

**NATIONAL
ADVISORY
COMMITTEE
ON
RESEARCH
IN THE GEOLOGICAL SCIENCES**



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**NINETEENTH ANNUAL REPORT
1968 - 1969**

**ANNUAL REVIEW AND
REPORTS OF SUBCOMMITTEES**

Published by the Geological Survey of Canada as GSC Paper 69-6

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REPORTS OF SUBCOMMITTEES**

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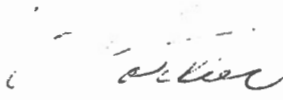
601 Booth Street,
Ottawa, October 31, 1969.

The Honourable J.J. Greene,
Minister of Energy, Mines and Resources,
Ottawa, Ontario.

Sir:

I have the honour to submit to you the Nineteenth Annual Report
of the National Advisory Committee on Research in the Geological Sciences
covering the period September 1, 1968 to August 31, 1969.

Respectfully submitted,


Y.O. Fortier,
Chairman.

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MEMBERS OF COMMITTEE

Dr. Y.O. Fortier, Chairman	Geological Survey of Canada, Ottawa, Ont.
Dr. E.W. Best	Triad Oil Co. Ltd., Calgary, Alta.
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Prof. A.R. Byers	University of Saskatchewan, Saskatoon, Sask.
Mr. H.K. Conn	Canadian Johns-Manville Co., Ltd., Asbestos, Que.
Dr. C. Dahlstrom	Chevron Standard Ltd., Calgary, Alta.
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Prof. G.V. Middleton	McMaster University, Hamilton, Ont.
Dr. B.R. Pelletier	Bedford Institute of Oceanography, Dartmouth, N.S.
Prof. E.W. Nuffield	University of Toronto, Toronto, Ont.
Prof. R.D. Russell	University of British Columbia, Vancouver, B.C.
Prof. Robert Sabourin	Université Laval, Quebec, Que.
Mr. Dennis A. Sharp	Department of Energy and Resources Management, Toronto, Ont.

THE YEAR IN REVIEW

The National Advisory Committee on Research in the Geological Sciences has a threefold purpose: to stimulate and coordinate geological research in Canada; to suggest research projects that should receive attention; and to aid in having these projects undertaken. Its function is to stimulate research by the universities, federal and provincial departments of mines and by other organizations equipped for the work.

The annual compilation of current research in the geological and related earth sciences in Canada for 1968-69 is published as a separate volume.* Current research projects included in this compilation were contributed mainly by the universities, federal and provincial departments of mines and other non-industrial institutions, although some were contributed by some of the larger oil companies. This compilation is useful in enabling research workers to see who are working in similar fields and on similar problems, and in indicating lines of research receiving the greatest attention and, by inference, those being neglected.

Other publications of the National Advisory Committee, in 1969, include the Proceedings of the Conference on Research in Tectonics (Kink Bands and Brittle Deformation) March 1968 (Geol. Surv. Can., Paper 68-52, 373 pages, 1969); Earth Science Symposium on Hudson Bay, February, 1968 (Geol. Surv. Can., Paper 68-53, 385 pages, 1969); and Symposium on the Geology of Coronation Mine, Saskatchewan (Geol. Surv. Can., Paper 68-5, 329 pages, 1969).

RESEARCH GRANTS TO UNIVERSITIES

Grants by the Geological Survey of Canada were initiated in 1951 at the instigation of this Committee to stimulate and support geological research in Canadian universities. Applicants must hold an academic staff appointment at a Canadian university; applications are received by the Director Geological Survey of Canada, Ottawa to May 1st of each year. They are reviewed by the Projects Subcommittee of the National Advisory Committee in June and the applicants notified at that time whether they will receive grants.

The National Research Council of Canada also awards grants-in-aid in the geological sciences (earth sciences) and on a much more substantial scale.** Applicants for N.R.C. grants apply by December 1st and are notified of awards in April of each year. The National Advisory Committee has full knowledge of grants in the geological sciences awarded by the National Research Council. In addition, to assure full coordination in the award of grants by the two organizations, one or more members of the National Research Council Grant Application Screening Committee serve on the Projects Subcommittee of the National Advisory Committee which reviews the applications to the Geological Survey.

For 1969-70, 131 applications (121 in 1968-69) were received by the Geological Survey for general grants-in-aid of research; the total of the grants applied for was \$563,929 (\$551,492 in 1968-69). One hundred and seventeen grants totalling \$225,242 (\$220,000 in 1968-69) were awarded to 25 universities. The names of the recipients, the titles of their research projects and the amounts awarded are listed in the appendix (p 47-55).

* Current Research in the Geological Sciences in Canada, 1968-69, National Advisory Committee on Research in the Geological Sciences; Geol. Surv. Can., Paper 69-5, 1969.

** Annual Report on Support of University Research, 1967-68, National Research Council, No. 10238, pp. 228-250.

For 1969-70, for the second year, as recommended by the Subcommittee on Storage and Retrieval of Geological Data and endorsed by the National Advisory Committee, up to \$50,000 was provided by the Geological Survey of Canada for special grants for research in the development of computer processible files of geological data (see report of Subcommittee on Storage and Retrieval of Geological Data, pp. 17-18). Applications for these grants which were received up to March 31, 1969 were reviewed in April by the Subcommittee on Storage and Retrieval of Geological Data. On the basis of the Subcommittee's recommendations, and with the approval of the National Advisory Committee, the grants were awarded by the Geological Survey in May, 1969. Six grants totalling \$50,000 were awarded to six universities. The names of the recipients, titles of the projects and amounts awarded are listed in the appendix (p. 56).

STORAGE AND RETRIEVAL OF GEOLOGICAL DATA

In 1965 the National Advisory Committee set up an ad hoc Committee under the chairmanship of S.C. Robinson to develop a national system for the storage and retrieval of geological data in Canada. In April, 1966 the ad hoc Committee presented an interim report*, and in April 1967 its final report**, to the National Advisory Committee. This report outlines the current status of electronic processing in the geological sciences and the advantages of establishing a national network of geological data files. The report includes a program for the implementation and continued development of a National System for storage and retrieval of geological data.

The National Advisory Committee adopted the report of the ad hoc Committee in April, 1967 and, as recommended in the report appointed a Subcommittee on the Storage and Retrieval of Geological Data under the chairmanship of Dennis A. Sharp, Department of Energy and Resources Management, Toronto. This Subcommittee was instructed to consider immediately the establishment and method of financing of the proposed Secretariat and the implementation of other proposals contained in the ad hoc Committee report.

In August 1968 the Subcommittee on Storage and Retrieval of Geological Data recommended that an independent body, to be called the Canadian Geoscience Data Institute, be established (pp. 24-29). A proposal to establish such an institute to be managed and funded jointly by the provinces, the federal government and industry was made at the Provincial Mines Ministers' Conference in September, 1968 by the Honourable J.J. Green, Minister of Energy, Mines and Resources (p. 24). Although the proposal was not accepted at that time, the Mines Ministers agreed to study it further and make further recommendations at their annual meeting in September, 1969.

To carry on in the meantime, a Secretariat for Geoscience Data has been established by the Geological Survey of Canada with Dr. Neil Burk, Jr., as National Coordinator (p. 17). The main functions of the Secretariat under Dr. Burk are to coordinate development of the grant-sponsored data research in the universities, to coordinate other file development activities showing an interest in the national system, to provide information and advice

* Interim Report of the Subcommittee on Storage and Retrieval of Geological Data in Canada, National Advisory Committee on Research in the Geological Sciences; Geol. Surv. Can., Paper 66-43, 1966.

** A National System for the Storage and Retrieval of Geological Data in Canada, report of the ad hoc Committee of the National Advisory Committee on Research in the Geological Sciences in Canada, 1967, available from the Geol. Surv. Can., Dept. of Energy, Mines and Resources, Ottawa.

in this field, and in cooperation with B.A. McGee, to produce and publish the Canadian Index to Geoscience Data.

INTERNATIONAL GEOLOGICAL CONGRESS-1972

Canada's invitation to the International Geological Congress to meet in Montreal in 1972 was extended at the Congress meeting in Prague, Czechoslovakia in August, 1968 and was accepted. A meeting of the Canadian National Committee for Geology made up of the Executive of the National Advisory Committee enlarged to include the presidents of the Alberta Society of Petroleum Geologists, the Geology Division of the Canadian Institute of Mining and Metallurgy, the Geological Association of Canada and the Mineralogical Association of Canada was held in Ottawa on December 9th, 1968. At this meeting the President (Dr. R.E. Folinsbee, University of Alberta), the Secretary-General (Dr. J.W. Armstrong, Geological Survey of Canada), and the Executive of the Organizing Committee for the 1972 Congress were appointed. This nucleus will add to its members to make up the Organizing Committee, the Honorary Committee and the Patrons. These together, will be fully responsible for the organization and management of the Congress in Montreal in 1972.

CHANGES IN PERSONNEL OF COMMITTEE

J.E. Blanchard, S.A. Ferguson, W.H. Mathews and C.W. Stearn retired from the Committee in 1968. All members join in expressing appreciation of the contribution of time and effort made by these men during their terms of office. We look forward to their continued support.

New members appointed are H.K. Conn, Canadian Johns-Manville Co., Ltd., Asbestos, Quebec; C. Dahlstrom, Chevron Standard, Ltd., Calgary, Alberta; B.R. Pelletier, Bedford Institute of Oceanography, Dartmouth, Nova Scotia; A.C. Turnock, University of Manitoba, Winnipeg, Manitoba.

REPORT OF THE SUBCOMMITTEE ON STRUCTURAL GEOLOGY

Presented by H.R. Wynne-Edwards

Members of Subcommittee

H.R. Wynne-Edwards (Chairman)	Queen's University, Kingston, Ont.
K. Barron	Department of Energy, Mines and Resources, Ottawa, Ont.
W.C. Brisbin	University of Manitoba, Winnipeg, Man.
P.M. Clifford	McMaster University, Hamilton, Ont.
C. Dahlstrom	Chevron Standard, Limited, Calgary, Alta.
E. Dimroth	Quebec Dept. of Natural Resources, Quebec, Que.
H. Morris	Cominco Limited, Kimberly, B.C.
D.K. Norris	Geological Survey of Canada, Calgary, Alta.
R.R. Potter	Department of Natural Resources, Fredericton, N.B.
R.A. Price	Queen's University, Kingston, Ont.
P.S. Simony	University of Calgary, Calgary, Alta.
J.O. Wheeler	Geological Survey of Canada, Vancouver, B.C.

INTRODUCTION

Nineteen sixty eight will be remembered as a year of review. The efforts of the Science Council of Canada to define a national science policy for Canada* and the Special Study of the Solid Earth Sciences commissioned by the Science Secretariat for the Science Council have occupied each of us for many hours and have caused a reappraisal of our aims and objectives.

Structural geology in Canada has made satisfactory progress in 1968-69 although few new and spectacular investigations were begun. Research on the structures of the continents has been overshadowed by the dramatic

* Towards a National Science Policy for Canada, Science Council of Canada, Report No. 4, 56 pages, October 1968.

results of the investigation of the ocean floors. We can anticipate a rapid rise in interest in structural geology as the implications of these discoveries are realized and evaluated against the structural record on the continents themselves.

The summary of current research in progress in structural geology is much condensed because individual research projects are reported on separately by the National Advisory Committee*. The Structural Subcommittee met on March 11, 1969 in Hamilton, Ontario, when its members also took part in a stimulating workshop on Plastic Deformation which is briefly reported on (pp. 7-8).

SUMMARY OF CURRENT PROGRESS IN STRUCTURAL GEOLOGY

Regional Studies

Numerous field investigations involving structural geology are in progress in Canada and at many scales. Most are being done in universities, and involve graduate students, but some are being sponsored or conducted by the provincial departments of mines. Still others were continued or started by the Geological Survey of Canada of which the most notable were studies in the northern and southern Cordillera, the Interior Plain and the Arctic Islands (including a major reconnaissance study of the bedrock over a large sector of Baffin Island); of the character and tectonic implications of Archean volcanic belts in the Canadian Shield; and of the Appalachian fold-belt in Newfoundland. The volume of research in structural geology per se by industry is more difficult to assess, but its nature and direction are discussed below.

During the meeting of the Subcommittee the need to integrate detailed structural studies within a sound framework of regional geological data was recognized as a growing problem. Without this framework, such studies may become isolated and irrelevant. This Subcommittee reaffirms its view that the greatest progress will come from coordinated studies with a general theme.

Applied Structural Geology

The total volume of research in structural geology as it bears on the origin and disposition of ore deposits has not changed markedly in the past few years. The emphasis, however, is changing towards the exhaustive, detailed investigation of individual ore deposits on the one hand, and the broad, regional investigation of the tectonic setting of ore deposits on the other - structural geology being an integral part of both types of project.

The trend of research on ore deposits in the future will be influenced by the realization that many ore deposits are formed at an early stage in the development of the rocks which enclose them (generally sedimentary or volcanic strata), so that the depositional environment and the early stages of deformation are of paramount importance. Different types of deposits may then be derived from these by metamorphism and deformation. Very early structures may have had a key role in localizing later ore solutions. If this is the case, an understanding of these early structures may be of great assistance in the search for ore in a wide range of deposits although their investigation is hampered by the subsequent deformation and metamorphism which may have obliterated many of the critical features.

This type of study brings with it an associated area of investigation: that of metamorphic and deformational effects on sulfides and other

* Current Research in the Geological Sciences in Canada, 1968-69, Geol. Surv. Can. Paper 69-5, 1969.

ore minerals. The average geologist in industry is technically untrained to undertake the study of complicated polyphase deformation or sulfide bodies, or to understand the significance of the fabric of sulfide minerals and their relationship to silicates. Good quality research in these fields will contribute significantly to present theories about ore deposits.

Structural research is important to petroleum geology. Comparative studies of the geometry of geological structures that could produce a general classification of structures would be of the greatest value, because they would enable predictions and correlations to be made from one belt to another. Recent descriptions of diapiric structures on Axel Heiberg Island, and of the style of concentric folds and thrusts in the foothills of British Columbia provide good examples.

There is much current interest in the possibility of oil in Canada's part of the continental margin, including the Arctic shelf and the Mackenzie Delta. This interest is largely based on analogy with offshore areas and in some instances on proprietary seismic data. There is very little published seismic information as yet. The suggestion (by J.W. Kerr) that Nares Strait between Greenland and Ellesmere Island is a rift and the published seismic data (by A.C. Grant) on the continental margin northeast of Newfoundland are connected topics to oil geologists, the one having to do with the mode of formation of a possible offshore sedimentary basin, and the other telling something of the structure in an offshore basin on the continental margin. Urgently needed is a series of widely spaced seismic reconnaissance lines that would provide a representative example of what exists on our continental margins. Detail and fill-in work would automatically be done by industry in areas which such reconnaissance lines suggest are of economic interest. The kinds of questions that now arise are (1) is the area between Canada and Greenland a rift or a graben and does it contain a sedimentary prism? (2) how extensive is the sedimentary prism off Labrador? (3) how does the Pacific continental margin differ from the Atlantic in terms of the younger sedimentary rocks and the base on which they rest?

Experimental Investigation

No substantial progress or new development in experimental work in structural geology can be reported for 1968-69. Rock mechanics, however, which is largely restricted to departments of mining engineering rather than of geology, is an expanding field. Results in rock mechanics are reviewed by the Canadian Advisory Committee on Rock Mechanics in an annual supplement to the Bulletin of the Canadian Institute of Mining and Metallurgy.*

Rock mechanics research by the federal government is conducted at the Mining Research Centre laboratories in Ottawa and Elliot Lake. There are five broad areas of interest: ground control, stability of slopes, blasting, rock properties, and rock breakage. A program of specialized structural studies in the Elliot Lake area has been initiated jointly by the Mines Branch and the Crustal Geology Division of the Geological Survey in conjunction with the rock mechanics research program, so that the techniques of rock mechanics can be applied to structural geology, and vice-versa. Research in rock mechanics takes place at the following Canadian Universities: Alberta, British Columbia, Carleton, Ecole Polytechnique, McGill, McMaster, Queen's Saskatchewan, Toronto, and Waterloo. Characteristically, the research is carried out in the departments of mining or engineering, and only rarely by geologists.

* Bibliography of Canadian Contributions in the Field of Rock Mechanics, Bull. Can. Inst. Min. Met., Vol. 62, No. 686, June, 1969, pp. 647-648

Mathematical Approaches

Because it is concerned with the physical properties of rocks, and with geometrical analysis, structural geology must depend heavily on mathematics. Interest in the application of methods of numerical analysis and model theory to structural geology is steadily growing, and in addition, the statistical manipulation of large volumes of numerical data is becoming commonplace. Computers are currently being used by the petroleum industry to store, retrieve and to display data on maps and cross-sections. As yet there is little or no interpretation by machine, although considerable mathematical manipulation of data is practical. The principal structural application is in trend surface analysis.

Electronic data processing methods lend themselves naturally to structural geology, and a number of projects involve the collection of structural and other field data in machine-processible form. Some university research on the development of computer-processible files of geological data is supported by the Geological Survey of Canada; these grants are awarded on the basis of recommendations of the Subcommittee on Storage and Retrieval of Geological Data (see pp. 17-18).

COMMUNICATION AMONG STRUCTURAL GEOLOGISTS

Conferences

The number of conferences devoted to structural geology and tectonics is steadily growing. The following meetings were held in 1968-69:

1. Kink Bands and Brittle Deformation, Ottawa, March, 1968. This was the first Canadian Conference on Research and Tectonics sponsored for the Structural Subcommittee by the National Advisory Committee. The meeting was organized by D.K. Norris and co-workers and the proceedings of the conference were published in March 1969*.
2. Structural Cross-section Across the Southern Cordillera, Vancouver, April 1, 1968. This symposium, organized by J.O. Wheeler and sponsored by the Geological Association of Canada, contained the latest results of the Southern Cordilleran Structure Project. The papers are to be published in 1969 by the Geological Association of Canada as Special Paper No. 6.
3. Fifth Canadian Symposium on Rock Mechanics, Toronto, December, 1968. The symposium was organized by Dr. R. Rice for the Canadian Advisory Committee on Rock Mechanics. The proceedings are to be published by the Mines Branch, Dept. of Energy, Mines and Resources.
4. The Second Canadian Conference on Research and Tectonics, Hamilton, March, 1969. The conference was organized by Dr. P.M. Clifford and Dr. M. Stauffer on behalf of the Structural Subcommittee of the National Advisory Committee on Research in the Geological Sciences. Invited speakers from Canada, Britain, and the United States contributed to a highly successful meeting lasting one and a half days which provoked great interest and lively discussion by the participants. The general theme was Plastic Deformation of Rocks, and the treatment by different authors ranged from broad large-scale syntheses, to detailed strain analysis of natural features, including mathematical simulation of deformation by methods involving the integration of small increments of strain.

* Proceedings, Conference on Research in Tectonics, Kink Bands and Brittle Deformation, National Advisory Committee on Research in the Geological Sciences, Geol. Surv. Can. Paper 68-52, 1969.

5. Chronological Evolution of the Eastern Canadian Shield, Albany, New York, March, 1969. This symposium was organized by H.R. Wynne-Edwards for the Northeastern Section of the Geological Society of America and included papers on the Superior, Southern, Churchill, Nain, and Grenville Provinces.

Future Conferences

At the first meeting of the Organizing Committee of the XXIV International Geological Congress in February 1969, it was agreed that a symposium on "Tectonic Styles in Canada", adopted by the Geological Association of Canada as its 25th Anniversary project, would form part of the proceedings of the Geological Congress in Montreal in August, 1972. The symposium, being organized by R.A. Price, Queen's University, will include presentations on the ten structural provinces of Canada described according to a standard format, so that they may be directly compared. The Geological Association of Canada will undertake the publication of the proceedings.

The Structural Subcommittee has agreed to investigate arrangements for a Third Canadian Conference on Research and Tectonics, preferably in western Canada, to be held in March, 1970. There is general agreement that the first two conferences were highly successful, and that they should continue to be held.

Structural Geology and Geophysics

The hiatus remarked on last year between structural geology and tectonics as practised by geologists, and tectonics and tectonophysics as practised by geophysicists is still a problem. It arises from a lack of effective communication between the two professions. The Solid Earth Sciences Study Group recognized some of the confusion by commissioning separate background papers on each of structural geology, tectonics and geotectonics, and tectonophysics. Much would be gained by freer exchange and a better interlocking of these studies at all levels.

Reviewing Services

At the 1968 meeting of the Subcommittee, it was agreed there was need for cooperation among structural geologists to ensure adequate coverage of the large volume of literature now appearing. A pilot project in which each member of the committee prepared abstracts which were circulated to their colleagues was organized last year by H.C. Morris. Mr. Morris has undertaken to continue the reviewing process on an expanded basis, starting with the June, 1969 issue of as many journals as possible. Efforts will be made to enlarge the reviewing group by recruiting individuals interested in structural geology outside the subcommittee. The proposal is to employ a format embodying firstly a comment as to the significance, merit, and value of the paper in the opinion of the reviewer, secondly the reviewer's comments on the article as a whole, and thirdly the author's abstract. The Structural Subcommittee will report further on this project next year, in the hope that the experience gained may be of value to geologists with other interests.

CONTINUING EDUCATION

A major recommendation of the Structural Subcommittee last year was that the National Advisory Committee establish a committee to investigate the desirability and feasibility of establishing a centre for

continuing education in the Earth Sciences. This special committee was established with E.W. Best as Chairman, and we await its report with interest.

The solution suggested last year to the problem of obsolescence among professional geologists in industry was the establishment of a professional retraining centre to which industry-employed geologists could go to refresh and enhance their education. A scheme as profitable and probably more practical would involve bringing the training to the individual. This would sidestep the difficulty of employees of industry being freed for long periods to attend an institution, and reduce substantially the over-all level of expenditure. It might also bring the program within reach of the ordinary staff geologist who would probably benefit most from further training. One solution might be to establish a travelling course in some aspect of geology which could visit a number of industrial centres. The program might at least be tested in this fashion.

Evening classes and intensive refresher courses have been instituted by a number of universities. These generally deal with particular techniques, such as computer applications, rock mechanics, instrumental analysis, etc.; for example, Dr. P.S. Simony has given a successful evening course at the University of Calgary recently on structural methods for the exploration geologist. The Subcommittee affirms its view that continuing education is essential to geologists as an alternative to professional obsolescence and is satisfied that sufficient need and interest exists for various types of retraining to be seriously considered.

GOALS AND OBJECTIVES IN CANADIAN STRUCTURAL GEOLOGY

The Structural Subcommittee in its 1968 report commented that because the number of structural geologists in Canada was small, there would be benefit in concentrating on specific problems. It then recognized the Cordilleran Structure Project as having the highest priority. The results of Phase I of this project were reported on in Vancouver in April, 1968, but the level of activity on the project has now declined. The Subcommittee expresses concern and reiterates its firm support of the objectives of the project and its concern that the first phase be completed as soon as possible. The necessary impetus can be provided if priority is assigned, in the field of structural geology, to grant applications for work falling within the project.

The National Advisory Committee on the recommendation of the Subcommittee endorsed a proposal last year (1968) for the preparation of a geological map of the eastern Cordillera incorporating company information. This is now being undertaken by Dr. N.C. Ollerenshaw, Geological Survey of Canada (Institute of Sedimentary and Petroleum Geology), in cooperation with the Alberta Society of Petroleum Geologists. The Committee hopes that later cooperative projects may include an investigation of the northern Cordillera, and of the Appalachian fold-belt.

RECOMMENDATIONS

The following recommendations to the National Advisory Committee were adopted at the Subcommittee meeting on March 11, 1969.

(1) That the National Advisory Committee continue to encourage the Cordilleran Structure Project by assigning priority to grant applications falling within that framework, and by direct advertising of this practice, if necessary.

(2) That the National Advisory Committee consider the structure and membership of its subcommittees, and that the principle be adopted that each newly

constituted subcommittee contain some new members as well as some experienced members who would serve another term.

(3) It is plainly desirable that some of the scientific information held confidentially by industry be released to the public domain. Release of such information should be on a voluntary basis, but some effective vehicle of transfer needs to be devised. The Structural Subcommittee therefore recommends that the National Advisory Committee attempt to establish guidelines for the release to the public domain of some of the valuable research information currently held confidentially by industry.

REPORT OF THE SUBCOMMITTEE ON STRATIGRAPHY,
PALEONTOLOGY AND SEDIMENTOLOGY

Presented by G.V. Middleton

Members of the Subcommittee

G.V. Middleton (Chairman)	McMaster University, Hamilton, Ont.
W.J. Braun	University of Saskatchewan, Saskatoon, Sask.
R.P. Glaister	Imperial Oil Company, Calgary, Alta.
H.J. Hofmann	Geological Survey of Canada, Ottawa, Ont.
J. Lajoie	Université de Montréal, Montréal, Qué.
G.B. Mellon	Alberta Research Council, Edmonton, Alta.
P.E. Schenk	Dalhousie University, Halifax, N.S.
H. Williams	Memorial University, St. Johns, Nfld.
C.G. Winder	University of Western Ontario, London, Ont.

SOLID-EARTH SCIENCES STUDY

Much of the activity of the Subcommittee this year has been related to the preparation of reports for the special study of the Solid Earth Sciences commissioned by the Science Secretariat for the Science Council. The Subcommittee considered preliminary versions of three reports prepared for the Study Group at a meeting at McMaster University on November 15th, 1968. Revised versions were then circulated for comment and further revised by three members of the Subcommittee in March, 1969. These three reports present a comprehensive statement on past, present and future prospects for stratigraphy, paleontology and sedimentology in Canada. The conclusions reached need not be repeated here but one matter arising from these briefs does merit comment.

The remarks received from paleontologists indicate a great diversity of opinion regarding the present and future status of paleontology in Canada. Some measure of disagreement is healthy, but the present disagreements seem excessive and suggest a lack of adequate communication between paleontologists in Canada. Seminars in paleontology have been held annually in Ontario and Quebec since 1965, sponsored by host universities. The Paleontological Committee of the Alberta Society of Petroleum Geologists also holds frequent meetings. Perhaps this type of meeting should be extended to other parts of Canada. A well organized session devoted to paleontology at the annual meeting of the Geological Association of Canada would draw

paleontologists from all over Canada and, hopefully, permit them to reach some degree of consensus regarding the policies that should be followed to foster paleontological studies in Canada.

RECOMMENDATIONS REGARDING ALLOCATION OF RESEARCH GRANTS

At the 1968 annual meeting of the National Advisory Committee* the subcommittees covering the different fields of the geological sciences were asked to consider what special fields should be selected for the concentration of research which might be named as fields of priority in inviting applications for research grants. This Subcommittee has identified several broad categories of research in its studies for the Solid Earth Sciences Study Group which it believes should be given special consideration in award of grants. These are:

- (1) Studies of ancient and recent sediments, especially those in which there is a close integration of stratigraphy, paleontology and sedimentology.
- (2) Theoretical studies of paleontology related to computer applications, biostratigraphy, environmental analysis and biological paleontology.
- (3) Studies of organic aspects of marine sedimentation.
- (4) Chemical sedimentology and associated branches of chemical oceanography and limnology.
- (5) Interdisciplinary areas in sedimentology including experimental physical sedimentology, integrated soil mechanical-sedimentological studies and computer simulation of sedimentation processes.
- (6) Application of stratigraphic principles to igneous and metamorphic rocks.

SYMPOSIA

Some years ago this Subcommittee suggested to the Geological Association of Canada that a symposium on flysch deposits should be organized for the annual meeting of the Association in Montreal in June 1969. This suggestion has been acted upon with the result that the Montreal meeting was of particular interest to "soft rock" geologists. The Subcommittee has suggested that the 1971 meeting of the Association in Sudbury should include a symposium on Huronian stratigraphy and sedimentation, but understands that a general symposium on Sudbury geology is all that is planned.

It is the view of the Subcommittee that the Geological Association of Canada cannot expect the full support of "soft rock" geologists unless it sponsors special sessions and field trips for geologists with interests in stratigraphy, paleontology and sedimentology.

SEDIMENTARY ROCK SUITES

In our 1968 report** this Subcommittee recommended that suites of sedimentary rocks be collected by university staff who were experts in different parts of the stratigraphic section and supplied to the Geological

* National Advisory Committee on Research in the Geological Sciences, Eighteenth Annual Report, Geol. Surv. Can. Paper 68-73, p. 3, 1969.

** Op. cit., p. 61 and 70.

Survey of Canada for distribution to Canadian universities for instruction at the advanced undergraduate and graduate levels.

Members and past members of the Subcommittee have now collected six suites with sufficient material to make up 20 sets of each. Dr. T.E. Bolton, Geological Survey of Canada, is looking after the distribution of these suites to interested Canadian universities.

TRANSLATIONS

All translations of foreign geological literature made by the Translation Bureau, Secretary of State Department, are stored in the library of the Geological Survey of Canada. Likewise copies of translations of geological literature made by National Research Council translation services are forwarded to the Geological Survey of Canada library.

The Subcommittee recommends that every effort be made to encourage the sending of copies of all translations made by or for Canadian geologists to the Geological Survey library where they will be available for all interested readers.

CURRENT RESEARCH

A detailed summary of current research is given in the annual surveys of Current Research in The Geological Sciences in Canada for 1967-68 and 1968-69 (Geol. Surv. Can. Papers 68-54, 69-5). The data given in Table 1 are taken from these reports. Such data are difficult to interpret because of the difficulty of classifying the projects and the great variation in reporting of projects. The one striking feature of the table is the large increase in the number of projects classified as "sedimentology". Such an increase corresponds to a large world-wide growth of interest in sedimentology.

Table 1

Number of research projects

Year	Stratigraphy and Paleontology	Paleontology	Sedimentology	Total
1965-66	118	65	36	219
1966-67	91	51	48	190
1967-68	116	73	92	281

It is impossible to summarize briefly the extensive stratigraphic work carried out in Canada by federal and provincial surveys, and industrial and university personnel. For the Geological Survey of Canada, brief summaries of work in progress are provided in the annual Reports of Activities (Geol. Surv. Can. Paper 68-1, 69-1). Major events of 1968 include the publication of the two-volume proceedings of the International Devonian Symposium and the publication of Geological Association of Canada, Special Paper No. 4 on the Geology of the Atlantic Region.

In paleontology the Devonian and Cretaceous systems are receiving the most study. Little activity on Cambrian faunas was reported for 1967-68, although a major revision of the Burgess Shale fauna is planned for the

near future. Micropaleontology is well represented and a recent paper by G.A. Bartlett (Can. Earth Sci., Vol. 5, p. 231, 1968) illustrates vividly the potential of the new scanning electron microscope for micropaleontological studies. Vertebrate paleontology is represented by active groups at the University of Alberta and the Royal Ontario Museum.

Most recently published paleontological studies appear to be contributions to stratigraphic paleontology, including notable studies by Jeletzky (Cretaceous), Frebold and Westermann (Jurassic), Tozer (Triassic), Mamet, Braun, Bamber and Macqueen (Mississippian), Mound, and Pollock (Devonian).

Studies with a more "biological" orientation are represented by the work of Copper on life habits of Devonian brachiopods and by Ferguson on tracks and sexual dimorphism.

In sedimentology, the Bedford Institute, Dartmouth, Nova Scotia and the Canada Centre for Inland Waters, Burlington, Ontario are particularly active in studies of recent sediments. The Bedford Institute has studies in progress (or just published) on sediments in the Arctic archipelago, Baffin-Labrador sea, Gulf of St. Lawrence, Bay of Fundy, Hudson Bay, West Indies, North Atlantic (including Scotia Shelf) and elsewhere. The Centre for Inland Waters laboratory at Burlington only recently began operations: most of the work so far has been in Lake Ontario and is not yet ready for publication. On the west coast, work at the University of British Columbia has included studies of glacial sediments on the continental shelf, a study of intertidal sediments of Boundary Bay, and a study of the marine environment on the top of the Bowie seamount (off Queen Charlotte Island). Among the many recently published studies of ancient sediments in Canada the following may be mentioned: studies by Wardlaw and McIntosh of the Devonian evaporites of Saskatchewan, and several studies of the chemical composition of sedimentary rocks (F.A. Campbell and T.A. Oliver on the carbonates and shales of the Ireton-Duvernary, E.M. Cameron on the Swan Hills Reef and J.F. Lerbekmo on Cretaceous-Paleocene bentonites).

REPORT OF THE SUBCOMMITTEE ON
STORAGE AND RETRIEVAL OF GEOLOGICAL DATA

Presented by D.A. Sharp

Members of Subcommittee

D.A. Sharp (Chairman)	Department of Energy and Resources Management, Toronto, Ont.
Robert Bergeron	Department of Natural Resources, Quebec, Que.
W.C. Brisbin	University of Manitoba, Winnipeg, Man.
C.F. Burk, Jr.	Geological Survey of Canada, Ottawa, Ont.
N.M. Ediger	Gulf Minerals Company, Toronto, Ont.
Robert G. Garrett	Geological Survey of Canada, Ottawa, Ont.
A.S. Gibson	Imperial Oil Enterprises, Ltd., Edmonton, Alta.
J.A. Gower	University of British Columbia, Vancouver, B.C.
R.R. Potter	Department of Natural Resources, Fredericton, N.B.
F. Raynes	Cominco Limited, Montreal, Que.
D.R.E. Whitmore	Geological Survey of Canada, Ottawa, Ont.
H.R. Wynne-Edwards	Queen's University, Kingston, Ont.
J.A. Sarjeant (Consultant)	DCF Systems Limited, Toronto, Ont.

INTRODUCTION

The Subcommittee met twice during 1968-69, in September 1968, in Quebec City, and in March 1969, in Calgary. In addition to the main Subcommittee, six working committees, each having a member of the Subcommittee as Chairman, were active during the year. Two of these committees convened meetings. A list of these working committees and their membership is attached as Appendix 1 to this report (pp. 21-23).

The work of the Subcommittee during the fiscal year 1968-69 was directed towards the implementation of the concepts and recommendations

contained in the ad hoc committee report, "A National System for Storage and Retrieval of Geological Data in Canada".*

A detailed review of the most efficient and practical methods of implementation was undertaken and, as a result of this review, the Subcommittee recommended to the Chairman, National Advisory Committee, the establishment of a permanent body - the Canadian Geoscience Data Institute. A copy of this submission is attached as Appendix 2 to this report (pp. 24-29).

SUBCOMMITTEE ACTIVITIES

25th Annual Conference of the Provincial Ministers of Mines

At the 25th Annual Conference of the Provincial Ministers of Mines, the Subcommittee's proposal to establish a permanent institute was presented to the Provincial Ministers of Mines by the Minister of Energy, Mines and Resources, the Honourable J.J. Greene, in his reply to the brief submitted to the Government of Canada following the previous Conference. The proposal was endorsed by the Minister, and to assist the delegates, copies of the proposal were distributed.

During the three-day meeting, considerable discussion took place, but the provinces were not prepared to accept the proposal in its entirety. Several provinces supported the concept in principle but there was a general lack of understanding of the institute concept and considerable apprehension was expressed as to the ultimate costs such participation would involve.

As a result of the review by the Ministers and Deputy Ministers and the discussions held by the Committee on Problems Relating to Exploration and Development, chaired by Dr. P.E. Auger, the following resolutions were submitted to the Ministers and were subsequently adopted.

"Recognizing the value of a National System for the storage and retrieval of geological data in Canada, the committee recommends that the Provincial Ministers of Mines ask the Federal Government that the Geological Survey of Canada, in collaboration with the Provinces, be requested to continue its excellent work in the field of data processing in order to implement the creation of the National System proposed by the ad hoc Committee on Storage and Retrieval of Geological Data in Canada".

It was further recommended,

"that the Provincial Ministers of Mines authorize further study by their respective Departments, into the creation of a permanent organization to implement the National System for storage and retrieval of geological data in Canada and to report back to the 1969 Conference of the Provincial Ministers of Mines".

* A National System for Storage and Retrieval of Geological Data in Canada, April 1967, available from the Geological Survey of Canada, Dept. Energy, Mines and Resources, Ottawa.

Secretariat for Geoscience Data

Subsequent to the 1969 Mines Ministers' Conference, the Geological Survey of Canada established, in October, 1968, the Secretariat for Geoscience Data and appointed Dr. Cornelius F. Burk, Jr. as national coordinator.

Dr. Burk commenced work at the Geological Survey of Canada's Calgary office and was transferred to Ottawa in March, 1969. His activities during these initial months consisted of establishing liaison with persons in industry, government and universities, coordinating the five university pilot projects supported by Geological Survey of Canada grants, closely following development of the SIS II system that will be used to produce the Canadian Index to Geoscience Data, organizing the Secretariat's files to provide fast response to requests for information, and writing reports and papers for publication and oral presentation.

Production and publication of the first editions of the Canadian Index will be the Secretariat's first major task, and in this connection, Brian A. McGee was asked by the Geological Survey of Canada to assist the national coordinator on a part-time basis.

Canadian Index to Geoscience Data

Considerable progress was made during the year in developing a national index to sources of Canadian geoscience data, to be called the Canadian Index to Geoscience Data. Of basic importance was conversion of Imperial Oil Limited's original information retrieval system (SIS) to a form suitable for operation on a widely available series of computers. The new system (SIS-II) was developed in a cooperative project by Imperial Oil Limited, the Geological Survey of Canada, and the universities of Saskatchewan and Calgary.

The Geological Survey of Canada provided the first contribution of indexing to the Canadian Index. Essentially, all G.S.C. publications issued since 1845 (approximately 8,000 geological maps, aeromagnetic maps and reports), were indexed for their data content by Mr. McGee and his assistants. The Quebec Department of Natural Resources provided a second major contribution of indexing following completion of a training program by a staff member at the G.S.C. Invitations to obtain such training had been extended by the Minister of Energy, Mines and Resources, to all provincial mines departments and it is hoped that others will avail themselves of this opportunity in the near future.

Present plans of the Secretariat for Geoscience Data call for publication of the first editions of the Canadian Index in late 1969.

University Grants

For 1968-69, up to \$50,000 was provided by the Geological Survey of Canada for special grants for research in the development of computer processible files for geological data. The following is a brief description of each of the five projects initiated during 1968 as a result of these grants.

1. Development of mineral deposits data file for a Precambrian area of Saskatchewan; research directed by Professor F.F. Langford, University of Saskatchewan. The file will include all reported occurrences and deposits in NTS quadrangle 73P, in the Lac La Ronge area. Published data and data from the provincial mineral assessment file will be the major sources. Mr. Wayne Kipling is the graduate student involved.

2. Development of a computer-processible file of mineral deposits data; research directed by Professor P.G. Sutterlin, University of Western Ontario. A file on all silver deposits in Ontario is being compiled, using data supplied by the Ontario Department of Mines. The most significant aspect of this project is the development of a free-form format (FFF) system that will have many other applications. The file-generation portion of the system is complete and available to other grantees. Mr. Gerald de Plancke, a senior student in Computer Sciences, is working with Professor Sutterlin.

3. Characteristics of oil and gas pools relative to the structure and stratigraphy of Alberta; research directed by Professor G.D. Williams, University of Alberta. A file of all occurrences in an area to be selected, probably in west-central Alberta, will be compiled using data from the Oil and Gas Conservation Board, the literature and, if possible, from industry. A complementary and partly overlapping file is being developed at the Institute of Sedimentary and Petroleum Geology. Mr. Jeff Dickie is the graduate student involved.

4. The geologic, geographic and temporal significance of the distribution of base-metal and precious-metal deposits of the world; research directed by Professor H.D.B. Wilson, University of Manitoba. Data are being compiled from the world's literature to create this file. Of necessity, the level of data will be more basic than in the aforementioned files, but an attempt is being made to make it comprehensive. Mr. Peter Laznicka, who is familiar with the east European and Russian literature, is working under Professor Wilson.

5. Electronic processing of field data from the Grenville Province in Quebec; research directed by Professor H.R. Wynne-Edwards, Queen's University. A large volume of field data collected by the Quebec Department of Natural Resources will be used to create the file. The data were assembled in the field on a pre-printed standard format to produce consistent, standardized records of observations and measurements, with provision for additional notes or remarks.

The Subcommittee has been more than pleased with the progress of these projects to date and is satisfied that the availability of grants for special projects is a most worthwhile concept.

For 1969-70, \$50,000 has been provided by the Geological Survey of Canada for similar grants for research in the development of computer-processible files for geological data (see p. 56).

Files of Data on Mineral Deposits

The working committee on mineral deposits data met once during the year. Its main objectives were to stimulate the development of a network of computer-processible files of data on mineral deposits in Canada and to develop and test standards for the recording of computer-processible mineral deposits data.

As a result of the research project on mineral deposits data being conducted by Dr. P.G. Sutterlin, University of Western Ontario, a more viable approach to the development of computer-processible files has evolved. Dr. Sutterlin's concept - a free-form format system - will enable the geologist to record, store and retrieve data more effectively. The proposed free-form format is non-hierarchical and greatly simplifies updating, re-structuring, and file merging.

The utilization of this system has been widely discussed during the past several months and development and refinement of the system are expected to continue under the direction of Dr. Sutterlin.

Files on Geological Field Data

The gathering of geological field data in computer-processible form has gained considerable momentum during the year. It is now generally realized that modern data-processing techniques are readily available to the earth scientist and are beneficial for the efficient handling of the vast amounts of geological field data being gathered in the many geological and geographical areas of Canada.

The working committee on geological field data met twice during the year, prior to the 1968 field season, to discuss plans for the use of data-processing techniques in the collection of geological field data and after the field season, to review the progress and results obtained.

Six individual projects oriented towards the collection of data in computer-processible form were conducted across Canada. These projects were: The Coast Range Batholith, Operation Norman and the operation in the Baffin Island area, all carried out by the Geological Survey of Canada; a stratigraphic description project undertaken by Canadian Pacific Oil and Gas Limited; the Manitoba Mines Branch structural geology project in the Canadian Shield; and the extensive program carried out by the Quebec Department of Natural Resources in cooperation with Queen's University.

The results from the 1968 field work were generally favourable, although room for improvement was clearly indicated and considerable apprehension was evident in the early stages. One important difficulty was the prediction, in advance, of the parameters to be recorded, but this created a major problem in only one of the six projects. All were enthusiastic about the potential benefits of gathering data in computer-processible form.

Files of Geophysical Data

The use of data-processing techniques in the collection and utilization of geophysical data is an accomplished fact. During the past year, the Subcommittee maintained close liaison with the Digital Well Log Data Subcommittee, Canadian Petroleum Association, which has been developing standard formats for the recording of well log data. These formats agree very closely with those being proposed by the American Petroleum Institute and are expected to be endorsed by the C.P.A. Board of Governors in May of 1969.

With the recent development of large participation geophysical surveys, wherein the costs of such surveys are shared by a consortium or group of companies, the importance of standards is becoming more critical. Industry and government have recognized this need and every effort is being made by all concerned to ensure that such standards are developed and used.

Files of Geochemical Data

A preliminary review of geochemical files was conducted during the year and it is apparent that considerable computer-processible data exist in this discipline. In view of these large amounts of data, priority will be given to encouraging the indexing of much of the geochemical data to accordance with the program presently under way with the Canadian Index to Geoscience Data.

OBJECTIVES AND TERMS OF REFERENCE OF THE SUBCOMMITTEE

Role of the Subcommittee

The original terms of reference for the Subcommittee on Storage and Retrieval of Geological Data revolved around,

taking the necessary steps to implement and develop a national system for the recording, storage and retrieval of data in computer-processible form pertaining to those disciplines that together comprise the earth sciences.

In view of the existence of the Secretariat and the recommendation to establish an Institute, many of the objectives of the Subcommittee will be accomplished by the Secretariat or Institute. In accepting this premise, it should be appreciated that the Subcommittee has concentrated its efforts only in the areas of collection, storage and retrieval. It is recommended that the implications of computer applications in the earth sciences be considered on a broader basis and that the emphasis be shifted from storage and retrieval to the rapidly growing areas of processing, analysis, simulation, and display of geological data. Accordingly, it is recommended that the Subcommittee's name be changed to the Subcommittee on Computer Applications.

Working Committees

During the past year, it has become increasingly more apparent that the role of the working committees has changed appreciably. In addition to making recommendations to the Subcommittee, the working committees were established to review special projects, to conduct pilot projects and to make recommendations for computer-processible files in the specific fields of geological field data, mineral deposits data, fossil fuels deposits data, geophysical data and geochemical data. The general objectives of the pilot projects were to provide common examples of data files of general interest and to provide a means for the practical evaluation of the principles and concepts developed by the ad hoc committee and the Subcommittee for general application in the national system.

Based on the recommendations of the working committees, several organizations have initiated files and are now actively engaged in the utilization of these files. The need is no longer for advisory committees but, rather, for user committees or groups of persons actively engaged in the creation and utilization of such files. Liaison between these persons and the Secretariat appears to be more practical and useful than the existing arrangement, whereby the working committees report directly to the Subcommittee on Storage and Retrieval of Geological Data.

The encouragement of such working committees should be initiated through, and coordinated by, the Secretariat for Geoscience Data and such committees would logically be supported by the participants rather than through National Advisory Committee funds.

Scientific Information Activities

Storage and retrieval of data is but one aspect of the larger field of science information and the Subcommittee's attention has been drawn to a number of projects of importance to geologists. Foremost is the American Geological Institute's Committee on Science Information, established in 1968. That committee has the following two responsibilities:

1. To develop a concept for a national information system in the geosciences, with the corresponding definition of general policy and long-range goals.
2. To formulate a tentative plan for geoscience information activities during the three-year period 1969-71.

Priorities have been assigned to work on bibliographic, library and data services, and to primary publications, but the committee is also concerned with scientific meetings, translations, vocabulary control, and current research. The recommendations of this United States committee will have far-ranging effects on Canadian scientists.

Although not directed solely to the geological community, two Canadian projects are worthy of mention. The National Science Library has instituted a selective dissemination of information (SDI) program that provides regular personalized searches of bibliographic tape files for Canadian scientists. No geological bibliographies are presently being processed, but these could be included in future. The second project is a report of the Science Secretariat on Scientific and Technical Information in Canada.* Its findings and recommendations will, no doubt, influence future information activities of geologists.

RECOMMENDATIONS

1. That the terms of reference of the Subcommittee on Storage and Retrieval of Geological Data be broadened to include all computer applications in the earth sciences, with a corresponding change in name to the Subcommittee on Computer Applications.
2. That the National Advisory Committee undertake a review of existing and proposed scientific information programs, in order to assess their impact on the geological community in Canada and to make appropriate recommendations.
3. That the National Advisory Committee encourage and assist wherever possible in the establishment of the Canadian Geoscience Data Institute.

APPENDIX 1 TO THE REPORT OF THE SUBCOMMITTEE ON STORAGE AND RETRIEVAL

Working Committees of the Subcommittee on Storage and Retrieval of Geological Data

Mineral Deposits Working Committee

N.M. Ediger (Chairman)	Gulf Mineral Company, Toronto, Ont.
W.C. Brisbin	University of Manitoba, Winnipeg, Man.
R.L. Cheesman	Department of Mineral Resources, Regina, Sask.
J. Dugas	Department of Natural Resources, Quebec, Que.
R.C.J. Edwards	Syngenore Explorations Ltd., Toronto, Ont.

* Scientific and Technical Information in Canada, Pt. 1, Science Council of Canada, Special Study No. 8, 1969.

Mineral Deposits Working Committee (cont.)

S.A. Ferguson	Department of Mines, Toronto, Ont.
W.D. Harrison	Falconbridge Nickel Mines Ltd., Falconbridge, Ont.
A.M. Kelly	British Columbia Research Council, Vancouver, B.C.
T. Podolsky	International Nickel Co. Ltd., Clarkson, Ont.
R.R. Potter	Department of Natural Resources, Fredericton, N.B.
D.R.E. Whitmore	Geological Survey of Canada, Ottawa, Ont.
H.R. Wynne-Edwards	Queen's University, Kingston, Ont.
J.A. Sarjeant (Consultant)	DCF Systems Limited, Toronto, Ont.

Canadian Index Working Committee

F. Raynes (Chairman)	Cominco Limited, Montreal, Que.
R. Bergeron	Department of Natural Resources, Quebec, Que.
C.F. Burk, Jr.	Geological Survey of Canada, Ottawa, Ont.
K.R. Dawson	Geological Survey of Canada, Ottawa, Ont.
A.S. Gibson	Imperial Oil Limited, Edmonton, Alta.
J.A.M. Haddon	Department of Mines, Toronto, Ont.
J.A. Sarjeant	DCF Systems Limited, Toronto, Ont.
D.R.E. Whitmore	Geological Survey of Canada, Ottawa, Ont.

Geological Field Data Working Committee

R. Bergeron (Chairman)	Department of Natural Resources, Quebec, Que.
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Geological Field Data Working Committee (cont.)

J.M. Grant	Labrador Mining & Exploration Co. Ltd., Montreal, Que.
W.W. Hutchison	Geological Survey of Canada, Vancouver, B.C.
P.J. Lesperance	University of Montréal, Montreal, Que.
J.A. Minchin	Canadian Pacific Oil and Gas Ltd., Calgary, Alta.
W.D. McRitchie	Manitoba Mines Branch, Winnipeg, Man.
V.G. Milne	Department of Mines, Toronto, Ont.
E.W. Reinhardt	Geological Survey of Canada, Ottawa, Ont.
A.A. Ruitenberg	Mines Division, St. George, N.B.
H.R. Wynne-Edwards	Queen's University, Kingston, Ont.
C.J. Yorath	Institute of Sedimentary and Petroleum Geology, Calgary, Alta.

Geochemical Data Working Committee

R.G. Garrett (Chairman)	Geological Survey of Canada, Ottawa, Ont.
J.A. Coope	Newmont Mining Corporation of Canada Ltd., Vancouver, B.C.
C.F. Gleeson	SOQUEM, Ste. Foy, Que.
B.M. Gunn	University of Montréal, Montreal, Que.
J.R. Smith	Saskatchewan Research Council, Saskatoon, Sask.
N.C. Wardlaw	University of Saskatchewan, Saskatoon, Sask.
W.J. Woolfe	Department of Mines, Toronto, Ont.

Fossil Fuels Working Committee

C.F. Burk, Jr. (Chairman)

Geological Survey of Canada,
Ottawa, Ont.Geophysical Data Working Committee

A.S. Gibson (Chairman)

Imperial Oil Enterprises, Ltd.,
Edmonton, Alta.University Grants Working Committee

W.C. Brisbin (Chairman)

University of Manitoba,
Winnipeg, Man.

C.F. Burk, Jr.

Geological Survey of Canada,
Ottawa, Ont.

D.A. Sharp

Department of Energy, and Resources,
Toronto, Ont.

APPENDIX 2
TO THE REPORT OF THE
SUBCOMMITTEE ON STORAGE AND RETRIEVAL

Proposal for Establishment of the
Canadian Geoscience Data Institute

1. Summary

The National Advisory Committee on Research in the Geological Sciences, whose members are drawn from industry, universities, research foundations, the Geological Survey of Canada and provincial departments of mines, reported in 1964 that many Canadian organizations had recognized the potential value of computer techniques for storing, retrieving and analyzing geoscience data, and were preparing to establish the necessary computer systems. Such systems would be used for exploration, research, planning, and administration. Although building the systems was technically feasible, difficulties were immediately encountered in collecting standardized or compatible data to place in the files. The problem was aggravated by continually increasing volumes of data being produced by more and more sources. The need for Canada-wide standards became clearly apparent.

For this reason the National Advisory Committee established an ad hoc committee comprising geologists from industry, universities the Geological Survey of Canada and provincial departments of mines, to study and report on this problem. Specifically, it was requested to consider whether a computer-oriented system for data storage and retrieval could be devised usable by any Canadian public or private organization.

The committee's recommendations to establish a National System for storage and retrieval of geological data were adopted unanimously by the National Advisory Committee at its April, 1967 meeting and published in September, 1967 by the Geological Survey of Canada on behalf of the National Advisory Committee. Requests for the report have come from throughout Canada

and the world, resulting in the distribution to date of about 2,000 copies. The report represents the world's first proposal to coordinate the dissemination of geoscience data on a national scale.

In order to implement the report's recommendations, the National Advisory Committee set up a new Subcommittee charged with establishing the necessary organization. After lengthy study and consultations with members of the ad hoc committee, the National Advisory Committee and other geologists throughout Canada, the Subcommittee recommends establishment of an independent body, the Canadian Geoscience Data Institute.

The proposed Institute will have a nine-man board of directors, an advisory board representing governments, universities and industry, and initially, staff comprising an Institute Director and a Chief Indexer, with secretarial assistance. It is proposed that the Institute be financed in its initial stages by contributions shared equally by the Government of Canada and the provinces, each province contributing an amount proportional to its share of Canadian mineral production. It is projected that within five years the Institute will be largely self-supporting.

It is proposed that the Institute begin operations on 1 April 1969, with an annual budget of \$100,000. Objectives of the Institute will be directed towards the scientific advancement of the geosciences and increased effectiveness in mineral resource exploitation in Canada through the development of a national network of computer-processible geoscience data files (the National System), operation of a National Index to geoscience data, the development of standards for data, and coordination of computer applications.

2. Background

In common with many other areas of science, the geosciences are facing serious problems with the ever-increasing volumes of data being produced by industry, universities, and government agencies. At the same time there has been a dramatic growth in the number and capability of computers, electronic display devices, and data-transmission media; this advancing technology holds the key to effective solution of these problems and offers a new vista for advancement in the geosciences.

In response to this opportunity, an ad hoc committee was formed in April, 1965 by the National Advisory Committee on Research in the Geological Sciences and charged with the responsibility of taking the necessary steps to develop a national system for storage and retrieval of geological data. This committee, chaired by Dr. S.C. Robinson, Geological Survey of Canada, and eight subcommittees comprised forty-four scientists representing a cross-section of disciplines, geography and employers in Canada. Twenty-eight formal meetings were held during a two-year period and in September, 1967 their report "A National System for Storage and Retrieval of Geological Data in Canada"* was published.

This report confirmed that computer technology indeed offered geoscientists a new tool for advancing their science. It provides a practical means for processing and using large volumes of data, including analysis, synthesis and selective retrieval, for modelling of geological processes, and for numerous operations otherwise impossible. The implications for increased effectiveness of mineral resource development are profound.

Equally evident to the committee was the realization that a transition from traditional to computer-oriented methods could not be

* Brisbin, W.C., and Ediger, N.M., Editors, 1967, A national system for storage and retrieval of geological data in Canada: National Advisory Comm. Research Geol. Sciences (available from Geol. Survey of Canada), 175 p. 4 tables, 12 figs., appendices.

accomplished simply or readily. Such a transition would involve the re-thinking of many fundamental scientific questions, experimentation with data-collection techniques, development of storage and retrieval programs, and other aspects requiring evolutionary development. Thus, the establishment of a permanent coordinating organization was recommended by the committee.

The urgency for implementing a National System was revealed by a census indicating at least 135 Canadian computer-processible files in operation by January, 1968. The lost opportunities, redundancy and wastefulness that would result from uncoordinated development of these and future, more extensive files is not difficult to imagine. The proposed Canadian Geoscience Data Institute, which would implement the National System, is described below.

3. Institute Concept

Objectives

The proposed Institute will be a national organization dedicated to the dissemination of geoscience data and information in the most useful, efficient and economical manner possible. Use of the Institute services will be voluntary. Its means of disseminating information will be principally by encouraging, coordinating and assisting other organizations in developing computer-processible files of geoscience data, and by creating a National Index to geoscience data. It is proposed that, initially, the Institute be financed by both the provincial governments and the federal government, but it is expected that the Institute will eventually be largely self-supporting through sale of its services. Objectives of the Institute will be directed towards the scientific advancement of the geosciences and towards increased efficiency in mineral resources exploitation in Canada. In particular, its objectives will be:

1. To establish a network of computer-processible geoscience data files in Canada, that is, implementation of the National System for storage and retrieval of geoscience data.
2. To develop, maintain and operate a National Index to geoscience data.
3. To assist and promote the development of standards for recording, transmitting and displaying geoscience data.
4. To advise the geoscience community on the development and implications of technological advances in the field of information processing.
5. To provide a clearing house for information concerning activity in development of computer-processible geoscience data files.

Organization

Initially, the proposed Institute will consist of four main components (see Appendix 1):

1. Board of Directors.
2. Advisory Board.
3. Institute Director.
4. Chief Indexer.

The nine-man Board of Directors will include three provincial members, two federal members, two industry members, one National Advisory

Committee member, and the Institute Director. The Board will meet at least annually to approve a budget, review Institute activities, consider submissions from the Advisory Board, and approve programs and policy for the coming year.

The Advisory Board to the Institute will be the Subcommittee on Storage and Retrieval of Geological Data, a subcommittee of the National Advisory Committee on Research in the Geological Sciences. This Subcommittee, the successor to the ad hoc committee, will provide technical advice and expertise to the Institute on matters relating primarily to the subject matter of the geosciences. Because of its broad representation and its historical role in formation of the Institute, it will act as an effective cross-Canada forum for the geoscience community on matters concerning computer-processible data and provide essential communication between the Institute and individual scientists.

The Director will be a full-time staff member of the Institute responsible for implementing policy set by the Board of Directors and will have over-all charge of Institute operations. He will be appointed by the Board of Directors.

The Chief Indexer will be a full-time staff member responsible for developing, maintaining and operating the National Index to geoscience data. He will be involved with providing services to the public, training indexers for participating organizations, and coordinating incoming contributions to the Index.

Consultants will be retained by the Board of Directors as required, to provide advice and services to supplement the knowledge and competence of the Board of Directors, the Advisory Board, and Institute staff. It is expected that consulting services will be utilized mainly in the fields of systems analysis, computer programing and related topics.

4. Benefits

Through Institute activities, data on the mineral resources of Canada will be made available in greater volume, in readily accessible and usable forms, and at lower cost. The efficiency of mineral exploration programs in each province will be increased and resource development will be stimulated. With geoscience data stored in computer-processible form throughout a national network of files, exploration and development programs will be able to focus data, drawn from a wide variety of sources and disciplines, on individual prospects. This will be achieved without loss of identity and ownership of data, in much the same way that a railway network allows free continent-wide passage of box cars, yet their owners maintain custody and control.

The academic and scientific communities will benefit from development of the National System through access to a greatly increased number of basic observations or measurements. Geoscientists will be able to test their hypotheses and ideas against data from many other areas. The quality of data will improve substantially as a by-product of using computer technology.

The adoption of the concepts and requirements of the National System will result in the following benefits.

1. Increased exploitation of Canadian natural resources.
2. Better exchange of data between those working in the same and related disciplines and places.
3. Availability of large quantities of data which may be selectively retrieved for further processing.
4. Encouragement of quantitative and objective approaches to the acquisition and treatment of geoscience data.

5. Encouragement of use of statistical techniques and theory in the geosciences.
6. Coherent development of computer applications in Canadian geosciences.

Of particular significance to individual provinces, the Canadian Geoscience Data Institute will enable the resource information produced by each province to be usefully combined with information on that province produced by other sources. Further, exploration companies and others will be able to compare data collected from one province with data collected elsewhere in Canada. Both benefits will provide an impetus to resource exploration and developments in each province.

Although organizations in several provinces have already commenced building computer-processible files within the framework of the National System as outlined in the published report, the need for an Institute to foster and coordinate this activity is essential if the National System is to realize its potential value to the geosciences and the Canadian resource industries.

Canada is in a unique position to establish a Geoscience Data Institute. The general awareness of data problems by the National Advisory Committee, their action in establishing a special committee which identified problems and recommended solutions, and the momentum this activity has produced, have provided the necessary background and experience to begin applying computer technology to the development of Canada's mineral resources on a realistic and potentially profitable basis.

5. Budget

The budget for the first year's operation is as follows:

Expenditures

Office space	\$ 3,000	
Capital equipment (office)	5,000	
Stationery, postage, telephone and other operating costs	3,000	
Salaries and related costs	40,000	
Travel	12,000	
Computer time (National Index)	15,000	
Consulting services	14,000	
Contingency	8,000	\$100,000

Financed by

Provincial Governments (see below)	50,000	
Government of Canada	50,000	\$100,000

It is proposed that the financial support from provincial governments of \$50,000 be divided among the contributing provinces in a manner related to their current rate of mineral production as follows:

<u>Province</u>	<u>1967 Production*</u> (millions of \$)	<u>1967 Production*</u> (% of Canada)	<u>Proposed Institute Grant</u> \$
Ontario	1,192.8	27.1	13,500
Alberta	996.8	22.7	11,500
Quebec	736.0	16.7	8,500
Saskatchewan	370.0	8.4	4,000
British Columbia	360.8	8.2	4,000

<u>Province</u>	<u>1967 Production*</u> (millions of \$)	<u>1967 Production*</u> (% of Canada)	<u>Proposed</u> <u>Institute</u> <u>Grant</u> \$
Newfoundland	259.8	5.9	3,000
Manitoba	186.6	4.3	3,000
New Brunswick	89.9	2.1	1,000
Nova Scotia	79.4	1.8	1,000
Prince Edward Island	1.7	0.04	500
			Total \$50,000

* Preliminary, from Mineral Information Bulletin MR90 (1968).

Financial support for the Institute will also be sought from the mining and petroleum industries, inasmuch as they will be major beneficiaries of Institute activities. However, since the machinery for soliciting such support will take some time to prepare, it is recommended that an invitation to provide financial assistance be deferred for the present.

Looking beyond the first year's operation, the total budget can be expected to increase, particularly for the National Index. At the same time, however, revenues for services rendered will also increase and will offset rising expenditures. The long-term budgetary objective of the Institute will be to recover most of its direct expenditures through the sale of services, with the remaining fixed expenditures for overhead and research covered by government and industry grants.

6. Proposals

In view of the pre-eminent position of the provincial departments of mines and the government of Canada as producers and custodians of geoscience information and data in Canada, and the benefits to them of participating in a coordinated geoscience information program, it is proposed:

1. That each province and the government of Canada endorse in principle establishment of the proposed Canadian Geoscience Data Institute and affirm its intention of providing financial support.
2. That 1 April 1969 be set as the date for commencement of Institute operations.

REPORT OF THE SUBCOMMITTEE ON QUATERNARY GEOLOGY

Presented by A. Dreimanis

Members of the Subcommittee

A. Dreimanis (Chairman)	University of Western Ontario, London, Ont.
L.A. Bayrock	Research Council of Alberta, Edmonton, Alta.
E.A. Christiansen	Saskatchewan Research Council, Saskatoon, Sask.
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S.C. Zoltai	Forestry Branch, Department of Fisheries and Forestry, Winnipeg, Man.

The present report deals mainly with suggestions for future research activities and improvements in higher education on Quaternary geology. The report is based on the correspondence with members of the Subcommittee, discussions at a meeting of the Subcommittee on March 19, 1969, and on reviews of current research in Quaternary geology published in 1967 and 1968.

RESEARCH: 1967-68

In 1967-68 at least 280 research projects in Canada dealt with Quaternary deposits in Canada, according to Henderson (1968), National Research Council of Canada (1968), and Ontario Economic Council (1968). For brief

progress reports of most of these research projects see Associate Committee on Quaternary Research (1968) and Geological Survey of Canada (1968). Because of the broad scope of the Quaternary research and its interdisciplinary aspects, many of the Quaternary research projects overlap with other geologic disciplines and with other branches of sciences, and therefore the actual number probably exceeds 300. Considering the earth science studies on Quaternary topics alone (National Research Council of Canada, 1968), the proportion of geologists to geographers, who received N.R.C. research grants in support of them in 1967-68, was one to two. This ratio indicates that twice as many Canadian geographers are doing research in Quaternary geology and geomorphology as are geologists.

According to Henderson (1968) at least 66 papers were published on Quaternary geology, geomorphology, recent sedimentation, groundwater geology and engineering geology in 1967-68. Nearly one third of them appeared in the N.R.C. Canadian Journal of Earth Sciences. In volume 5 (1968) of this journal 13 per cent of all papers were on Quaternary topics; 3 per cent on groundwater, and at least 2 per cent contained Quaternary data as minor items. Most of the 22 papers published by the Canadian Geotechnical Journal, 1968, deal with engineering geology and soil mechanics of Quaternary deposits, particularly clays. Publications of note in the past year include:

Catastrophic advance of the Steele Glacier, Yukon, Canada, by L.A. Bayrock, Boreal Inst., U. of Alta., Occ. Publ. 3, 1967, 35 pp.

A catalogue of selected air photography, by H.S. Bostock, Geol. Surv. Can., Paper 57-48, 1968, 163 pp.

Deglaciation studies in Kamloops region, an area of moderate relief, British Columbia, by R.J. Fulton, Geol. Surv. Can., Bull. 154, 1967, 36 pp. and maps.

Le periglaciaire par l'image, by L.E. Hamelin et F.A. Cook, Les Presses de l'Université Laval, 1967, 237 pp.

Some aspects of environmental geology, by D.F. Hewitt, Ont. Dept. Mines, Industrial Mineral Report 26, 1968, 19 pp.

Pleistocene geology of the Guelph area, by P.F. Karrow, Ont. Dept. Mines, Geol. Report 61, 1968, 38 pp. and map.

Glacial map of Canada, by V.K. Prest, D.R. Grant, and V.N. Rampton, Geol. Surv. Can., Map 1253A, 1968.

Nomenclature of moraines and ice-flow features as applied to the glacial map of Canada, by V.K. Prest, Geol. Surv. Can., Paper 67-57, 1968, 32 pp.

A method of predicting soil erosion in the Rocky Mountain forest reserve, Alberta, By N.W. Rutter, Geol. Surv. Can., Paper 67-67, 1968, 32 pp.

Some problems of the Quaternary palynology in the western mainland region of the Canadian arctic, by J. Terasmae, Geol. Surv. Can., Paper 68-23, 1968, 26 pp.

Groundwater resources and hydrogeology of the Annapolis-Cornwallis valley, Nova Scotia, by P.C. Trescott, N.S. Dept. Mines Mem. 6, 1968, 159 pp. and maps.

Surficial geology of the Foremost-Cypress Hills area, Alberta, by J.A. Westgate
Res. Counc. Alta. Bull. 22, 1968, 122 pp. and maps.

Properties and behaviour of freezing soils, by P.J. Williams, Norweg. Geotechn.
Inst. Publ. Hr. 72, 1968, 119 pp.

SUGGESTIONS FOR INCREASED RESEARCH ACTIVITIES

Though most aspects of Quaternary geology require continuous research, some problems or areas are in special need of attention. Particular attention should be paid to the following fields, which are basic for the proper interpretation of Quaternary deposits and environments, and significant in applied geology.

1. Mapping. Factual knowledge of the areal and stratigraphic distribution and interrelationship of the Quaternary deposits on land and in water (on continental shelves and in lakes) is essential for further detailed research. Consequently programs for mapping the Quaternary geology and geomorphology should be established by provincial agencies where such programs do not exist, and expanded in the provinces where they are still minimal; federal support should be given where the provinces are unable to carry out this work alone. Test-drilling, including sampling, is essential in areas with insufficient exposures, as demonstrated by a recent paper of E.A. Christiansen in the Canadian Journal of Earth Sciences (1968: p. 1167-1174). Field studies should be supplemented by laboratory investigations. Stratigraphic profile sections, or at least stratigraphic columns should be added to published Quaternary maps.

The maps and sections should include information useful to Quaternary geologists, geomorphologists, environmental geologists, hydrogeologists, pedologists, foresters, biologists and everyone concerned with planning and development of natural resources. Many existing maps do not include such essential information and do not meet present-day standards.

The Geological Survey of Canada and various other federal and provincial government agencies have mapped vast areas of Canada during the last 15 years, but most of the surveys have been of a regional and reconnaissance type; detailed maps cover only a few scattered areas. Normally, soil mapping should follow Quaternary geological mapping, but, in fact, Quaternary geological mapping programs are at least a generation behind soil mapping programs, as is the case in Ontario.

It is difficult to make full use of applications of Quaternary geology if maps are not available. Quaternary geology maps are needed not only in the more densely populated areas but also in less settled areas for large-scale engineering projects (dams, highways, pipelines, cables). Underwater maps of surficial deposits are useful in laying submarine cables and pipelines, in erecting drilling platforms, and in providing information on the character of sea or lake bottoms for the fishing industry.

Vast regions in Canada require detailed Quaternary mapping but priority must be given to urban areas, to key areas of Quaternary stratigraphy and to areas with urgent problems in environmental geology and land-use planning.

2. Detailed investigation of Quaternary deposits. In addition to areal and stratigraphic mapping, detailed field and laboratory studies of glacial and related meltwater and wind deposits should be expanded to find out what factors determine their lithologies, textures, chemical compositions, permeabilities, densities, and various other physical properties. Similarly, landforms and their internal structures require systematic studies. The results of such investigations are of both theoretical and economic significance. Many of such studies are of particular potential economic importance in mineral exploration, engineering geology, environmental geology and water supply.

At present, most of the parameters and boundaries (particle size, etc.) used in studying Quaternary deposits, have been either chosen from studies of sorted sediments, or have been selected arbitrarily. When investigating non-sorted deposits (till) or poorly sorted sediments, the mode of transport and deposition of these materials should guide the selection of the parameters and the particle-size boundaries most characteristic for them, as demonstrated in a paper by the writer of this report at the INQUA Till Symposium, 1967 (in press, University of Poznan, Poland).

3. Present geologic processes. More studies of present geological processes (glacial, stream, wind, wave current, mass movements, etc.) should be made because a better understanding of present processes will aid interpretation of past processes. Particular attention should be paid to areas where deposits are now forming and can be compared with nearby deposits formed in the immediate past. From both the theoretical and practical viewpoints such as mineral exploration in glaciated terrains, studies of the following processes are of major importance: (1) mechanism of glacial movement; (2) incorporation of rock debris in ice and its transport; (3) orientation of particles during the transport and deposition; (4) physical and chemical changes of drift material during transport and deposition, and subsequent to deposition.

Northern Canada is particularly suitable for research on sedimentary and geomorphic processes related to permafrost and for gathering background data for better interpretation of Quaternary environments. Simulation of natural conditions by controlled experiments in the laboratory may assist in solving some problems, particularly those related to the geological action of water and wind.

4. Postglacial environmental changes. Increased attention should be paid to the postglacial record of deposits, landscapes, dynamic processes, and to biological and climatic changes to provide a record of the development of the environment leading up to the present.

5. Interdisciplinary research. Many research projects require an interdisciplinary approach, particularly studies of environmental changes. Hence interdisciplinary programs of research should be fostered in which scientists with Quaternary background from several disciplines work as a team. Numerous examples of such interdisciplinary programs could be listed; a few examples follow:

(1) Stratigraphic investigations of selected areas, both on land and in water, with participation of Quaternary geologists, sedimentologists, geophysicists, engineering geologists, hydrogeologists, pedologists, physical geographers, climatologists, botanists, zoologists, archeologists and specialists from other fields. Some such projects require cooperation of only a few of these specialists, for example investigations of paleontological aspects of stratigraphy and environmental studies, dealing particularly with vertebrates, molluscs, insects, diatoms, pollen and other microfossils, require the participation of geologists, paleontologists, zoologists and botanists. Current investigations of the Bow River gravels, Alberta, may be mentioned as an example (see Canadian Journal of Earth Sciences, 1968, v. 5, p. 1455-1488).

(2) Refinement of absolute dating techniques and development of new ones capable of dating the entire Quaternary succession may need a wide range of participants because of the variety of the techniques that may be applied, and the variety of materials and environments.

(3) Past environments, including the role of man as a geologic agent (see paper by R.F. Legget presented at Inter. Geol. Congress, Prague, 1968).

(4) Global plate tectonics: the central theme of a symposium on Recent crustal movements, March 17-18, 1969.

EMPLOYMENT: 1969

Although the information is incomplete, it appears that this year at least 13 permanent positions have been or will be available for graduates with advanced degrees (M.Sc. or Ph.D.) in Quaternary geology, geomorphology and hydrogeology. Summer employment for more than 95 students was available of which 17 jobs were for graduates and 78 for undergraduate students. Probably not more than 108 graduates and students with advanced or elementary training in Quaternary geology, geomorphology and hydrogeology are available in Canada; the problem of higher education in these fields is considered acute.

HIGHER EDUCATION

Research in Quaternary geology depends on the number with higher education in this particular field and the attitude of geologists other than Quaternary toward Quaternary geology. This problem has been discussed by L.A. Bayrock (1969) but is so vital for further progress in Quaternary research, that it deserves further discussion.

1. Undergraduate geology studies: Twenty years ago only two geology departments in Canadian universities offered courses in glacial and Pleistocene geology. Today about half the departments offer courses in Quaternary geology (either Pleistocene or recent aspects of it) but only about half of these departments require all geology students to take the course; the others offer the Quaternary course as an option. Because of the increasing general interest in Quaternary geology outside geology departments many non-geologists attend these courses, in some universities in greater numbers than geologists. Of the 50 per cent of geology departments not offering courses in Quaternary geology about 20 per cent teach the elements of Quaternary geology in geomorphology courses.

Undergraduate instruction in Quaternary geology depends to a large degree on the attitude of non-Quaternary geologists in geology departments and whether or not they consider Quaternary geology an essential course in the undergraduate curriculum. All of Canada is either covered by Quaternary sediments or has been affected by Quaternary erosional processes. Quaternary geology is particularly suitable for the study of geological processes going on today. It is particularly valuable in teaching dynamic geology, geomorphology, stratigraphy, and in training students in research, especially when field observations of local Quaternary deposits are combined with quantitative laboratory analyses and interpretation of aerial photos and maps.

Among Canadian geologists, despite the important contributions of some, Quaternary geology and geomorphology have always played secondary roles as compared to bedrock geology. The result has been that most Canadian geology students have had no Quaternary geology courses, and have graduated with little knowledge in this field. Yet most work in a Quaternary environment, but with little understanding of it.

In many Quaternary or geomorphology courses insufficient time is allocated to field and laboratory training and research assignments, although such training is essential for an understanding of the complex actual natural conditions, and is of particular importance in making stratigraphic interpretations.

2. Undergraduate courses for non-geologists: The rapidly increasing interest in Quaternary deposits among those outside the field of geology requires that

at least the elements of Quaternary geology be taught to a greater extent than is done at present to students in other fields such as the biologic sciences, agriculture and engineering.

3. Graduate studies: Graduate studies in Quaternary geology are possible in about half the geology departments of Canadian universities; at least two others intend to offer graduate studies in the near future. One of them (Brock University) plans to specialize in Quaternary research.

The interdisciplinary approach at the graduate level is hampered at some universities by lack of essential courses. One of the greatest needs is to establish means whereby a graduate student specializing in the Quaternary in a particular department may have instruction in appropriate facets of other disciplines in other departments. Establishment of at least one Quaternary research institute in Canada similar to that at the University of Washington (Seattle) is desirable.

J.C. Ritchie proposed more than a year ago that, as a temporary expedient, graduate students be permitted to move from one university to another in order to take the courses they need. However, there are many difficulties in the implementation of such a plan.

Interdisciplinary Quaternary discussion groups attracting, in addition to Quaternary specialists, non-geology students and graduates, are very desirable. Such groups have been active recently at two centres in Ontario and one in Alberta.

The number of graduates at Canadian universities particularly with Ph.D. degrees, is small. Several subcommittee members have noted an acute shortage of graduates in Quaternary geology and the related fields of geomorphology, engineering geology and hydrogeology.

4. Instruction in Quaternary Geology outside of Geology Departments: In the past because of lack of understanding of Quaternary geology among many Canadian geologists and the attitude that Quaternary research does not require special training, a vacuum has existed in instruction and research in this subject in Canadian geology departments. As a consequence several geography departments, realizing the importance of the subject, have undertaken instruction in, and investigation of, the geological aspects of the Quaternary. Likewise several European universities and research institutions, particularly in non-glaciated or partly glaciated areas, such as France, England, Belgium, southern Germany and Austria, with the tradition of emphasizing the morphologic aspects of Quaternary studies, have tended to include Quaternary geology in geography departments and institutes. With modern developments in the earth sciences, greater specialization and emphasis on stratigraphy, laboratory investigations and the quantitative evaluation of field and laboratory data, Quaternary geology is gradually returning to its proper place - the geology departments. The interest of geographers and other non-geologists in Quaternary geology is appreciated, but Quaternary geology is an integral part of geology, and as such should be in the geology departments of our universities. Interdisciplinary aspects may be fostered by provision of additional courses in other departments or by joint staff appointments.

CONFERENCES: 1969

In 1969 a number of conferences dealing with various interdisciplinary aspects of Quaternary Research were held or are planned. The following are of particular interest to Canadian Quaternary geologists:

January 14-15

3rd Canadian conference on permafrost,
Calgary, Alta.

February 22	Geobotany conference of southern Ontario and adjacent areas, Toronto, Ont.
March 6-7	Seminar on geological engineering aspects of landslides, Edmonton, Alta.
March 15	Pleistocene and urban geology sessions at the Geol. Soc. America, Northeastern Section annual meeting, Albany, N.Y.
March 17-18	Symposium on recent crustal movements, Ottawa, Ont.
April 12	Symposium on geomorphology, Guelph, Ont.
May 2-4	41st Annual Meeting of the New York State Geological Association, Plattsburg, N.Y.
May 5-7	12th Conference on Great Lakes Research Ann Arbor, Mich.
May 10-11	Midwest Friends of Pleistocene Field Conference, Cypress Hills, Sask.
May 13-14	Symposium on pedology and Quaternary research, Edmonton, Alta.
May 15-16	Symposium on tills, Columbus, Ohio.
May 23-25	Eastern Friends of Pleistocene 32nd Field Conference, Sherbrooke, Que.
June 6	Quaternary session, Geol. Assoc. Canada, Annual Meeting, Montreal, Que.
August 18-22	Annual meeting of the Canadian Assoc. of Geographers, St. Johns, Nfld.
August 30-September 6	VIII International Quaternary Congress, Paris, France.
December 8-9	22nd Annual Canadian Soil Mechanics Conference with the theme, geology and engineering, and a symposium on urban geology, Kingston, Ont.

RECOMMENDATIONS

(1) Because factual knowledge of the areal and stratigraphic distribution of Quaternary deposits on land and in waters of Canada is essential for further detailed research and development, systematic mapping programs of Quaternary geology and geomorphology should be carried out to include all Canada. These programs should be guided by coordinated planning by federal and the provincial agencies. The mapping should include stratigraphic investigations and test drilling to a greater extent than in the past.

(2) Because most of Canada is covered by Quaternary deposits, and because a proper knowledge and understanding of Quaternary geology is essential

in various related fields such as environmental geology, engineering and urban geology, hydrogeology, at all levels of planning, in the search for economic minerals and for development of various natural resources, more attention should be paid to instruction in Quaternary geology and geomorphology in the geology departments of Canadian universities.

(3) The Subcommittee on Quaternary Geology notes with concern that present federal recruiting programs for summer students and career introduction have caused confusion and have been detrimental to students, employers and this scientific field as a whole. Hiring procedures should be reviewed and modified so that more consideration is given to the interests of students and employers.

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REPORT OF THE SUBCOMMITTEE ON
MINERALOGY, GEOCHEMISTRY AND PETROLOGY

Presented by E.W. Nuffield

Members of the Subcommittee

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L.A. Clark	McGill University, Montreal, Que.
A.D. Edgar	University of Western Ontario, London, Ont.
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G.G. Perrault	Ecole Polytechnique, Montreal, Que.
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The following table is based on Current Research in the Geological Sciences in Canada, 1966-67, 1967-68 and 1968-69 (Geol. Surv. Can., Papers 67-58, 68-54 and 69-5).

Category	Number of Research Projects		
	1966 - 67	1967 - 68	1968 - 69
Mineralogy			
Specific minerals	29	28	45
General problems	27	34	26
Geochemistry			
Experimental phase equilibria	*	42	41
Other	108	92	67
Petrology and Petrography	110	101	107
Geochronology	20	26	53
TOTALS	294	323	339

*Not reported separately; probably included with geochemistry and petrology.

The Table shows no significant changes between 1966 and 1969; in fact the number of projects in the different categories are remarkably consistent.

The commission by the Science Secretariat of a special study of the solid-earth sciences in the spring of 1968 has had an important effect on Canada's geology departments in the past year; it has been a year of introspection. The members of the Subcommittee have an intense interest in the work of the Study Group and in the possible implications of its forthcoming review and recommendations. This has greatly influenced Subcommittee discussion, correspondence, and the preparation of this report. Our discussions have not centred particularly on the subdisciplines, mineralogy, petrology and geochemistry. Our brief to the Study Group deals with matters that affect the whole of the science of geology because we are mindful that briefs on these particular subdisciplines are still in preparation by other individuals and will be available in 1970. They will likely form the basis of much useful future discussion.

The policy of awarding Geological Survey of Canada research grants continues to provoke the interest of members. The Subcommittee suggests that funds be made available for a new type of grant which is intended to counteract a typically Canadian impediment to the development of academic centres of excellence.

POLICY OF GRANTING AID IN SUPPORT OF RESEARCH

The National Advisory Committee has recently asked the Subcommittees "to consider what special fields should be selected for concentration of research, which after study and endorsement by the National Advisory Committee would be named as fields of priority in inviting applications for grants".* The correspondence that the Chairman has had with members of the Subcommittee yielded a wide variety of topics but for various reasons, the members are not prepared to settle on any one, or even a few topics for recommendation to the Advisory Committee. The Subcommittee's recommendations are not on areas or subjects of research that should have priority but rather on the mechanism of granting research funds.

The recommendation that follows grew out of a discussion of a typically Canadian problem faced particularly by younger university geologists. The great distances in this thinly populated country effectively isolate Canadian university geologists, except perhaps along the Toronto-Montreal axis. The contacts that young scientists make as postgraduate students and later as postdoctoral fellows rapidly fade as they join geology departments scattered across Canada. The easy interchange of ideas ceases and the scientific growth of the individual is slowed. Conventions and large general meetings have only a limited impact on the problem. Professional-type, single-subject, attendance-by-invitation symposia and work shops are better, but lack an important ingredient. This Subcommittee believes that a more effective method of maintaining contacts between scientists and of promoting the interchange of ideas, would be to make it possible for them to come together to work jointly on research projects. To accomplish this, the Subcommittee proposes new grants, having more than one principal investigator, for joint work and study at specific locations (which may be in the field, or in the laboratory, or both) on specified problems for periods of the order of one to three months. Two types of joint grants are visualized:

(1) grants of not more than \$10,000 per grant year and designed to allow two or three individuals to join in a common effort. Individuals would apply separately for funds for travel, board and lodging, equipment, etc.

* National Advisory Committee on Research in the Geological Sciences, Eighteenth Annual Report, 1967-68; Geol. Surv. Can., Paper 68-73, p. 3, 1969.

(2) grants of between \$10,000 and \$50,000 per grant year and designated perhaps as National Objective Grants because their basic function would be the improvement of the national level of academic excellence. The organizer would apply for the entire grant. He would outline the principal area of research and its objective, submit a proposed list of participants and accept the responsibility of drawing up an informal pre-print publication immediately following the conclusion of the work. He would apply for travel, board and lodging, and for the payment of service costs such as analytical facilities, computer time, etc. if applicable. Once the grant was made, he would issue formal invitations and arrange accommodation, equipment and all other details.

The Subcommittee considers that individual grants should be continued, but with stricter screening.

DECENTRALIZATION OF GOVERNMENTAL RESEARCH ORGANIZATIONS

The Subcommittee recognizes that not only are the distances between academic centres greater in Canada than in the United States, but the sizes of the centres are generally smaller. As a consequence, in most geology departments there is only one structural geologist, one mineralogist or one paleontologist, etc. The proposed National Objective Grants would bring these individual specialists into periodic working contact. Some members of the Subcommittee feel that the federal government can help combat the problem of "oneness" by a studied policy of establishing research laboratories in the vicinity of universities throughout the country, when no special advantage accrues to its location in Ottawa. They feel that many governmental research groups could just as conveniently and efficiently be located on the campus of a university, drawing their stimulus from the science departments of that university rather than from sister organizations in Ottawa. It is not suggested that existing research establishments, with all their extensive physical plant and equipment, be broken up and moved elsewhere. Rather that the government should consider locating newly established research groups and institutions in provincial centres outside Ottawa, particularly in the west and in the Atlantic Provinces. Such a move would help create several centres of excellence in various specialized fields of the earth sciences across Canada.

One possible way of accomplishing this in an equitable manner would be to make the universities, as beneficiaries of decentralization, responsible for initiating the move. Interested universities could thus be asked to make a case for locating government research institutions in their vicinity.

THE IMPORTANCE OF GEOLOGICAL SCIENCES IN CANADA

Although a public awareness of geology in Canada is on the increase, the members believe that the geological sciences are not yet receiving the emphasis and support they deserve. This is reflected in the amount of direct financial support of research in the geological sciences compared to that received by other basic sciences. In the past two years the total N.R.C. grants for operating expenses and major equipment were:

Summary of N.R.C. Operation Grants

	1968-69	1969-70
Biology (total)	\$ 7,135,000	\$ 7,497,000
Chemistry	5,397,000	5,903,000
Physics	2,749,000	3,052,000
Earth sciences	2,612,000	2,889,000

The members do not underestimate the importance of the other sciences; they believe, however, that Canadian physical environment favours geology as one of the areas in which Canadian science can best achieve a position of excellence. It is clear, for example, that physics and chemistry depend very little on geographical location and physical environment; there are few, if any, compelling natural advantages that would favour Canadian research in these two basic sciences over research done in other, more affluent countries. On the other hand, the geographical location and the vast area of Canada with its attendant variety and scope of geological problems, together with the great importance of the mining industry in the Canadian economy, offer an opportunity and an incentive to develop an area of scientific excellence in the earth sciences that can hardly be duplicated elsewhere.

This has not been generally recognized. The relatively lesser place given to geology in the hierarchy of Canadian science is evident not only from the figures quoted above, but also from even a casual examination and comparison of the facilities available to the various sciences on Canadian university campuses. In almost every case, physics and chemistry have larger and better equipped buildings, more technical staff and, in many cases, greater prestige in the eyes of university administrations (who often base their judgements on the amount of financial support received from outside sources) and of the public - including future scientists now in the nation's high schools - who must necessarily judge by external appearances.

To correct this underserved and undesirable imbalance, the members think that the order of priorities in the governmental support of scientific research, as reflected especially in financial grants, should be adjusted in order to put the earth sciences at least on par with other sciences, such as physics and chemistry. Given this amount of financial encouragement, both the quantity and the quality of scientific research in geological sciences should increase to the point where it would gain for Canada not only the material benefits that would necessarily follow the growth of research in an area vital for an important segment of Canadian primary industry, but also a position of pre-eminence and prestige in the eyes of the international scientific community.

SYMPOSIUM ON EXPERIMENTAL SILICATE AND SULPHIDE PETROLOGY

Last year (1967-68) we reported a successful symposium on Experimental Methods in Petrology and Ore Deposits at the University of Western Ontario. A second symposium, on Experimental Silicate and Sulphide Petrology, was held at the University of Toronto on February 18-19, 1969. Twelve papers were read, representing seven universities in Ontario and one from Quebec, and the Mines Branch, Ottawa, to an audience of 80 to 90 composed mainly of university and governmental staff, and graduate students.

REPORT OF THE SUBCOMMITTEE ON MINERAL DEPOSITS

Presented by A.E. Buller

Members of the Subcommittee

A.E. Buller, Chairman	Consulting Geologist, Toronto, Ont.
J.M. Carr	British Columbia Department of Mines, Victoria, B.C.
R.W. Hutchinson	University of Western Ontario, London, Ont.
R. Jure	Denison Mines Ltd., Toronto, Ont.
L.C. Kilburn	Falconbridge Nickel Mines Ltd., Toronto, Ont.
R.J.M. Miller	Noranda Mines Ltd., Toronto, Ont.
A.J. Naldrett	University of Toronto, Toronto, Ont.
W.G. Wahl	Consulting Geologist, Toronto, Ont.

A review of our report of last year and of the Survey of Current Research in the Geological Sciences in Canada in the field of mineral deposits (Geol. Surv. Can. Paper 69-5) indicates that research is following much the same pattern as that of recent years. This Subcommittee's philosophy remains essentially unchanged in its view that there is not enough emphasis on research in the field of mineral deposits.

The following comments and recommendations amplify and to some extent modify those contained in last year's report.

RESEARCH PROJECTS AND GRANTS

The Subcommittee considers that Geological Survey grants for research to universities should primarily support projects not already supported by the National Research Council; they should be complementary to N.R.C. grants rather than supplementary. Although it is desirable to support fewer but larger integrated and "project-oriented" projects rather than many small ones, the Subcommittee considers this should not be a firm or all-embracing policy. Not all research investigations can be or should be organized into broad integrated projects; there is need for individual excellence in research and such excellence needs support.

The Subcommittee feels strongly that the National Advisory Committee should concern itself not with supporting field studies as against laboratory research or vice versa, but with encouragement of projects including integration of field and laboratory studies; that is, with projects concerned with mineral deposits in their complete geological context. Mapping projects should receive equal consideration with other types of study. Although the Subcommittee recognizes and endorses the value of laboratory work in mineral

deposits geology, it believes preference should be given to those laboratory projects having a field orientation and practical application or significance. In listing projects in order of priority for grant support, the Subcommittee would follow such a preference and so recommends.

The Subcommittee emphasizes its support for the several important field programs currently under way which are of fundamental nature; it would encourage projects of this type. It does, however, stress the importance of systematic periodic reporting for all such projects to ensure that results are outlined and future plans reviewed. The importance of completing and publishing results of such projects is underscored.

Despite the above endorsement of major field projects, the Subcommittee emphasizes that such programs should not replace the over all mapping coverage on both reconnaissance and semi-detailed scales that has long been the "mainstay" of governmental activity. Government mapping, as always, must include factual lithological, structural and other geological data. However, the particular needs of industry in mapping based on current theories of ore genesis are not always adequately taken into account in government mapping activities. There is need for greater liaison between industry and governments in this regard so that the more significant and meaningful maps can be produced.

The Subcommittee again endorses joint university-government projects such as Project Pioneer and the suggestions for similar projects made in last year's report by J.M. Carr.* It also urges continuation of glacial studies applied to development of methods of mineral exploration, such as those initiated by H.A. Lee.**

The Subcommittee reiterates its 1968 comments with regard to the desirability of developing specialists in government geological surveys who are particularly concerned with all aspects of the geology of certain mineral deposit types. However, this approach, if carried to an extreme, may be in conflict with the need for the study of mineral deposits in the broadest geologic context. The Subcommittee suggests that the mineral deposit section of the Geological Survey of Canada should also include studies dealing with mineral deposits in this broader context and in relationship to one another in sequence of time, stratigraphy and tectonics.

The Subcommittee again emphasizes its support for research projects concerned with computer applications in the mineral deposit field; support for current programs and policies in this area should be continued.

The Subcommittee urges that research funds be made available for research and development on new geochemical, geophysical and remote sensing devices and techniques. This appears essential to maintain Canada's current primary world position in this field, and requires government support in view of the high cost of such work. Small, private contracting companies with limited sales potential are unable to finance such research and development individually, and need government support and tax incentives.

THE ROLE OF THE SUBCOMMITTEE

The Subcommittee recommends that it should screen the applications for Geological Survey of Canada research grants in the mineral deposits field annually, and prepare a list of priorities which would be used by the National Advisory Committee in their review of the applications as a basis for their recommendations as to the award of the grants. Such a priority list could be prepared by individual Subcommittee members from copies of the grant applications received and forwarded to them by the Subcommittee chairman. The

* National Advisory Committee on Research in the Geological Sciences, Eighteenth Annual Report, Geol. Surv. Can. Paper 68-73, p. 15, 1969.

** Lee, Hulbert A., and Lawrence, D.E.: A New Occurrence of Kimberlite in Gauthier Township, Ontario; Geol. Surv. Can. Paper 68-22, 1968.

The individual lists would then be submitted to the Subcommittee chairman for his final "averaged" listing. It is the opinion of the Subcommittee that it should have more responsibility and that to have the Subcommittee screen the applications for grants would be one way of accomplishing this.

With respect to the makeup of the Subcommittee, it is suggested that membership should be broadened to 9 persons including the chairman, three of whom should be drawn from Western Canada, three from Ontario-Quebec and three from the Maritime Provinces. Of these nine, three should represent industry, three governments - either federal or provincial - and three universities.

COOPERATION BETWEEN INDUSTRY, GOVERNMENT AND THE UNIVERSITIES

As a comment in this general area which, although not directly related to research, does influence the overall pattern and direction of research in mineral deposits, the Subcommittee considers that cooperation and communication between industry, the universities and government agencies, all of whom are engaged in mineral deposits work, is inadequate. Improvement here would be tremendously beneficial in many respects, not the least of which is in the training of personnel for industry. It is essential that the needs and problems of industry, universities and government be mutually understood each by the other, and that means of increasing and continually fostering this understanding should be actively sought.

Among numerous specific suggestions in this regard are the following:

- (a) Establishment of a "Standing Liaison Committee" on which all three groups would be represented to coordinate the efforts of the three groups and to promote cooperation and improve understanding.
- (b) Provision by industry of visiting lecturers to the universities.
- (c) Short retraining programs at the universities appear desirable with participation by government and industry personnel; such programs would aid in bringing the three groups into active contact. Provincial governments might hire more students for summer field programs and perhaps also new graduates on one- to two-year contracts to provide them with sound geological field experience.

REPORT OF THE SUBCOMMITTEE ON
GEOPHYSICAL METHODS APPLIED TO GEOLOGICAL PROBLEMS

Presented by R.D. Russell

Members of the Subcommittee

R.D. Russell (Chairman)	University of British Columbia, Vancouver, B.C.
A.E. Beck	University of Western Ontario, London, Ont.
B. Caner	Dominion Astrophysical Observatory, Vancouver, B.C.
H.J. Greenwood	University of British Columbia, Vancouver, B.C.
E.R. Kanasewich	University of Alberta, Edmonton, Alta.
D.I. Ross	Bedford Institute, Dartmouth, N.S.
H.D.B. Wilson	University of Manitoba, Winnipeg, Man.
J.T. Wilson	University of Toronto, Toronto, Ont.

Following the retirement of Dr. J.E. Blanchard as chairman of this Subcommittee in 1968 it was reformed with an entirely new membership.

This Subcommittee considers its principal contribution is to stimulate communication between geologists and geophysicists. With this end in view, an informal meeting was held on February 19, 1969 in the Geological Survey of Canada building, Ottawa. The subject matter for this workshop was the nature of the Mohorovicic discontinuity. Seven invited summary reports were presented, and these were followed by an informal discussion. The topics of the summary reports are listed below:

1. A new understanding of continent-ocean relationships, presented by J. Tuzo Wilson, Erindale College, University of Toronto.
2. Crustal structure in the Western Archean shield, presented by H.D.B. Wilson, University of Manitoba.
3. New data on the structure of the Mid Atlantic Ridge, presented by Charlotte Keene, Dalhousie University.
4. Velocity structure above and below the Moho, presented by E.R. Kanasewich, University of Alberta.
5. Some phase equilibrium aspects of the Moho, presented by H.J. Greenwood, University of British Columbia.
6. Electrical conductivity structure of the lower crust and upper mantle, presented by B. Caner, Dominion Astrophysical Observatory, Vancouver.

7. Heat-flow measurements and heat-flow anomalies, presented by A.E. Beck, University of Western Ontario.

This meeting was highly successful. The fact that several of those presenting papers (all distinguished in their own areas of research) met others for the first time at this meeting is a good indication that the meeting fulfilled its objective. Although not organized as a formal symposium, the meeting attracted an audience ranging from 50 to 100.

At the 1968 annual meeting of the National Advisory Committee this Subcommittee was asked to prepare a status report on remote sensing for presentation at the 1969 annual meeting. Shortly after this request was made, a comprehensive report on remote sensing became available. Those interested are referred to: Remote Sensing (Short Course Lecture Notes), American Geological Institute, 1444 N Street NW, Washington, D.C. 20005, 1968 (approx. 150 pages).

The Canadian Geophysical Bulletin,* published annually by the National Research Council of Canada, contains summaries of Canadian activities in geophysics together with bibliographies of published papers for the year under review.

* Canadian Geophysical Bulletin, Vol. 21, December, 1968. National Research Council of Canada, Ottawa.

APPENDIXGEOLOGICAL SURVEY OF CANADA RESEARCH
GRANTS TO CANADIAN UNIVERSITIES

1969-70

General Grants

<u>Name, Department & University</u>	<u>Project Title & Amount</u>
Anderson, G.M. Geology Toronto	Geochemistry of the York River nepheline pegmatites and gneisses. (\$1,720)
Assad, J.R. G�nie g�ologique Ecole Polytechnique	M�tallog�nie des gites m�talliferous. (\$1,720)
Azzaria, L.M. G�ologie Laval	Geochemistry of mercury in mineral exploration. (\$1,720)
Barnes, C.R. Earth Sciences Waterloo	Ordovician conodonts from the Arctic. (\$1,720)
Bartlett, G.A. Geol. Sciences Queen's Univ.	Quaternary deposits in and adjoining the Gulf of St. Lawrence and Atlantic Continental margin: biostratigraphy, paleoecology, paleoclimatology, and paleo-oceanography based on microfaunas. (\$1,720)
Bayliss, P. Geology Calgary	Clay mineralogy and boron deduced paleosalinity of shales in the Mackenzie and Arctic Island. (\$1,720)
Berard, J. G�nie g�ologique Ecole Polytechnique	L'alt�rabilit� des roches en fonction de la porositi� et de la surface sp�cifique. (\$1,720)
Berry, L.G. Geol. Sciences Queen's	Crystal structure studies of minerals. (\$1,720)
Beswick, A.E. Geology Laurentian	Alkali metal distributions in granite melts and vapours. (\$1,720)
Brisbin, W.C. Geology Manitoba	A study of deformational history and deformational environments within the granitic crust of the Precambrian Shield of northwestern Ontario and eastern Manitoba. (\$1,000)

Name, Department & University	Project Title & Amount
Brown, R.L. Geology Carleton	Structural studies in northern Appalachians. (\$1,720)
Brueckner, W.D. Geology Memorial	(a) Southern Avalon geology, and/or (b) Geomorphic problems in Newfoundland. (\$1,720)
Burley, B.J. Geology McMaster	Study of petrology's residual system at 6 Kb H ₂ O pressure. (\$1,720)
Burwash, R.A. Geology Alberta	Radioactivity of Precambrian basement rocks. (\$1,300)
Caldwell, W.G.E. Geol. Sciences Saskatchewan	The Upper Cretaceous Judith River Formation in the Canadian Great Plains. (\$3,000)
Campbell, F.A. Dept. of Geology Calgary	Study of the Ice River Complex. (\$1,580)
Carmichael, D.M. Geol. Sciences McGill	Structure, metamorphism, and geochronology along a cross-section of the Grenville Province, south- east of Chibougamau. (\$1,720)
Carroll, R.L. Redpath Museum McGill	Collecting of Mississippian terrestrial vertebrates. (\$4,500)
Carson, M.A. Geography McGill	The long-term stability of natural slopes. (\$1,720)
Chao, G.Y. Geology Carleton	Determination of the crystal structure of carleton- ite and weloganite. (\$1,720)
Clark, A.H. Geol. Sciences Queen's	Comparative study of the mineralogy, geochemistry and environment of formation of strata-bound lead- zinc-silver and pyritic copper deposits, southern Iberia. (\$2,500)
Clark, G.S. Geology Manitoba	Rb-Sr isotopic age studies in southeastern Manitoba and northwestern Ontario. (\$1,500)
Clark, L.A. Geol. Sciences McGill	Geochemical subdivision, stratigraphic correlation, and genesis of rhyolitic volcanic rocks, north- western Quebec. (\$1,720)

Name, Department & University	Project Title & Amount
Clarke, W.B. Physics McMaster	Development of new dating methods. (\$1,720)
Clifford, P.M. Geology McMaster	Deformation studies in Archean terrains. (\$1,720)
Cole, T.J.S. Physics Carleton	Application of Rb-Sr dating to geotectonic problems. (\$1,720)
Crocket, J.H. Geology McMaster	A search for iridosmine in the Elliot Lake uraniferous conglomerates. (\$1,720)
Cronan, D.S. Geology Ottawa	The geochemistry and mineralogy of lacustrine ferromanganese deposits and associated sediments from Ontario. (\$1,720)
Darling, R.G. G�nie g�ologique Ecole Polytechnique	Rock exploration geochemistry around the Louvicourt massive sulfide deposit. (\$1,720)
Dixon, O.A. Geology Ottawa	Ordovician-Silurian carbonates of Somerset and Prince of Wales islands, District of Franklin. (\$1,720)
Doig, R. Geol. Sciences McGill	Petrologic and isotopic studies of alkaline rocks and rocks of the Grenville Province. (\$1,720)
Edgar, A.D. Geology, Western Ontario	Geochemistry of the Montgarry, Manitoba lithium-bearing pegmatites and other zoned pegmatites. (\$1,720)
Farquhar, R.M. Physics, Toronto	Age determinations and isotope studies of Precambrian terrains in the Canadian Shield. (\$1,720)
Farrar, E. Geol. Sciences Queen's	K-Ar and fossil fission track geochronology. (\$1,720)
Fawcett, J.J. Geology Toronto	Stability of the muscovite chlorite-quartz assemblages. (\$1,720)
Ferguson, R.B. Geology Manitoba	Detailed mineralogy of the Tanco (Chemalloy) Mine in the Li-Cs-Ta pegmatite at Bernic Lake, Manitoba. (\$1,720)

Name, Department & University	Project Title & Amount
Fox, R.C. Geol. & Zoology Alberta	(a) Early Tertiary microvertebrates from southern Alberta (b) Geographic and vertical distribution of dinosaurian taxa, Oldman Formation, Late Cretaceous, Alberta. (\$1,720)
Fyson, W.K. Geology Univ. of Ottawa	Relation of minor to major structures in the Maritime Provinces. Structural analysis of Lower Paleozoic rocks, Mt. Albert area, Gaspé Peninsula. (\$1,720)
Gees, R.A. Geology Dalhousie	Marine geology of the eastern seaboard of Canada and other selected areas. (\$1,720)
Govett, G.J.S. Geology New Brunswick	(1) Geochemical orientation, St. Stephen nickel occurrence. (2) Computer analysis of applied geochemical data in New Brunswick. (\$1,720)
Greenwood, B. Geography Toronto	Intertidal sedimentation. (\$2,500)
Greiner, H.R. Geology New Brunswick	Fossil fishes of the Maritime provinces, with special emphasis on the palaeoniscidae. (\$580)
Grundy, H.D. Geology McMaster	Crystallography of the framework silicates. (\$1,720)
Hall, D.H. Geology Manitoba	Origin of deep-seated magnetism in the Archean crust of eastern Manitoba. (\$1,720)
Hills, L.V. Geology Calgary	Beaufort wood. (\$1,200)
Hogarth, D.D. Geology Ottawa	Lapis lazuli near Lake Harbour District N.W.T. (\$1,720)
Hooper, K. Geology Carleton	A problem arising out of studies in eastern Canadian microfaunas and sediments. (\$1,000)
James, R.S. Geology Toronto	Synthesis and stability of iron bearing chlorites at water-vapour pressures to 10 kilobars. (\$2,760)

Name, Department & University	Project Title & Amount
Keen, M.J. Geology Dalhousie	Geological and geophysical studies in Baffin Bay. (\$1,720)
Kennedy, M.J. Geology Memorial	Structural relationships within the Appalachians of northwestern Newfoundland. (\$1,720)
Knop, O. Chemistry Dalhousie	Structural studies of minerals. (\$1,720)
Kretz, R. Geology Ottawa	Petrology of crystalline rocks near Yellowknife, N.W.T. (\$1,720)
Lajoie, J. Géologie Montreal	Publication of G.A.C. Special Paper No. 7 "Flysch sedimentology in North America". (\$5,500)
Lajtai, E.Z. Geology New Brunswick	Dispersion of indicators by glacial transportation. (\$1,720)
Leblanc, G. Géologie Laval	Etude préliminaire de la micro-séismicité dans la région de Quebec. (\$1,720)
Ledoux, R.L. Géologie Laval	Etude de la décomposition de la muscovite, de la phlogopite et de la biotite. (\$1,500)
Lenz, A.C. Geology Western Ontario	Late Silurian and Early Devonian paleontology, biostratigraphy and paleogeography of north- western Canada. (\$2,600)
Liberty, B.A. Geol. Sciences Brock	Paleozoic mapping in southern Ontario. (\$2,000)
Mathews, W.H. Geology British Columbia	Urban geology, City of Vancouver. (\$1,300)
McAllister, A.L. Geology New Brunswick	A study of strataform ore deposits of northern Appalachia. (\$1,720)
McGugan, A. Geology Calgary	Permian stratigraphy and paleontology. (\$1,720)
McNutt Geology McMaster	A study of the rare earth elements in rocks and minerals. (\$1,720)

Name, Department & University	Project Title & Amount
McTaggart, K.C. Geology British Columbia	Glauconite schists at Pinchi Lake, B.C. (\$985)
Medioli, F. Geology Dalhousie	Foraminifera ecology on the Scotian Shelf and other selected areas. (\$1,720)
Mirynech, E. Geol. Sciences Brock	Mineralogical and sedimentological analysis of the surficial deposits of the Belleville-Picton-Kingston-Tweed area, Ontario. (\$1,720)
Morris, D.W. Geology New Brunswick	Nearshore sediment transport, Bay of Fundy. (\$2,500)
Morton, R.D. Geology Alberta	Studies on the nature and origin of certain ore deposits from the Yukon, N.W.T., Saskatchewan and Norway. (\$1,720)
Mountjoy, E.W. Geol. Sciences McGill	Petrography and stratigraphy of Upper Devonian carbonate complexes, Alberta. (\$1,720)
Mukherji, K.K. Geotech. Sci. Loyola	Thermoluminescence study of Black River-Trenton Groups in southwestern Ontario. (\$760)
Naldrett, A.J. Geology Toronto	Field and experimental studies relating to nickel sulfide mineralization at Hope, B.C. and Duluth, Minn. (\$1,720)
Neale, E.R.W. Geology Memorial	Structural, petrologic, and economic studies along the Grenville Front in Newfoundland, Labrador, (\$1,720)
Neilson, J.M. Geol. Sciences Queen's	The Grenville Front in the Mistassini region, Quebec. (\$1,720)
Nelson, S.J. Geology Calgary	Historical geology of western Canada. (\$2,500)
Noble, J.P.A. Geology New Brunswick	Evolution and distribution of Lower and Middle Devonian faunas of western Canada, a dynamic model. (\$1,000)
Norris, G. Geology Toronto	Palynology of the Mesozoic of western Canada. (\$1,720)
Pajari, G.E. Geology New Brunswick	The mineralogy and petrochemistry of the St. George complex, New Brunswick. (\$1,720)

Name, Department & University	Project Title & Amount
Peach, P.A. Geol. Sciences Brock	Trace element study of lake-bottom sediments. (\$1,720)
Perrault, G. Geol. Engineering Ecole Polytechnique	Mineralogy and petrology of Mount St. Hilaire, Que. (\$1,720)
Perrault, G. Geol. Engineering Ecole Polytechnique	Publication of M.A.C. Symposium: Alkaline rocks the Montereian Hills. (\$4,500)
Philpotts, A.R. Geol. Sciences McGill	Investigation of Montereian rocks. (\$1,720)
Pouliot, G. Génie géologique Ecole Polytechnique	La mesure de la structure des argiles glaciaires par méthodes de diffraction X. (\$1,720)
Price, R.A. Geol. Sciences Queen's	Structure and tectonic evolution of the south- eastern Canadian Cordillera. (\$6,160)
Rankin, D. Physics Alberta	Magnetotelluric studies of deep crustal structure in Alberta. (\$1,720)
Riva, J. Géologie Laval	Study of Lower Ordovician graptolite faunas at Lévis and in Gaspé, Que. (\$1,720)
Ross, J.V. Geology British Columbia	Structural and mechanical properties of the common amphibolite facies minerals. (\$1,720)
Rust, B.R. Geology Ottawa	The sedimentary history of the St. Clair River delta, Ont. and carbonate petrology and depositional environments of the Hull Formation (\$1,720)
Schenck, P.E. Geology Dalhousie	Paleocurrent and basin analysis of the Meguma Group (Lower Paleozoic), Nova Scotia. (\$1,720)
Schwarcz, H.P. Geology McMaster	Radiometric dating of cave deposits by uranium series disequilibrium. (\$1,720)
Schwerdtner, W.M. Geology Toronto	Kinematic significance of hornblende lineations and sillimanite lineations. (\$1,720)
Scott, S.D. Geology Toronto	Stability relations and defect chemistry of iron sulphide minerals. (\$1,720)

Name, Department & University	Project Title & Amount
Seguin, M.K. Géologie Laval	Recherche sur l'application des méthodes electiques et électro-magnétiques en prospection géophysique. (\$1,720)
Shaw, D.M. Geology McMaster	Geochemical studies on Grenville rocks and minerals. (\$1,720)
Sherwood, H.G. Mineral Engineering Nova Scotia Tech. College	Mineralogical study of seafloor minerals. (\$1,720)
Simony, P.S Geology Calgary	Geology of the Rocky Mountain Trench. (\$4,430)
Sinclair, A.J. Geology British Columbia	Fission track dating of mineral deposits and related plutonic rocks. (\$1,720)
Smith, D.G.W. Geology Alberta	A geochemical and mineralogical investigation of spilites. (\$2,500)
Smith, F.G. Geology Toronto	Grain growth in metamorphic rocks. (\$1,200)
Smitheringale, W.G. Geology Memorial	The secondary dispersion of uranium and related elements in the Long Range Mountains, Newfoundland. (\$1,000)
Stelck, C.R. Geology Alberta	Phytoplankton of Cretaceous sections of western Canada. (\$3,200)
Stevens, G.R. Geology Acadia	Corroboration of fabric indicators of Nova Scotia Triassic lavas by collation with modern Icelandic lava flows. (\$3,365)
Talbot, J.L. Geology Lakehead	Development of retrograde cleavage in basement complexes. (\$1,720)
Tanguay, M.G. Geol. Engineering Ecole Polytechnique	Optical processing of aerial photo patterns by coherent light. (\$4,807)
Terasmae, J. Geol. Sciences Brock	Postglacial geochronology and palynology of the Hamilton area, Ontario. (\$1,255)
Thom, B.G. Sub-Arctic Laboratory McGill	Postglacial shorelines development along a portion of the North Shore, St. Lawrence. (\$1,720)

Name, Department & University	Project Title & Amount
Turnock, A.C. Geology Manitoba	Metamorphism and igneous intrusion in the Precambrian of eastern Manitoba. (\$1,720)
Vagners, U.J. Geology Acadia	Study of Quaternary sediments in the Maritime Provinces. (\$4,000)
Valiquette, G. Génie géologique Ecole Polytechnique	Petrologie des granites à molybdène. (\$1,720)
Van Loon, J.C. Geology Toronto	Determination of rare earth elements by atomic absorption and atomic fluorescence spectroscopy. (\$1,720)
Walker, R.G. Geology McMaster	Turbidity current flow in the Ordovician Cloridorme Formation, Gaspé, Quebec. (\$1,720)
Waterhouse, J.B. Geology Toronto	Permian brachiopod zones of western Canada. (\$1,720)
Watkinson, D.H. Geology Toronto	Experimental study of relationships between niobium mineralization and carbonatites. (\$1,720)
West, G.F. Physics Toronto	Geophysical studies of the Lake Superior Keweenawan Basin. (\$1,720)
Westermann, G.E.G. Geology McMaster	Forma and function of ammonoid shells. (\$1,720)
Westgate, J.A. Geology Alberta	Quaternary tephrochronological studies (volcanic ash chronology) in western Canada: characterization of Quaternary pyroclastic deposits in western Canada. (\$1,720)
Williams, H. Geology Memorial	Stratigraphy, age and origin of the Random Formation, eastern Newfoundland. (\$1,720)
Yole, R.W. Geology Carleton	Petrology and microfacies analysis of Ordovician rocks, eastern Ontario and Devonian rocks, Mackenzie Valley. (\$1,720)
Young, G.M. Geology Western Ontario	Stratigraphy, sedimentation and trace element geochemistry of Early Proterozoic sedimentary rocks. (\$2,000)

Special Grants for Research
in Development of Computer-Processible Files

1969-70

Name, Department & University	Project Title & Amount
Gunn, B.M. Geology Montreal	Geochemical data processing. (\$9,500)
Kramer, J.R. Geology McMaster	Water analysis and water quality related to geological field data. (\$5,000)
Smith, F.G. Geology Toronto	Storage and retrieval of data required in scientific research in geochemistry. (\$4,600)
Sutterlin, P.G. Geology Western Ontario	Development of a geochemical data file using the free-form format system. (\$13,400)
Wilson, H.D.B. Geology Manitoba	The geologic, geographic and temporal significance of the distribution of base metal and precious metal deposits of the world. (\$8,500)
Wynne-Edwards, H.R. Geological Sciences Queen's	Electronic processing of field data from the Grenville Province in Quebec. (\$9,000)