the Dominion. Some of the most noteworthy localities of its occurrence are those in the province of Quebec, as —near the mouth of the Quetachoo River, in Manicougan Bay, on the north shore of the Gulf of the St. Lawrence, where it occurs disseminated in a bed of quartz six inches thick, in the form of nodules from one to three inches in diameter, and in flakes which are sometimes twelve inches broad, by one-fourth of an inch in thickness; at Harvey Hill in the township of Leeds (Megantic Co.), occurring in small rounded masses of fine granular structure, in veins of quartz and bitter-spar; and the township of Aldfield (Pontiac Co.), where perfect and very handsome crystals have occasionally been found, and others, less perfect but of considerable dimensions are met with.

173. MOLYBDITE—Has been met with in the form of an earthy yellow powder on molybdenite, in the township of Alleyn (Pontiac Co.),

in the province of Quebec, and in the township of Ross (Renfrew Co.), in the province of Ontario.

174. MONAZITE—In the form of a nodular mass, was found at the Villeneuve mica mine, in the township of Villeneuve, Ottawa county, province of Quebec (Ann. Rep. Geol. Can., vol. ii, p. 11 T, 1886). Dr. F. A. Genth has recently made an analysis of a specimen from this locality, the results of which are given in Am. Jour. Sci., 3 ser., vol. xxxviii, p. 203, 1889.

175. MORDENITE—Occurs imbedded in trap, some two or three miles east of Morden or French Cross, in King's county, province of Nova Scotia. Anal., H. How, Journ. Chem. Soc., new series, vol. ii, p. 100, 1864.

176. MORENOSITE—Is mentioned by Dr. Hunt as having been observed, as an efflorescence of minute acicular greenish-white crystals, on an ore of nickel from the Wallace mine, Lake Huron, province of Ontario.

177. MUSCOVITE—Large plates and crystals of this species occur in a vein of graphic granite on Alumette Lake, at Montgomery's clearing, about five miles above Pembroke, Renfrew county, province of Ontario. It is met with, in association with black tourmaline, on Yeo's Island in the Upper St. Maurice (Portneuf Co.), and abundantly, and not unfrequently, in crystals of very large dimensions, in a coarse pegmatite vein (described in note to "Albite"), in the township of Villeneuve (Ottawa Co.), province of Quebec. A rose-colored mica, closely resembling, if indeed not identical with, the rose-colored muscovite of Goshen, Mass., has recently been met with by Mr. C. W. Willimott, in the township of Villeneuve (Ottawa Co., P. Que.). It was associated with pale green muscovite, in a matrix composed of albite with a little white translucent quartz.

178. NAIL-HEAD-SPAR—Very fine specimens of nail-head-spar are found at Teny Cape, Hants county, in the province of Nova Scotia.

179. NATROLITE—Handsome specimens of this mineral are found at Swan Creek (Cumberland Co.), Cape Blomidon (King's Co.), and Gate's Mountain (Annapolis Co.), etc., in the province of Nova Scotia. It occurs, associated with analcite, in some of the dykes cutting the Trenton limestone at the reservoir extension, Montreal

(Hochelaga Co.), province of Quebec. Anal., B. J. Harrington, Rep. Geol. Can., 1874-75, p. 303.

180. Nephelite—Is stated, by Dr. Hunt, to occur in white crystals, with small grains of blue sodalite, in the nepheline syenite of Brome Mountain (Brome Co.), it also occurs, as a constituent of a similar rock, at Montreal (Hochelaga Co.), and Belœil (Rouville Co.), province of Quebec. See also note to "Elaeolite."

181. Nephrite—This mineral has been found by Dr. G. M. Dawson, in the valley of the lower Fraser (British Columbia), in the vicinity of Lytton, on the site of an abandoned Indian village, in small water-worn boulders, evidently derived from the beaches of the river, some having been merely more or less broken, whilst others had been sawn or otherwise partly manufactured into implements (Can. Rec. Sci., vol. ii, p. 364, 1886-87). It has also been found (as first announced in Science, April 20, 1888), by Dr. G. M. Dawson and Mr. W. Ogilvie, on the Lewes River, a tributary of the Yukon, North-west Territory (Ann. Rep. Geol. Can., vol. iii, p. 38 B, 1887), but has not as yet been found *in situ.*

182. Niccolite—Has been found, in admixture with Domeykite, in a vein cutting a bed of amygdaloid on Michipicoten Island, Lake Superior, province of Ontario. Anal., T. S. Hunt, Geol. Can., 1863, p. 506.

183. Nitre—Has been found in cavities in calcareous tufa, on the Nazco River, and has also been met with at Big Bar, Fraser River, province of British Columbia.

184. Obsidian—Is found in large aud small masses on the higher eastern slopes of Il-ga-chuz Mountain, but the most notable locality for this mineral is the mountain named Beece, or Anahim's Peak, an isolated summit between the Il-ga-chuz and Tsi-tsutl Mountains, in the upper Blackwater country (G. M. Dawson, Rep. Geol. Can., 1876-77, pp. 78, 79); it also occurs at Tsooskatli, the upper part of Masset Inlet, (on a small islet north-east of Tas-kai-guns), Queen Charlotte Islands (id.—ib., 1878-79, p. 88 B), and other localities in British Columbia.

185. Octahedrite—Is reported, by Professor How, as occurring in small but fine crystals, in quartz, at Sherbrooke, Guysborough county, province of Nova Scotia.

186. Oligoclase—Occurs in more or less perfect crystals, in groups, of a white or faintly greyish-white color, in the township of Hull (Ottawa Co.), and a white, rarely greenish or greyish, felspar, having the composition of oligoclase forms, with black hornblende, the intrusive diorite of Mount Johnson (Iberville Co.), province of Quebec. A white to pale grey felspar, also referable to this species, is the constituent of a coarse crystalline diorite occurring at the Fournier mine, in the township of South Sherbrooke, Lanark county, in the province of Ontario. Analyses, T. S. Hunt, Geol. Can., 1863, p. 477; B. J. Harrington, Rep. Geol. Can., 1873-74, p. 198.

187. Ontariolite—A scapolite from the township of Galway, Peterborough county, province of Ontario, has been called Ontariolite by C. U. Shepard (Am. Journ. Sci., 3 ser. vol. xx, p. 54, 1880). [The value of an approximate analysis given, is destroyed by the impurity of the material analyzed; thus far it has no claim to be considered an independent species—Dana, Min., App. iii, p. 106, 1882.]

188. Opal—Common opal or semi-opal is mentioned by Dr. How, as occurring at a few localities in the province of Nova Scotia. See also notes to "Cacholong," "Hyalite," "Tripolite."

189. Orthoclase—This felspar is very abundant among the rocks of the Laurentian system, and well-defined cleavable masses of a reddish, greyish-white or white color, may be obtained in many localities, some of the most important (Laurentian) of which are—the townships of North Burgess and Elmsley (Lanark Co.), Ross, in large crystals, and Sebastopol, also in very large crystals (Renfrew Co.), in the province of Ontario—Grenville and Chatham (Argenteuil Co.), and most of the townships of Ottawa county. Also occurs in veins cutting altered slates in the townships of Leeds and Inverness (Megantic Co.), and Sutton (Brome Co.); and in the trachytes of Chambly, Brome and Shefford Mountains, and Mount Royal, province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, pp. 475,476: G. C. Hoffmann, Rep. Geol. Can., 1876-77, pp. 511,512.

190. Pargasite—Finely terminated crystals of dark-green pargasite, sometimes an inch in diameter, are found implanted upon, or imbedded in, a greenish-white pyroxene, at the High Falls and at the Ragged Chute, on the Madawaska, in the township of Blyth-

field, Renfrew county, province of Ontario. Anal., T. S. Hunt, Geol. Can., 1863, p. 466.

191. Pearl-spar—Is abundant, generally associated with calcite and gypsum, in cavities and geodes in the dolomites of the Niagara formation; also, in association with calcite, gypsum, barite and quartz, in geodes in the dolomites of the Calciferous formation, and is found in many of the metalliferous veins of Lake Superior and Lake Huron, province of Ontario—and occasionally in those of the Eastern Townships of the province of Quebec.

192. Pectolite—Occurs in radiated fibrous aggregations, the fibres being an inch and a quarter and less in length, at Cathcart (now McKellar's) Point, Thunder Bay, Lake Superior, province of Ontario.

193. Peristerite—The felspar described by Dr. Thompson under this name (in allusion to its beautiful blueish opalescence)—a variety of albite, occurs in large cleavable masses, with quartz, in veins in the township of Bathurst (Lanark Co.), and in a vein made up of a fine-grained mixture of reddish-white albite and quartz, enclosing large cleavable masses of the opalescent albite, on the north shore of Stoney Lake, near the mouth of Eel Creek, in Burleigh (Peterborough Co.), province of Ontario. Analysis of a specimen from first-named locality, T. S. Hunt, Geol. Can., 1863, p. 477.

194. Perthite—The Perthite of Dr. Thompson (a flesh-red aventurine felspar, which, as shown by Breithaupt, consists of interlaminated albite and orthoclase) occurs in large cleavable masses, in pegmatite veins cutting Laurentian strata, in the township of North Burgess, Lanark county, province of Ontario.

195. Petalite—Is here mentioned among the minerals of Canada, upon the authority of Dr. Bigsby, according to whom this mineral was found, with tremolite, in a large boulder on the lake shore, at Toronto, York county, province of Ontario.

196. Petroleum—The most important oil springs are in the township of Enniskillen, in the western peninsula of Ontario, but it also occurs in other townships of this section of the country, as for instance those of Mosa, Oxford and Dereham. It is found, in small quantity, on Great Manitoulin Island in Lake Huron, province of Ontario—also on the St. John River, and on a branch of Silver Brook, and other localities in the county of Gaspé, province of Quebec.

197. PHLOGOPITE—This mineral is of very common occurrence among the crystalline limestones of the Laurentian system, through which it is sometimes more or less abundantly disseminated in the form of small scales or crystals. The largest specimens are generally found in beds near to bands of quartzite or pyroxenic gneiss, which often limit the crystalline limestones, or are interstratified with them. It is also met with imbedded in massive pyroxene rock. Large plates are obtainable in the townships of Grenville (Argenteuil Co.), Buckingham, Templeton etc. (Ottawa Co.), in the province of Quebec—and in the townships of North and South Burgess, in the province of Ontario. Anal., T. S. Hunt, Geol. Can., 1863, p. 495.

198. PICKERINGITE—Occurs as an efflorescenee on the shale of a sheltered cliff on the banks of the Meander, Newport, Hants county, province of Nova Scotia. Anal., H. How, Journ. Chem. Soc., new series, vol. i, p. 200, 1863.

199. PICROLITE—This variety of serpentine is met with in the townships of Bolton (Brome Co.), Shipton (Richmond Co.), etc., in the province of Quebec. Anal., T. S. Hunt, Geol. Can.. 1863, p. 472.

200. PITCHSTONE—A pitchstone-porphyry, and pitchstone with veins of agate, occurs on the eastern extremity of Michipicoten Island, Lake Superior, province of Ontario.

201. PLATINUM. NATIVE,—The earliest reference to the finding of native platinum in Canada, is that by Dr. T. Sterry Hunt (Rep. Geol. Can., 1851-52, p. 120), who mentions having observed it, in association with iridosmine, in the gold washings of the Rivière du Loup and Rivière des Plantes, Beauce county, in the province of Quebec. It has since been met with, according to Dr. G. M. Dawson (Ann. Rep. Geol. Can., vol. iii, 1887, Part R), in association with placer gold in several localities in the province of British Columbia—occurring in notable quantity in the region of the Upper Similkameen and Tulameen Rivers, in minute scales where the gold is "fine" but increasing in coarseness to small pellets and nuggets in places where "coarse" gold is found. Coarse grains and pellets have, so far, been found only on Granite, Cedar and Slate Creeks, all entering the Tulameen on the south side. He also mentions its occurrence, in fine scales with gold, on Tranquille River, Kamloops Lake; at a place ten miles below Lillooet on the Fraser River, and in nearly all the tributaries of the Yukon

River which have been worked. Analyses, G. C. Hoffmann, Trans. Roy. Soc. Can., vol. v, sec. iii, p. 17, 1887—and an abridged statement of results, Ann. Rep. Geol. Can., vol. ii, p. 5 T. 1886.

202. POLYDYMITE—What is regarded as evidently a ferriferous variety of this mineral is found in association with pyrrhotite, chalcopyrite, some pyrite, etc., at the mines of the Canadian Copper Company, Sudbury, District of Nipissing, province of Ontario. Anal., F. W. Clarke and C. Catlett, Am. Journ. Sci., 3 ser., xxxvii, p. 372, 1889.

203. PREHNITE—Occurs chiefly in the trap rocks of Lake Superior, sometimes forming distinct veins, as on Slate River an affluent of the Kaministiquia, and with imbedded nodules of native copper on an Island near St. Ignace—province of Ontario. It has also been found in the Laurentian of the township of Templeton (Ottawa Co.) in the province of Quebec. Analyses, E. J. Chapman, Can. Journ., 2 ser., vol. xii, p. 267, 1869 ; B. J. Harrington, Rep. Geol. Can., 1877-78, p. 34 G.

204. PSEUDOMORPHOUS QUARTZ—Fine specimens of quartz pseudomorph after chabazite, have been found at Horse-shoe Cove, Cape d'Or, and of quartz pseudomorph after stilbite, at Clarke's Head (Cumberland Co.), province of Nova Scotia. Silicified wood is found in the vicinity of the Elbow of the South Saskatchewan River, and very characteristic specimens of the same at Ross Coulée, Irvine, District of Assiniboia, North-west Territory.

205. PSILOMELANE—Occurs, in association with pyrolusite, at Douglas, Hants county, province of Nova Scotia.

206. PYRALLOLITE—Occurs in beds in the crystalline limestone of Grenville (Argenteuil Co.), and Clarendon (Pontiac Co.), in the province of Quebec—also in the townships of Ramsay (Lanark Co.), and Rawdon (Hastings Co.), in the province of Ontario. Analyses, T. S. Hunt, Geol. Can., 1863, p. 471—and of a specimen from Portage du Fort, township of Clarendon, B. J. Harrington, Rep. Geol. Can., 1876-77, p. 484.

207. PYRITE—Is very widely distributed throughout the Dominion. The following are a few of the localities where it is met with in a crystalline form :—in fine crystals at La Have (Lunenburg Co.) and Seven Mile Plain (Hants Co.), in the province of Nova Scotia —in large cubical crystals in a vein of copper ore in the township

of Melbourne (Richmond Co.), province of Quebec—in perfect octahedra at Elizabethtown (Leeds Co.), also in a crystalline form in many of the veins and gneissoid rocks of the townships of Madoc, Elzevir and Tudor (Hastings Co.), and in the trap dykes of Lakes Superior and Huron, province of Ontario.

208. PYROLUSITE—Is met with near Kentville (King's Co.), at Springville (Pictou Co.), Musquodoboit (Halifax Co.), Onslow (Colchester Co.), near Amherst (Cumberland Co.), and at Walton and other places, especially at Teny Cape, in Hants county, province of Nova Scotia. This mineral also occurs at several places in the counties of Westmorland, Albert, St. John and King's,—the most important deposit being at Markhamville, in the parish of Upham, King's county,—in the province of New Brunswick.

209. PYROXENE—Is of common occurrence, especially among the rocks of the Laurentian system, where it not unfrequently forms beds, or large segregated veins, which sometimes consist of pure proxene, at other times of pyroxene in admixture with other minerals, constituting pyroxenite. It also sometimes occurs disseminated in beds of magnetite and, in the form of grains and imperfect crystals, it is common in the beds of limestone. Among the numerous localities of its occurrence may be mentioned:—Kildare (Jolliett Co.), the townships of Argenteuil and Grenville (Argenteuil Co.), Buckingham, Templeton, Portland, Wakefield and adjoining townships (in Ottawa Co.), and Litchfield (Pontiac Co.), in the province of Quebec. The townships of North Elmsley and North Burgess (Lanark Co.), and elsewhere in this part of the province of Ontario. Very large crystals of pyroxene are not unfrequently met with in the above referred to townships of Templeton, Portland and Wakefield, as also in the townships of Sebastopol and Blythfield (Renfrew Co.), in the province of Ontario—and a very handsome lilac-colored pyroxene occurs in the augmentation of the aforementioned township of Grenville. See also notes to "Augite," "Coccolite," "Diallage," "Fassaite," "Malacolite," "Sahlite."

210. PYRRHOTITE—Occurs in many localities; among which may be mentioned the townships of Barford (Stanstead Co.), Sutton and Bolton (Brome Co.), where it is associated with copper ores; St. Francois (Beauce Co.) associated with pyrite, arsenopyrite, etc., and St. Jérôme (Terrebonne Co.) associated with pyrite—in the province of Quebec. Abundantly, more or less associated with

chalcopyrite, in McKim and adjoining townships (District of Nipissing); accompanying pyrite in Elizabethtown (Leeds Co.), at Balsam Lake (Peterborough Co.), province of Ontario. A very interesting twin crystal found by Dr. Harrington at the Elizabethtown deposit (Anal., B. J. Harrington, Rep. Geol. Can., 1874-75, p. 304), was examined by Dr. E. S. Dana, Am. Jour. Sci., vol. xi, p. 386, 1876.

211. Retinalite—Is found, imbedded in crystalline limestone, in the township of Grenville (Argenteuil Co.), and on Calumet Island (Pontiac Co), in the province of Quebec. Analyses, T. S. Hunt, Geol. Can., 1863, p. 471.

212. Rhodochrosite—Has not, as yet, been found in Canada in distinct examples, but occurs in admixture with many of the manganese ochres, and is also present, in traces, in some of the altered strata of the Eastern Townships of the province of Quebec.

213. Ripidolite—Has, so far, not been identified with certainty as occurring in Canada. A chloritic mineral occurring—in uneven folia, of an olive-green color and pearly lustre—in association with apatite, quartz, pyrite and calcite, in the township of Templeton (Ottawa Co.), province of Quebec, has been examined by Dr. Harrington (Rep. Geol. Can., 1877-78, p. 34 G), and found to have, approximately, the composition of ripidolite. A foliaceous mineral found in a serpentine rock in the adjoining township of Buckingham would, so far as it has yet been examined, also appear to be referable to this species.

214. Rock Crystal—Is found, in large crystals, at South River (Antigonish Co.); in perfect crystals at Spencer's Island (Cumberland Co.); at Sandy and Mink Coves (Digby Co.), etc., in the province of Nova Scotia. In crystals (known as Quebec diamonds) showing unusual modifications in form, in fissures and cavities in limestone rocks in the vicinity of Quebec, and in large transparent crystals, in quartz veins, at Harvey's Hill mine (Leeds Co.), province of Quebec. Also in good crystals in cavities of the quartz veins of the Bruce mines, Lake Huron, and similar veins at Thunder Bay, Lake Superior, province of Ontario.

215. Rose quartz—Is found at Westfield (Queen's Co.) and, in the form of pebbles, near the town of Shelburne (Shelburne Co.), in the province of Nova Scotia.

216. RUTILE—Occurs, in the form of needles in quartz, at Scot's Bay (King's Co.), province of Nova Scotia. In small orange-red grains in the ilmenite of St. Urbain, Bay St. Paul (Charlevoix Co.); in small red flattened crystals in the chloritic schists of the township of Sutton (Brome Co.); in minute grains in the black sand obtained in the washing of the auriferous gravel at Rivière du Loup (Beauce Co.), and in somewhat large crystals, occasionally geniculated, in a gangue of dolomite and barite, in the township of Templeton (Ottawa Co.), province of Quebec. It has been found in tolerably distinct crystals in crystalline limestone on Green Island in Moira Lake, in the township of Madoc (Hastings Co.), and in the form of delicate acicular crystals, in quartz cavities at the Wallace mine, Lake Huron, province of Ontario. See also note to "Sagenite."

217. SAGENITE—A transparent quartz penetrated with needles of rutile is stated, by Professor How, to have been found at Scot's Bay, King's county, province of Nova Scotia.

218. SAHLITE—The most common variety of pyroxene met with in the apatite deposits of Ottawa county, province of Quebec, would appear to be a lime-magnesia-iron pyroxene or sahlite. On peculiarities in forms of crystals from this locality, see results of observations by B. J. Harrington, Rep. Geol. Can., 1877-78, p. 18 G.

219. SALAMMONIAC—Has been met with, in association with native sulphur, constituting a deposit on the cliffs of shale on Smoky River, North-west Territory. Anal., G. C. Hoffmann, Rep. Geol. Can., 1875-76, p. 420.

220. SAMARSKITE—Has been found on lots one and two of the second range of Maisonneuve, Berthier county, province of Quebec. [When first met with, this township was not laid out, consequently the locality could not be given more definitely than as it appears in the report, here referred to, viz., just beyond the north-western limits of Brassard (the adjoining township), Berthier Co.]. Anal., G. C. Hoffmann, Rep. Geol. Can., 1880-82, p. 1 H.

221. SAPONITE—Occurs in cavities in the trap of St. George or Hog Island, Richmond Bay, north coast of Prince Edward Island. Anal., B. J. Harrington, Can. Nat., 2 ser., vol. vii, p. 179, 1875.

222. SELENITE—Is met with in greater or less quantity at several of the gypsum deposits in the province of Nova Scotia, as at Oxford, River Philip (Cumberland Co.). In the province of New Brunswick it is especially abundant at Petitcodiac (Westmorland Co.), where the gypsum deposit, which has a breadth of about forty rods and a total length of about one mile, is traversed through its entire extent by a vein of nearly pure selenite eight feet wide. This mineral is also met with in the provinces of Quebec, Ontario, Manitoba and elsewhere.

223. SENARMONTITE—Occurs, with native antimony, stibnite, valentinite and kermesite, in veins traversing argillite in the township of Ham, Wolfe county, province of Quebec.

224. SERPENTINE—Is met with abundantly among the metamorphic rocks of the Eastern Townships and Gaspé peninsula, in the province of Quebec, where it forms vast masses, which are frequently almost free from other admixture, but at times enclose diallage, actinolite, garnet and chromite; or are intermixed with carbonate of lime, dolomite and occasionally ferruginous magnesite. Extensive beds, mostly containing intermixed carbonate of lime and dolomite, occur in the townships of Thetford and Coleraine (Megantic Co.), Broughton (Beauce Co.), South Ham and Garthby (Wolfe Co.), Melbourne (Richmond Co.), Orford (Sherbrooke Co.), and Bolton (Brome Co.); around Mount Albert in the Shickshock Mountains, and at Mount Serpentine near Gaspé Bay, in Gaspé county. Among the massive and nearly pure Laurentian serpentines may be mentioned those of the townships of Grenville (Argenteuil Co.), in above named province—and North Burgess (Lanark Co.), in the province of Ontario. See also notes to "Chrysotile," "Picrolite" and "Retinalite." Analyses, T. S. Hunt, Geol. Can., 1863, p. 472.

225. SEYBERTITE—Is mentioned by Dr. Hunt, as occurring, with small crystals of blue spinel, in a crystalline limestone in the seigniory of Daillebout, Joliette county, province of Quebec.

226. SIDERITE—A bed of spathic iron, varying in thickness from six to ten feet, occurs in sandstones of the Millstone-grit formation, near Sutherland's River, Pictou county, province of Nova Scotia. Occurs in thin veins in Huronian rocks in the Nerepis valley, and is also diffused to a considerable extent through rocks of Devonian age in the northern part of Charlotte county, in the province of

New Brunswick. Is found in quantity, in beds, on Flint, Davieu's, and other islands of the Nastapoka group, eastern coast of Hudson Bay—and is also met with in quantity in the township of McIntyre, Thunder Bay, Lake Superior, province of Ontario. See also notes to "Clay iron-stone," "Sideroplesite." Analyses, Gordon Broome, Rep. Geol. Can., 1866-69, p. 442; B. J. Harrington, ib., 1877-78, p. 47 G.

227. SIDEROPLESITE—Occurs in the ankerite deposits of Londonderry, Colchester county, province of Nova Scotia. Anal., H. Louis, Trans. N. S. Inst., vol. v, p. 50, 1879-82.

228. SILICIFIED WOOD—See note to "Pseudomorphous quartz."

229. SILVER. NATIVE,—Nuggets and grains of native silver have been found in washing for gold in a great many parts of British Columbia, the largest being obtained in the Omenica district. It also occurs, in association with argentite, at the various mines enumerated in the note to "Argentite."

230. SMALTITE—Has been met with in the form of minute crystals, in association with chalcopyrite, in the township of McKim, District of Nipissing, province of Ontario. Ann. Rep. Geol. Can., vol. ii, p. 11 T, 1886.

231. SMOKY QUARTZ, CAIRNGORM STONE — Is met with in several localities in the province of Nova Scotia, amongst the most noted being Paradise River and the neighborhood of Bridgetown and Laurencetown in Annapolis county; is also found at Mud Village (Lunenburg Co.), at Margaret's Bay (Halifax Co.), and of very dark color at Little River, about five miles from Halifax.

232. SOAPSTONE—See note to "Talc."

233. SODALITE—Occurs in the nepheline-syenites of Brome (Brome Co.), Montreal (Hochelaga Co.), and Belœil (Rouville Co.), in the province of Quebec. A very beautiful blue sodalite, in large specimens, has been found by Dr. G. M. Dawson, in abundance, in the vicinity of Ice River, a tributary of the Beaver-foot, in the Rocky Mountains, province of British Columbia. Anal., B. J. Harrington, Trans. Roy. Soc. Can., vol. iv, sec. iii, p. 81, 1886.

234. SPECULAR-IRON—Amongst other localities, is met with in tabular crystals at Sandy Cove, Digby Neck (Digby Co.), province of

Nova Scotia; in tabular crystals, or thick plates, in the township of Leeds (Megantic Co.), also in thick plates in the township of Shefford (Shefford Co.), in the province of Quebec.

235. SPERRYLITE—This recently discovered and highly interesting mineral, arsenide of platinum, was found at the Vermilion mine, township of Denison, District of Algoma, province of Ontario. Anal., H. L. Wells, Am. Jour. Sci., 3 ser., vol. xxxvii, p. 67, 1889; on the crystalline form of Sperrylite, S. L. Penfield, ibid, p. 71.

236. SPESSARTITE—Is found, together with black tourmaline, uraninite, monazite, etc., in a coarse pegmatite vein—composed of microcline, albite, muscovite and white and smoky-brown quartz—in the township of Villeneuve, Ottawa county, province of Quebec.

237. SPHAEROSTILBITE—Has been met with by Professor How, at Hall's Harbor, King's county, province of Nova Scotia.

238. SPHALERITE—Is somewhat widely distributed, being found, but most frequently in small quantities only, in all the provinces of the Dominion. It is met with, in greater or less abundance, in almost every metalliferous vein which has been opened on the east and north shores of Lake Superior, and an important deposit of the same is situate some eleven miles north-east of Rossport (formerly McKay's Harbor) on the north shore of that lake, province of Ontario. Also occurs in quantity in the township of Calumet—where it is associated with more or less galenite and a little pyrite,—Pontiac county, in the province of Quebec.

239. SPINEL—Small translucent octahedrons of blue spinel are found in a bed of crystalline limestone in the seigniory of Daillebout (Joliette Co.), in the province of Quebec. Large and not unfrequently very symmetrical black crystals, sometimes an inch or even two inches in diameter, occur in crystallized limestone in Burgess (Lanark Co.), and similar crystals, though less perfect, are found, together with fluorite, apatite and crystals of white orthoclase, in a vein of flesh-red calcite in the township of Ross, Renfrew county, province of Ontario.

240. SPODUMENE—Is said, by Dr. Hunt, to have been observed in a small rolled mass of granite near Perth, Lanark county, in the province of Ontario.

241. STAUROLITE—Occurs in mica-schists of Moore's Lake, near to Moore's Mills, Charlotte county, province of New Brunswick.

242. STEATITE—See note to "Talc."

243 STEELEITE—Is found imbedded in red clay in cavities in Triassac trap, at Cape Split, thirteen miles west of Cape Blomidon, King's county, province of Nova Scotia.

244. STELLARITE—The name given by Professor How to the so-called "stellar" or "oil-coal," which occurs with bituminous coal (in a seam five feet thick, of which one foot ten inches are stellarite) at the Acadia mines on the Acadia Coal Company's area, Pictou county, province of Nova Scotia. Analyses, H. How, Min. N.S., p. 24, 1869. Sir William Dawson, referring to this substance (Acadian Geology, 3rd ed., 1878, p. 339) says:—"The material known as stellar-coal is, as I have maintained in previous publications, of the nature of an earthy bitumen; and, geologically is to be regarded as an underclay or fossil soil, extremely rich in bituminous matter, derived from decayed and comminuted vegetable substances. It is, in short, a fossil swamp muck or mud which, as I have elsewhere pointed out, is the character of the earthy bitumens and highly bituminous shales of the coal formation generally."

245. STIBNITE—An important deposit of this mineral exists in the parish of Prince William (York Co.), in the province of New Brunswick, where it is contained in numerous large and well-defined veins of quartz, filling lines of dislocation in highly tilted argillaceous slates and quartzites: also at Rawdon—where, in association with a little quartz and calcite, it constitutes a vein cutting talcose slates,—and West Gore, Hants county, province of Nova Scotia. It is found in small radiating prismatic crystallizations, with native antimony, valentinite, senarmontite and kermesite, in veins in argillite, in the township of South Ham (Wolfe Co.), province of Quebec. It has been met with in small quantities, in association with pyrite and mica, in a band of crystalline dolomite in the township of Sheffield (Addington Co.), and in small masses mixed with tremolite, under similar conditions, in the township of Marmora (Hastings Co.), province of Ontario—also occurs near Foster's Bar, about twenty-three miles from Lytton, Fraser River, province of British Columbia.

246. STILBITE—Is abundant, and exhibits a large number of crystallized varieties, often of great beauty, at Partridge Island (Cumberland Co.), Hall's Harbor and Morden (King's Co.), and Margaretville

(Annapolis Co.), in the province of Nova Scotia. Anal., H. How, Phil. Mag., 5 ser., vol. i, p. 134, 1876.

247. STRONTIANITE—Occurs, in the form of white fibrous tufts, in cracks in concretionary limestone masses in the Utica slate of St. Helen's Island, Montreal, province of Quebec. Anal., B. J. Harrington, Trans. Roy. Soc. Can., vol. i, sec. iii, p. 81, 1882-83.

248. SULPHATITE—The water of the so-called Sour Springs of Tuscarora (Brant Co.), as also that of a spring in the south-west corner of Niagara, and of one at St. David's, in the same township (Lincoln Co.), and of another about a mile and a-half above Chippewa (Welland Co.), in the province of Ontario, are all remarkable for containing a large proportion of free sulphuric acid. Analyses, T. S. Hunt, Geol. Can., 1863, pp. 540, 545.

249. SULPHUR. NATIVE,—Has been met with in the form of shattered crystals, in a gypsum quarry in Colchester county, province of Nova Scotia. It occurs as a deposit from sulphurous springs in several localities in the province of Ontario, as at Charlotteville (Norfolk Co.), and in Clinton (Huron Co.), at which latter place there is a deposit affording masses of pure yellow compact, or fine-grained, sulphur, together with small transparent crystals of the same. Has also been found, in association with sal-ammoniac, as a deposit on cliffs of shale on Smoky River, North-west Territory. Anal., G. C. Hoffmann, Rep. Geol. Can., 1875-76, p. 420.

250. SYLVANITE—Occurs, in association with argentite and more or less galenite and chalcopyrite, in a gangue of white sub-translucent quartz, at the Huronian mine, township of Moss, District of Thunder Bay, province of Ontario.

251. TACHYLITE—Occurs, according to Dr. G. M. Dawson (Rep. Geol. Can., 1876-77, p. 84), as masses in agglomerate, near the entrance of Peninsula Bay, Fraser Lake, province of British Columbia.

252. TALC—Talc in crystalline foliated masses is sometimes met with in Canada, but it more frequently forms beds of a compact or schistose variety of steatite or soapstone, interstratified with serpentine, magnesite, or clay-slate, and often enclosing actinolite, or bitter-spar. These beds, which occur in strata of Pre-Cambrian or Cambrian age, and are often of considerable thickness and extent, lie principally in the townships of Bolton, Sutton and

Potton (Brome Co.), in the province of Qnebec. An unctuous foliated rock, consisting of talc with intermixed carbonates of lime and magnesia, and small quantities of quartz and magnetite, is found in the Laurentian of the township of Elzevir (Hastings Co.), in the province of Ontario. Analyses, T. S. Hunt, Geol. Can., 1863, p. 469.

253. TENNANTITE—Occurs, in association with chalcopyrite, pyrite, quartz, etc., at the Crown mine, Capelton, Sherbrooke county, in the province of Quebec. Anal., B. J. Harrington, Trans. Roy. Soc. Can., vol. i, sec. iii, p. 80, 1882-83.

254. TETRAHEDRITE—Ordinary tetrahedrite (containing only a little silver) occurs, in a gangue of ankerite, in the vicinity of Foster's Bar, about twenty-five miles above Lytton, Fraser River, and a more or less argentiferous tetrahedrite, associated with variable amounts of galenite and small quantities of one or more, or all, of the following minerals, viz., pyrite, chalcopyrite, bornite, sphalerite, is found at the Illecillewaet mines, between the north and south branches of the Illecillewaet River, Selkirk Range, and at the International claim on the west side of Kootanie Lake; on Ottertail Creek and Carbonate Creek; at Cherry Creek, thirty-three miles east of the head of Okanagan Lake; at some of the Stump Lake mines, Nicola Valley; on Jamieson Creek, which flows into the North Thompson River, and elsewhere in the province of British Columbia.

255. THOMSONITE—Specimens of this mineral, in the form of radiating crystals, have been found at the North Mountains of King's county, province of Nova Scotia. See also note to "Mesole."

256. TITANITE—Occurs in minute amber-colored grains and crystals, in the granitoid trachytes of Brome (Brome Co.), Shefford (Shefford Co.), and Yamaska (Yamaska Co.) Mountains, and in the diorite of Mount Johnson (Iberville Co.)—in crystals, often of considerable size, of a clove-brown or chocolate-brown color, in the Laurentian of the townships of Argenteuil and Grenville (Argenteuil Co.), Buckingham, Templeton, Wakefield and Hull (Ottawa Co.), and at the Calumet Falls in Litchfield (Pontiac Co.), in the province of Quebec. It is also met with in the Laurentian of the townships of Sebastopol—where very large crystals are sometimes found, also fine twin crystals, and a massive form —(Renfrew Co.), North Burgess—of a honey-yellow color—and

North Elmsley (Lanark Co.), and other townships in this part of the province of Ontario. Analyses, T. S. Hunt, Geol. Can., 1863, 503, and B. J. Harrington, Rep. Geol. Can., 1877-78, p. 28 G.

257. TOURMALINE—Principally black, but not unfrequently brown—is of comparatively common occurrence, in many places, in rocks of the Laurentian series. Among the numerous localities of its occurrence may be mentioned:—Near Hunterstown—where a single transparent brown crystal. remarkable for its modifications, was obtained—(Maskinongé Co.): at Calumet Falls in the township of Litchfield, fine translucent, rich yellowish-brown colored, highly modified crystals with brilliant faces—(Pontiac Co.); in the township of Clarendon—brown crystals of great beauty—(Pontiac Co.): in the townships of Grenville and Argenteuil—black crystals—(Argenteuil Co.); also black crystals on the west side of the North River at St. Jérôme (Terrebonne Co.)—in the province of Quebec. In the province of Ontario:—the townships of North Elmsley, North Burgess and Bathurst (Lanark Co.), Ross—where crystals almost equal in beauty to those from the Calumet Falls have been found,—and Blythfield (Renfrew Co.), Galway and Stoney Lake in Dummer (Peterborough Co.), and Charleston Lake in Leeds county.

258. TRAVERTINE—Deposits from calcareous springs—the material of which is in some instances hard and solid, at other times porous and tufaceous—are abundant in many parts of western Ontario, being met with in the counties of York, Wentworth, Oxford, Wellington, Grey, Simcoe, etc.

259. TREMOLITE—Is abundant in the Laurentian limestones at the Calumet Falls in Litchfield (Pontiac Co.), province of Quebec; also in the townships of Blythfield (Renfrew Co.), and Dalhousie (Lanark Co.), and short thick and highly modified prisms of a white transparent tremolite, have been observed by Professor Chapman, in a white crystalline limestone in the township of Algona (Renfrew Co.), province of Ontario.

260. TURGITE—Occurs with brown hematite at Teny Cape, Hants county, province of Nova Scotia. Anal., H. How, Phil. Mag., 4 ser., vol. xxxvii, p. 268, 1869.

261. ULEXITE—Occurs with cryptomorphite, Howlite, mirabilite, halite, Arragonite and selenite in the gypsum deposits of Hants

county—as at Clifton quarry, Windsor; Brookville; Trecothick's quarry; Three Mile Plains; Winkworth; Newport Station—province of Nova Scotia. Anal., H. How, Phil. Mag., 4 ser., vol. xxxv, p. 32, 1868.

262. Uraconite—Was observed by Dr. Hunt, in the form of a sulphur-yellow crystalline crust, lining fissures in magnetite in the township of Madoc (Hastings Co.), and by Professor Chapman, in a deposit of magnetite in the township of Snowden (Peterborough Co.), province of Ontario.

263. Uralite—Good specimens, showing the partial and complete alteration of pyroxene to uralite, have been found in the township of Templeton, Ottawa county, province of Quebec. Analyses, B. J. Harrington, Rep. Geol. Can., 1877-78, p. 20 G et seq.

264. Uraninite—Has been found at the Villeneuve mica mine, in the township of Villeneuve, Ottawa county, province of Quebec. Ann. Rep. Geol. Can., vol. ii, p. 10 T, 1886.

265. Valentinite—Is found with native antimony, stibnite, senarmontite and kermesite, in veins in argillite, in the township of South Ham, Wolfe county, province of Quebec.

266. Vesuvianite—Occurs in yellow crystals, with garnet, pyroxene and zircon, in calcite, in the township of Grenville, and in large brown crystals, with tourmaline, at the Calumet Falls in Litchfield (Pontiac Co.): in large brownish-red crystals in a quartzose rock, in the township of Templeton (Ottawa Co.), and Dr. Harrington has recorded the finding of small prisms of green idocrase imbedded in cinnamon stone, in the township of Wakefield, in the same county—province of Quebec.

267. Vivianite—An earthy form of this mineral, of a bright blue color, occurs underlying a bed of bog iron-ore in Côte St. Charles, Vaudreuil (Vaudreuil Co.), in the province of Quebec. It has also been met with, in a similar form, at the "Ramparts," Porcupine River, Yukon district, North-west Territory.

268. Wad—This variety of bog-manganese has been met with in Bolton (Brome Co.), Stanstead (Stanstead Co.), Tring, Aubert-Gallion and Ste. Marie (Beauce Co.), and several other localities in the province of Quebec. At Parrsborough (Cumberland Co.) and in Halifax county; at the head of Lewis Bay (Cape Breton

Co.), and in association with the iron ore of the Martin Brook mines at Londonderry (Colchester Co.), province of Nova Scotia. Anal., H. Louis, Trans. N.S. Inst., vol. iv, p. 427, 1878.

269. WERNERITE—Scapolite is very frequently met with in the Laurentian; it occurs in large crystals and cleavable masses, with pyroxene and sphene, in Hunterstown (Maskinongé Co.); in the townships of Grenville—in the Augmentation of, pale lemon-yellow—(Argenteuil Co.), Templeton—where good, and occasionally very large though less perfect, crystals are met with—Portland and Wakefield, etc. (Ottawa Co.), and Calumet Island—lilac-colored—(Pontiac Co.), province of Quebec. In very large, but imperfect crystals, on Turner's Island in Lake Clear, in the township of Sebastopol, at Golden Lake in the adjoining township of Algona (Renfrew Co), and in good crystals in the township of Ross, in the same county—province of Ontario. Analyses, T. S. Hunt, Geol. Can., 1863, p. 474, and F. D. Adams (showing presence of chlorine in scapolites), Rep. Geol. Can., 1877-78, p. 32 G.

270. WILSONITE—Fine specimens of this mineral are found in the townships of Portland, Templeton and Hull (Ottawa Co.), in the province of Quebec. As there met with, it is most frequently intimately associated with scapolite, the two minerals occasionally blending into each other. It also occurs in the townships of Bathurst—the locality of its first discovery by Dr. Wilson—and North Burgess (Lanark Co.), in the province of Ontario.

271. WINKWORTHITE—The name proposed by Professor How for a mineral found by him, in gypsum at Winkworth, Hants county, province of Nova Scotia. Analyses, H. How, Phil. Mag., 4 ser., vol. xli, p. 270, 1871. [Assumed to require further investigation.]

272. WITHERITE—Occurs in a silver-bearing vein—the veinstone of which consists of calcite and quartz with some fluorite, carrying argentite and native silver—at Twin Cities mine, near Rabbit Mountain, Thunder Bay, Lake Superior, province of Ontario.

273. WOLFRAMITE—Was found by Professor Chapman, in a large boulder of gneiss, on the north shore of Chief's Island, in Lake Couchiching, province of Ontario. Anal., T. S. Hunt, Geol. Can., 1863, p. 503.

274. WOLLASTONITE—Fibrous Wollastonite is often found in the limestones of the Laurentian series, associated with pyroxene, felspar,

quartz, mica and other minerals. Some of the best known localities of its occurrence are: St. Jérôme and Morin (Terrebonne Co.), and the township of Grenville (Argenteuil Co.), in the province of Quebec—and the townships of North Burgess (Lanark Co.), and Bastard (Leeds Co.), in the province of Ontario. Anal., Mr. Bunce, Geol. Can., 1863, p. 465.

75. ZIRCON—Small brownish crystals of zircon, with tourmaline, are found in granitic veins which traverse gneiss on the North River, in St. Jérôme (Terrebonne Co.); reddish-brown crystals, which are sometimes half an inch in diameter, occur, in association with wollastonite, pyroxene, sphene, plumbago, etc., in abundance in the crystalline limestone of the township of Grenville (Argenteuil Co.), and it is of frequent occurrence, often in fine crystals, in the apatite veins of Templeton and adjoining townships (Ottawa Co.), province of Quebec. Handsome crystals, including fine twins of zircon, are found in the township of Sebastopol, also large and good crystals of the same in the adjoining township of Brudenell (Renfrew Co.); in small crystals in a graphitic vein in the township of North Burgess (Lanark Co.), and in a syenitic rock on Pic Island in Lake Superior, province of Ontario.

276. MENACCANITE—See notes to "Ilmenite," "Iserite."

277. BOURNONITE—Was identified by Mr. R. A. A. Johnston in samples of ore (sent to the survey for assay) from the following localities in the province of Ontario, viz., lot 18, range 8, of the township of Marmora (Hastings Co.), the material in this instance consisting of bournonite in association with small quantities of chalcopyrite and pyrite in a gangue of quartz; and from the east half of lot 22, range 3, and west half of lot 22, range 4, of the township of Darling (Lanark Co.), the material from the first of these two localities consisting of bournonite disseminated through a somewhat fine crystalline dolomite, while that from the last mentioned consisted of bournonite with some chalcopyrite in a gangue of white sub-translucent quartz.

278. HYALITE—Good specimens of this mineral were obtained by Mr. J. McEvoy from cavities in a dark grey foliated basalt occurring near Hīh-hūm Lake, south of Loon Lake, British Columbia.

279. MICHEL-LÉVYTE—Barium sulphate crystallizing, according to A. Lacroix, in the monoclinic system (Comptes Rendus, vol. 118, p.

1126). The locality of occurrence, which is described as being near Perkins' Mill, is on lot 12, range 12 (about three miles, following the path, from Perkins' Mill) of the township of Templeton, Ottawa county, province of Quebec. Material from this locality has been examined by Dr. Edward S. Dana, who informs me "that he finds it to possess peculiarities in cleavage and lustre like those noted by Lacroix, which, however, he is disposed to regard as due to pressure. It differs from normal barite chiefly in the peculiar development of one of the prismatic cleavages. No variation in optical character from the requirements of the orthorhombic system was observed, while the optical properties are throughout those of ordinary barite." See "On the Barium Sulphate from Perkins' Mill, Templeton, province of Quebec, by Edward S. Dana." Am. Journ. Sci., 3rd ser., vol. xxxix, p. 61, 1890.

280. Prase—A breccia, consisting of angular fragments of prase cemented together with white chalcedony, was found by Dr. G. M. Dawson filling cavities in Tertiary basaltic rocks in mountains at head of Nicoamen River, British Columbia.

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(*NEW SERIES.*)

ABBREVIATIONS.

Al.	District of Alberta.	N.W.T.	North-West Territory.
B.C.	British Columbia.	O.	Province of Ontario.
Ma.	Manitoba.	Q.	Province of Quebec.
N.B.	New Brunswick.	Sk.	District of Saskatchewan.
N.S.	Nova Scotia.	V.Is.	Vancouver Island.

* In the present index, (S) placed after the numbers of the pages refers to Part S for 1888, and (*s*) to Part S for 1889, both in this volume.

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