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NATIONAL ADVISORY COMMITTEE ON RESEARCH IN THE GEOLOGICAL SCIENCES

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EIGHTEENTH ANNUAL REPORT
1967-1968

ANNUAL REVIEW AND
REPORTS OF SUBCOMMITTEES

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ANNUAL REVIEW AND
REPORTS OF SUBCOMMITTEES

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1969

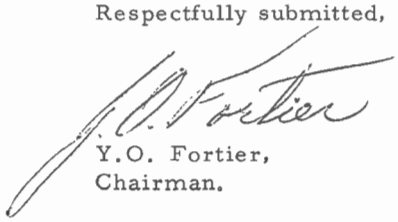
601 Booth Street,
Ottawa, October 31, 1968.

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

Sir:

I have the honour to submit to you the Eighteenth Annual Report of the National Advisory Committee on Research in the Geological Sciences covering the period September 1, 1967 to August 31, 1968.

Respectfully submitted,



Y.O. Fortier,
Chairman.

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Meetings: April 29-30, 1968.

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Prof. R.E. Folinsbee	University of Alberta, Edmonton, Alta.

Dr. C.S. Lord	Geological Survey of Canada, Ottawa, Ont.
Prof. E.W. Nuffield	University of Toronto, Toronto, Ont.

Meeting: June 11, 1968, Ottawa.

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 first part of the report gives a summary of the work of the Committee over the period September 1, 1967 to August 31, 1968. This is followed by the reports of the subcommittees. These reports cover the different fields in the geological sciences, record developments in 1967-68 and suggest further problems for study. An appendix lists the research grants to Canadian universities for 1968-69 which were awarded by the Geological Survey of Canada on the basis of the National Advisory Committee's recommendations.

The annual compilation of current research in the geological and related sciences in Canada is published as a separate volume*. It records information on research by the universities, federal and provincial departments and research councils and foundations.

Other current publications of the National Advisory Committee include the final report of the Ad Hoc Committee on Storage and Retrieval of Geological Data entitled "A National System for Storage and Retrieval of Geological Data in Canada" which is distributed for the Committee by the Geological Survey of Canada. Publications in preparation which will be published by the Geological Survey for the Committee early 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, 1968); Proceedings of the Earth Science Symposium on Hudson Bay, February 1968 (Geol. Surv. Can., Paper 68-53, 1968); and the final report on the Comprehensive Study of the Coronation Mine, Manitoba.

RESEARCH GRANTS TO UNIVERSITIES

Grants by the Geological Survey were initiated in 1951 at the instigation of the Committee to stimulate and support geological research in Canadian universities. Applicants must hold an academic staff appointment at a Canadian university; applications are received 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 for research in the geological sciences and on a much more substantial

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* Current Research in the Geological Sciences in Canada, 1967-68, National Advisory Committee on Research in the Geological Sciences; Geol. Surv. Can., Paper 68-54, 1968.

scale*. Applicants for NRC 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 1968-69, 121 applications (100 in 1967-68) were received by the Geological Survey for general grants-in-aid of research; the total of the grants applied for was $551,492 ($370,377 in 1967-68). One hundred and twelve grants totalling $220,000 ($185,000 in 1967-68) were awarded to 24 universities. The names of the recipients, the titles of their research projects and the amounts awarded are listed in the Appendix (p. 91).

For 1968-69, 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 processable files of geological data (see Report of Subcommittee on Storage and Retrieval of Geological Data, p. 44). Applications for these grants, which were received up to March 31, 1968, 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 1968. The total of the seven grants applied for was $81,635. Five grants totalling $43,000 were awarded to five universities. The names of the recipients, titles of the projects and amounts awarded are listed in the Appendix (p. 99).

When the Geological Survey grants were intiated in 1951 practically no other grant funds were available for geological research although the National Research Council awarded a few thousand dollars for mineralogic projects (mainly crystallography). However, by 1958 NRC had increased its support of research in the geological sciences to $28,000 for operating grants plus $75,000 for major equipment grants; GSC grants had increased to $50,000. From 1958 to the present the increase in NRC support for research in the geological sciences has been increased to $1,185,000 by 1966, to $1.5 million in 1967 and probably about $1.8 million in 1968. The Geological Survey grants have also increased from $10,000 in 1951 to $185,000 in 1967 and $220,000 in 1968 or about 12 per cent of the amount awarded by NRC.

The large increase in NRC grants has resulted in the majority of applicants for GSC grants also receiving substantial grants from NRC. In fact, in the last few years 75 to 80 per cent of the applicants for GSC grants have been awarded grants for the same or similar projects a month or so before the applications for GSC grants are reviewed. As a consequence, 75 to 80 per cent of the GSC applications are, in effect, for supplements to NRC grants. Because NRC awards on the average are less than 2/3 of the amount requested these supplements are needed and justified. However, it means that in reviewing the GSC applications, after providing for the 20 to 25 per cent not already receiving NRC grants, the Projects Subcommittee has no

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* Annual Report on Support of University Research, 1966-67, National Research Council, No. 9662, pp. 148-164.

recourse but to divide the balance equally between the 75 to 80 per cent of the applicants receiving NRC grants whose projects have already been reviewed by NRC.

This has led the National Advisory Committee to consider means whereby the GSC grants may be directed to fields or major projects which the Committee through its Subcommittees consider as particularly deserving of support; it is considered this could prove more rewarding than the present wide diffusion of support. It would mean the grants would be directed and to some degree project oriented but there would be no departure from support of individual excellence. The Subcommittees have been asked 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. It is expected that this change in policy will be implemented gradually as the Committee and its Subcommittees use increasing influence in directing research to desirable major projects.

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 presented 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 such a system.

The National Advisory Committee adopted the report of the ad hoc Committee, and, as recommended in the report, appointed a Subcommittee (at first called a Standing Committee) on the Storage and Retrieval of Geological Data in Canada under the chairmanship of Dennis A. Sharp, Department of Energy and Resources Management, Toronto. The Subcommittee was instructed to consider immediately the establishment and method of financing of the proposed secretariat and the implementation of the other recommendations in the report.

The Subcommittee on Storage and Retrieval of Geological Data has had a year of productive and satisfying activity. Its report (p. 44) includes sections on the proposed secretariat to implement the National System

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* 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 Geological Survey of Canada, Department of Energy, Mines and Resources, Ottawa, Ontario.

and ensure its continued development; the activities of its seven subcommittees on files of mineral deposits data, geochemical data, geological field data, geophysical data, on the National Index, and on university grants-in-aid of research. Appendices list the seven subcommittees and their members and outline the proposed organization of the secretariat.

EARTH SCIENCE SYMPOSIUM ON HUDSON BAY

The National Advisory Committee and the NRC Associate Committee on Geodesy and Geophysics co-sponsored an Earth Science Symposium on Hudson Bay in Ottawa, February 19-20, 1968.

Some 20 papers were presented covering the history, Quaternary geology, on-shore and off-shore bedrock geology, bathymetry and sedimentology, and seismic, gravity and magnetic studies of the Bay. About 150 geoscientists from universities, industry, and government attended the symposium.

The proceedings will be published on behalf of the sponsoring committees by the Geological Survey of Canada (Geol. Surv. Can., Paper 68-53, 1968, in press).

TECTONICS RESEARCH CONFERENCE

The National Advisory Committee sponsored a Tectonics Research Conference held in Ottawa at Ottawa University, March 14-15, 1968.

The conference explored the area where laboratory studies of brittle failure in geological materials may provide new insight and criteria for understanding similar failure conditions in the field; and conversely, where field studies may assist in understanding brittle deformation in the laboratory. Thirteen structural specialists were invited to contribute papers — six from the United States, two from Great Britain and five from Canada. Of four half-day sessions, two dealt with brittle fracture of geological materials, one with kink folding and one was devoted to general discussion. Seventy-eight geoscientists from the United States, Great Britain and Canada participated in the conference.

The proceedings, including discussions, will be published on behalf of the National Advisory Committee by the Geological Survey of Canada (Geol. Surv. Can., Paper 68-52, 1968, in press).

INTERNATIONAL GEOLOGICAL CONGRESS - 1972

The Canadian Government has given approval in principle to inviting the International Geological Congress to meet in Canada in 1972.

The Canadian National Committee for Geology, composed 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 met in Ottawa in December 1967. At this meeting R. E. Folinsbee, University of Alberta was appointed to head the Canadian delegation to the Congress in Prague, Czechoslovakia in August 1968 and extend the formal invitation to the Congress

to meet in Canada in 1972. Subject to Canada's invitation being accepted, Montreal will be the site for the 1972 Congress. R. E. Folinsbee will head the Organizing Committee for the Congress, and J. E. Armstrong, Geological Survey of Canada will be Secretary-General. An exhibit about Canada has been prepared for the 1968 Congress in Prague showing Canada's attractions as a site for the 1972 Congress.

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES

Canada is an active member of the International Union of Geological Sciences (IUGS) and many of the Union's international commissions, committees and working groups have Canadian members. The IUGS issues about four circular letters a year containing current information about the Union, future international meetings, reports on recent meetings, abstracts of papers presented to symposia, progress reports on international research projects and reports on IUGS commissions, committees and affiliated organizations. IUGS circular letters may be ordered from the Secretary-General, IUGS, Mechelse Steenweg 206, Antwerp, Belgium.

International Upper Mantle Project

The International Upper Mantle Project is sponsored by the International Council of Scientific Unions (ICSU) and the affiliated International Unions of the Geological Sciences (IUGS) and Geodesy and Geophysics (IUGG). The program is directed toward understanding processes in the mantle that influence development of the earth's crust.

The Project is coordinated by the International Upper Mantle Committee (UMC) which was set-up jointly by the IUGS and the IUGG. In addition there are national committees in 50 countries. The International Upper Mantle Committee consists of a bureau, the chairmen of two commissions, reporters of nine working groups, representatives of ICSU unions and committees, and a UNESCO representative.

Canadian representation on the Committee and its working groups are:

J. M. Harrison (Bureau, ICSU)
C. H. Smith (Deputy Secretary-General)
G. D. Garland (IUGG Secretary-General)
J. T. Wilson (Reports for Tectonics)
B. D. Loncarevic (Member of Commission on Continental Margins and Island Arcs)
R. E. Folinsbee (Member of working group on Physics and Chemistry of the Upper Mantle)
E. Irving (Member of working group on Magnetism)
E. R. W. Neale (Member of working group on Tectonics)

The activities of the national committees are documented in the reports presented at the IUGG assembly in Zurich, September 1967, copies of which are available.

The International Committee has stimulated, sponsored or funded numerous symposia on related problems. Examples during the past year include:

1. Symposia on Upper Mantle Project, Hyderabad, India, January 3-7, 1967.
2. UMC Symposium on Geophysical Theory and Computers, Trieste, September 18-22, 1967.
3. Symposia on World Rift Systems and Continental Margins and Island Arcs, Zurich, September 27-29, 1967.
4. Pan American Conference on Upper Mantle Project, Mexico City, March 1968.

In the near future a number of meetings and symposia are scheduled including:

1. Symposium on Origin of Andesite, Eugene, Oregon, July 1-5, 1968.
2. Symposia at Int. Geol. Congress, Prague, August 1968.
3. Study group on Comparison and Subdivision of Mountain Chains, Switzerland, August 1968.
4. Study group on Explosion Seismology, Leningrad, August 28-September 2, 1968.
5. Fifth UMC Symposium on Geophysical Theory and Computers, Tokyo, August 1-8, 1968.
6. UMC Symposium on Phase Transitions, Canberra, Australia, January 6-10, 1969.
7. Symposium on Structure of Inland and Continental Seas, Madrid, September 1969.

Through these symposia, and its working groups, the International Upper Mantle Committee receives and sponsors recommendations covering national and international endeavors related to the objectives of the Project. For example, it has played a large role in stimulating the development of an Andean geophysical program drawing together the efforts of a number of Latin-American countries to study the problems of the Andes. As part of Phase III of the project (1968-70) the Committee is preparing an extensive monograph on the crust and upper mantle.

The Upper Mantle Project was evolved on the heels of the International Geophysical Year and has done a great deal to foster international collaboration, as well as collaboration among geologists and geophysicists. Its impact on the acceleration of earth science research is difficult to measure but undoubtedly has been considerable.

Metamorphic Map of the World

The IUGS Commission for the Geological Map of the World has set up a working group for the cartography of the Metamorphic Belts of the World. In June 1967, the working group presented a scheme of metamorphic facies for the cartographic representation of regional metamorphic belts which was published in IUGS Newsletter No. 2, 1967, pp. 57-72. This paper presents a system for portrayal of metamorphic belts based on temperature and pressure, portraying these properties as interpreted from mineral assemblages.

H. L. James, Chief Geologist, United States Geological Survey was appointed representative for North America on the project. He organized a meeting attended by a number of North American petrologists at the annual meeting of the Geological Society of America in New Orleans in November 1967. They opposed the plan for preparing a map based on the P-T series as proposed by the working group on the grounds that it would be too generalized, could not show basic data, and the interpretation of P and T may change

because their theoretical basis is not firm. They proposed that the various groups proceed with compilations based on legends suitable for their particular regions. When this has been done an assessment of the results will be made for further synthesis.

In Canada, J. E. Reesor, Geological Survey of Canada, has been coordinating preliminary preparations for a compilation of a metamorphic map by the Geological Survey. The Cordilleran Section has started a compilation for that region and a similar compilation for the Appalachian Region is planned.

International Geological Correlation Program

The proposed International Geological Correlation Program is a long term joint IUGS - UNESCO program which would be carried out by IUGS and its individual member countries and financially supported by UNESCO. Priority will be given to the establishment of clear documentation and universally acceptable definitions for a stratigraphic scale to provide the basic framework for time correlation and earth history. In this, emphasis will be placed on the establishment of stratotypes or what are really reference sections of time stratigraphic units which can be used as standards of correlation.

Important topics that fall within the scope of the project include: 1. clarification of principles of correlation, and the standardization of terminology and means of cartographic representation; 2. the application and evaluation of methods of time correlation; 3. the promotion of quantitative methods and data processing with respect to geological correlation; 4. the study of patterns in time and space of geological events (e. g. volcanic, plutonic, tectonic, metamorphic, climatic, eustatic, magnetic); and 5. the study of the genesis of economic deposits in relation to other events of earth history.

The Secretary-General, IUGS has asked that the proposed program be discussed on a national basis and comments sent to the IUGS Secretariat in time for the IUGS Council meeting in Prague in August 1968 and at a meeting of the UNESCO General Conference in November 1968. The International Geological Correlation Project and its program have been discussed by the National Advisory Committee and more particularly by the Subcommittee on Stratigraphy, Paleontology and Sedimentology. Although some Canadian biostratigraphers have expressed concern over the philosophy of correlation underlying early outlines of the project (March 1967), there is general agreement on the need for a program to establish internationally acceptable definitions for the stratigraphic scale. The National Advisory Committee fully supports the proposed International Geological Correlation Program and hopes it will be endorsed at the IUGS Council meeting in Prague in August and at the UNESCO General Conference in Paris in November 1968.

CHANGES IN PERSONNEL OF COMMITTEE

W. D. Brueckner, J. T. Fyles, G. G. L. Henderson, Guy Perrault and C. J. Sullivan retired from the Committee in 1967. 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 in 1967 are: E. W. Best, Triad Oil Co. Ltd., Calgary, Alta.; R. A. Blais, Ecole Polytechnique, Montreal, Que.; A. Dreimanis, University of Western Ontario, London, Ont.; G. V. Middleton, McMaster University, Hamilton, Ont.; R. D. Russell, University of British Columbia, Vancouver, B. C. P. E. Grenier, Department of Natural Resources, Quebec has been re-appointed for a second term.

REPORT OF THE SUBCOMMITTEE ON

GEOPHYSICAL METHODS APPLIED TO GEOLOGICAL PROBLEMS

Presented by J. E. Blanchard

Members of Subcommittee

J. E. Blanchard (Chairman)	Nova Scotia Research Foundation, Halifax, N. S.
W. C. Brisbin	University of Manitoba, Winnipeg, Man.
L. S. Collett	Geological Survey of Canada, Ottawa, Ont.
L. W. Morley	Geological Survey of Canada, Ottawa, Ont.
R. D. Russell	University of British Columbia, Vancouver, B. C.

During the past year the chairman has had the opportunity of attending, as guest, the meetings of the Associate Committee on Geodesy and Geophysics of the National Research Council of Canada and a number of its subcommittees' meetings. He has also attended meetings of the Canadian Advisory Committee on Rock Mechanics.

There has been a great increase during the past few years in appreciation of the mutual problems of geologists, geophysicists and engineers who are interested in the solid earth. Much has been accomplished through cooperative efforts such as the Upper Mantle Program. However, there is room for more active cooperation and there are problems of information dissemination. Some examples follow.

Certain groundwater hydrologists who wish to use downhole exploration geophysical techniques appear to be quite unaware of the similarity of their problems to those which the petroleum industry solved many years ago. One finds workers in rock mechanics rediscovering techniques that were evolved, evaluated and discarded many years ago by geophysicists. Soil mechanics engineers are attempting to relate, quantitatively, information regarding the engineering properties of soils using soil classifications which most sedimentologists would consider to be so inexact as to be ambiguous. There seems to be duplication in the measurement and interpretation of remnant magnetism in rocks. Great interest has been expressed in remote sensing devices at many of the meetings but there seems to be little common knowledge of what the various groups in Canada are doing in this field.

There are also many problems in the financial support of research because of the larger amounts of money available for research and the increasing numbers of research workers. For example, it seems to have been found necessary to develop fund-granting formulae which tend to obscure originality and ability in order to expedite the allocation of funds.

Some of these problems have relatively simple answers but for most there are, as yet, no obvious answers. The Science Secretariat of the Privy Council Office is attempting to assess science needs in Canada. Presumably, the purpose is not only to increase our fund of knowledge but also assist in organizing science in Canada so that we get the maximum results from our efforts. The Science Secretariat has already organized surveys of a number of disciplines and a number of reports have been published. It would seem that most of these suggest that increased funds are more important than a more organized approach to science in Canada.

REVIEW OF CURRENT RESEARCH

As in the 1965 and 1966 reports, the reader is again referred to the comprehensive review of geophysical research given in the Canadian Geophysical Bulletin, Volume 20, 1967 published by the National Research Council. This volume, as has been the custom, reports geophysical research in the seven disciplines of the International Union of Geodesy and Geophysics and also in exploration geophysics. While not all the geophysical research in Canada is of direct concern to geology, this report provides information on research of interest not only to this subcommittee but to several other subcommittees of the National Advisory Committee on Research in the Geological Sciences as well.

For more detailed accounts of research projects the reader is referred to the annual compilation of Current Research in the Geological Sciences in Canada, 1967-68 (Geol. Surv. Can., Paper 68-54, 1968).

CANADIAN CONFERENCES ON GEOPHYSICS

The Subcommittee on Exploration Geophysics of the Associate Committee on Geodesy and Geophysics of the National Research Council organized the Canadian Centennial Conference on Mining and Groundwater Geophysics with the support of the National Research Council and the Geological Survey of Canada. The Conference was held, October 22-27, 1967 in Niagara Falls; over 700 delegates registered representing 50 countries. Fifty-six papers were presented covering the role of geophysics and development of mineral resources; geophysics as an aid to geological mapping; state of the art; groundwater; base metals; iron; precious metals; radioactive minerals; industrial minerals; and national geophysical facilities. The proceedings will be published by the Geological Survey of Canada by late 1969.

An Earth Science Symposium on Hudson Bay was held in Ottawa, February 19 and 20, 1968, under the auspices of the National Advisory Committee on Research in the Geological Sciences and the Associate Committee on Geodesy and Geophysics of the National Research Council. The symposium was convened by Dr. Peter Hood, Geophysics Division, Geological Survey of Canada. Some 20 papers were presented dealing with the geology and geophysics of the crust and upper mantle beneath Hudson Bay, with more than 150 participants. Some 30 of these were geologists and geophysicists from Calgary, Alberta, which indicates the interest of the petroleum industry in the oil and gas possibilities of the sediments under Hudson Bay. The proceedings of the symposium will be published on behalf of the sponsoring committees by the Geological Survey of Canada (Geol. Surv. Can., Paper 68-53).

In conjunction with the regular Canadian Association of Physicists' meeting held at the University of Toronto, a two-day symposium on Earth Physics was organized by the Earth Physics Division. Some 30 papers were presented to about 150 participants. The symposium was convened by Drs. G. F. West and D. York, University of Toronto. The meeting was so successful that arrangements were made to hold a two-day Earth Physics Symposium at the Canadian Association of Physicists' meeting in Calgary, June 5 and 6, 1968. About 30 papers were presented.

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

The 14th General Assembly of the International Union of Geodesy and Geophysics was held in four cities in Switzerland, September 25 to October 4, 1967. Because of the large number of people attending the meetings, and the difficulty of finding suitable places to hold them, it has been decided to attempt to restrict future meetings of the International Union of Geodesy and Geophysics Assembly to business concerning the various disciplines. The various disciplines will hold either individual or joint symposia during the years between meetings of the Assembly. For example, the International Association of Scientific Hydrology has tentatively scheduled the following symposia for the next several years:

1. Use of Analog and Digital Computers (Arizona, December 1968).
2. Symposium on Forecasting of Floods (Australia, 1967).
3. Symposium on Hydrology of Glaciers (Cambridge, England, 1969).
4. Symposium on Hydrometry (Koblentz, 1969).
5. Symposium on Land Subsidence (Japan, 1969).
6. Symposium on Deltas (Rumania).
7. Experimental and Representative Basins (New Zealand, 1970).
8. World Water Balance (London, 1970).
9. 12th Pacific Science Congress (Australia, 1971).
10. Hydrology of Snow and Ice (Canada, 1971).

Other disciplines are making similar arrangements for the next four years.

The reader's attention is drawn to the Canadian Upper Mantle report presented at the Switzerland meeting. This is an excellent review of the progress and accomplishments of the Canadian Upper Mantle Program. Of particular interest to geologists is the chapter on Tectonics (of Canada), by Dr. J.O. Wheeler, Geological Survey of Canada.

CONFERENCE ON THE GEOPHYSICS AND GEOCHEMISTRY OF THE MOHOROVICIC DISCONTINUITY

In its 1966 report this subcommittee promised to look into the possibility of holding scientific meetings on such topics as the measurement of absolute stress in the crust of the earth and research on high pressure and high temperature phenomena. Various subjects have been considered. The measurement of absolute stress in the crust of the earth is a most important subject to earth scientists; up to the present it has been of most active concern to those primarily interested in mining engineering problems. A number of conferences have been held on the subject, but very few papers have been presented at geophysical or geological meetings although at the 1968 American

Geophysical Union meetings in Washington, some four papers were presented on field measurements of absolute stress. However, because of the similarity in fields of interest of the recent symposium on Kink Bands and Brittle Fracture held in March 1968 (p. 4) and sponsored by the National Advisory Committee, it was decided not to organize a meeting on absolute stress at this time.

Because of the growing number of workers in high pressure and high temperature geochemical and geophysical phenomena in Canada and the large amount of field information which has been gathered about the upper mantle and crust in Canada during the Upper Mantle Program, consideration is being given to organizing a meeting of the Subcommittee on Geophysical Methods Applied to Geological Problems and other interested subcommittees at which papers will be presented and formal discussion periods arranged to present the latest ideas on the nature of the Mohorovicic Discontinuity.

DISCUSSION OF REPORT

In discussion of the report, several members expressed approval of the suggested conference on the Geophysics and Geochemistry of the Mohorovicic Discontinuity. It was felt it should be a small meeting or workshop which might be held in conjunction with a meeting of the Subcommittee, and possibly other interested subcommittees of the National Advisory Committee in the spring of 1969 or 1970.

REPORT OF THE SUBCOMMITTEE ON MINERAL DEPOSITS

Presented by A. E. Buller

Members of 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.
L. C. Kilburn	Falconbridge Nickel Mines Ltd., Toronto, Ont.
A. J. Naldrett	University of Toronto, Toronto, Ont.
W. G. Wahl	Consulting Geologist, Toronto, Ont.

Current research in the field of mineral deposits seems to be following the same general pattern it has in recent years. An analysis of the types of projects listed for 1967-68 does not bear out the assertion of the 1967 report* of this subcommittee which states that "geologists in universities and research institutions tend to be preoccupied with the tools and instruments of physics and chemistry" nor in fact did the projects listed for 1966-67. In this regard Dr. Naldrett comments:

> "This claim is totally unsupported by the 1966-67 compilation of current geological research in Canada. I have classified all mineral deposit projects into laboratory and field projects. Anything that rested primarily on the use of the electron-probe, the ore microscope, instruments for trace-element analysis or for isotope analysis I classified as a laboratory project; anything that involved the geophysics, geology, structure or stratigraphy of a mine or area around a mine I classified as a field project. The answer was 16 laboratory to 48 field projects — hardly a take-over by the laboratory man. There were only two of the laboratory projects that fell within my own estimation of the term — that is that they were experimental studies (one of phase equilibria, one of mineral deformation) that could be applied to interpreting field problems. The remainder were analytical studies of field material — some of them, such as studies of the distribution of precious metals, would be of very direct assistance to the mining companies concerned."

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* National Advisory Committee on Research in the Geological Sciences, Seventeenth Annual Report; Geol. Surv. Can., Paper 67-71, pp. 22-23, 1968.

This subcommittee believes that the National Advisory Committee should concern itself, not with supporting field studies as against laboratory research or vice versa, but with encouraging the integration of field and laboratory studies which will consider mineral deposits in their complete geological context. Such studies should be field oriented; it must be recognized that an accurate and complete geologic map is an absolutely essential starting base for any mineral deposit study. The National Advisory Committee should therefore support pure mapping projects to the same extent it does projects involving laboratory research.

We also agree that not enough basic laboratory research (experimental work) is being done in Canada and recommend that this be given serious consideration, particularly by the Geological Survey of Canada. Soundly conceived and well carried out experimental studies can be of great help to the field geologist in interpreting field problems and in providing him with new questions and new hypotheses to be checked in the field. Such studies, if carried out as an integral part of the overall program of the Geological Survey are bound not only to advance fundamental knowledge but also to stimulate the staff. In this connection Dr. Naldrett writes:

> "I agree with the 1967 report of this subcommittee that much laboratory work has been misdirected and I agree entirely that what we must emphasize is the value of a coordinated field and laboratory approach. I place field first, because I also agree that high-calibre field mapping must form the foundation of any approach to the understanding of an ore deposit or mining camp. On the basis of this mapping, backed by thin section, polished section and chemical study, the field geologist will arrive at one or a number of possible hypotheses about the origin of a deposit. Unfortunately ore deposition is an exceptional rather than a common-place process and generally occurs in places isolated from our surface environment. Consequently it is only rarely that we can substantiate our hypotheses by appealing to the principle of uniformity and by observing deposition taking place before our eyes.
>
> "It is because of this that the experimental or theoretical geologist can be so much help. He can test the hypotheses either by direct experiment, proving whether they are feasible or not, or by accumulating the required chemical data and calculating whether they are feasible. In addition, by using geothermometers and geobarometers, he can define the conditions of ore deposition in terms of depth and temperature; and by studying reactions that occur in experimental systems approximating to the total environment of an ore deposit he can suggest to the field man critical evidence to look for in the rocks that may have a bearing on the origin of the ore.
>
> "In pointing out the importance of the joint approach I think we should stress that:
>
> 1. Far more laboratory work, of a rigorous type, should be designed to test field hypotheses. We should discourage the shot-gun approach to analytical or experimental work (I think this is what the 1967 report of this subcommittee was really criticizing). Far too many people analyse a group of minerals for their trace element or isotope content in the fond but forlorn hope that something useful will come out of their work. Similarly too many experimentalists study a chemical system in the hope that it will be useful without really thinking out how it can be applied before they start their work — all too often it is never applicable.

2. We require a new breed of field geologist who understands the modern scientific approach inherent in applying experimental and theoretical work and in looking for the required criteria as he maps his rocks in the field. Last year's report emphasized that field geologists should be well trained in interpreting their mapping in terms of the physical processes of deposition and intrusion. This year we should also emphasize that he should attempt to understand the chemical processes involved."

Several important field programs of a fundamental type are currently underway. These include:

1. Geological Survey projects such as -
   a. comprehensive studies of certain Keewatin volcanic belts,
   b. glacial studies aimed at developing mineral exploration methods,
   c. regional metallogenic studies.
2. Regional geochemical studies by the New Brunswick Department of Lands and Mines.
3. Project Pioneer being carried out jointly by the University of Manitoba and the Manitoba Department of Mines.

This subcommittee recommends continued support and intensification of programs of this type, both by the Geological Survey and by provincial departments of mines.

The more detailed integrated studies of restricted mineral districts within provinces might best be carried out by joint Provincial Department — Geological Survey programs, or by joint University — Provincial Department programs like Project Pioneer. In this regard J.M. Carr suggests as desirable programs:

1. An integrated attack on the Nicola mineral belt, employing 1-mile regional geological mapping with stratigraphic subdivision and chemistry, separation of plutonic units, recognition of dyke swarms according to age and type, data accumulation for all known mineral occurences, aeromagnetics, and gravity or seismic evaluation of basement configuration variously under plutonic bodies and volcanic/sedimentary basins and grabens.
2. Stepped-up stratigraphic-structural studies of the Takla-Hazelton Groups.

The glacial studies initiated by H. A. Lee* to develop mineral exploration methods are particularly important; it is recommended that they be broadened and intensified. In this regard W. G. Wahl writes:

"It is suggested that the work initiated by H. A. Lee of the Geological Survey be expanded to cover all types of surficial material. Special emphasis should be placed on the physical and chemical changes of the ore minerals during transport."

Much more reliable data are required in all fields and aspects of geology, and projects which involve only data collecting will and should be with us indefinitely. However, the time has certainly come when the Geological Survey in particular, as well as others, should be seriously concerned with

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

critical analysis and synthesis of the data now available. Within the Mineral Deposits Section of the Geological Survey, the assignment of specialists who will be concerned with all aspects of the geology of individual metals or closely related small groups of metals, is a most desirable and welcome development. The Geological Survey is urged to ensure that the work of this Section is strongly supported, that it be broadly based and that it consider mineral deposits in their total geologic context.

The subcommittee notes the increasing interest being taken in the application of computers to geologic problems. This is in no small measure due to the activities over the past year of the Subcommittee on Storage and Retrieval of Geological Data which was appointed in 1967 by the National Advisory Committee to carry on the work of the ad hoc Committee (see p. 44). We recommend that the National Advisory Committee continue to support the Subcommittee on Storage and Retrieval of Geological Data both directly and through the support of research projects concerned with computer applications.

The development of remote sensing devices and techniques and their application to geology should be encouraged.

The possibility of using satellites to gather geological data not otherwise easily obtainable should be considered seriously.

The subcommittee is concerned that the descriptions of research projects submitted to the Secretary of the National Advisory Committee for inclusion in the published compilations of Current Research in the Geological Sciences in Canada, too often do not give enough information for the reader to judge either their purpose or their worth; some few seem designed to impress rather than to inform. Many would be greatly improved if they stated clearly and simply what is being done, how and why.

DISCUSSION OF REPORT

In discussion of the report several members noted with pleasure the advocacy of mapping projects as a vital part of geological research. It was pointed out that this is recognized by the National Research Council and the Geological Survey of Canada both of which award grants in support of field work. Other university members expressed appreciation of the collaboration of provincial and federal geological surveys in supporting field research by awarding thesis area projects to graduate students, and in other ways. With reference to the suggestion that the Geological Survey carry out more experimental laboratory research on the formation and origin of ore deposits, the Chairman said that the Survey's policy was to carry on only a small amount of such purely laboratory research; such research is considered to be primarily the function of the universities.

REPORT OF THE SUBCOMMITTEE ON MINERALOGY, GEOCHEMISTRY AND PETROLOGY

Presented by E. W. Nuffield

Members of Subcommittee

E. W. Nuffield (Chairman)	University of Toronto, Toronto, Ont.
B. J. Burley	McMaster University, Hamilton, Ont.
L. A. Clark	McGill University, Montreal, Que.
A. D. Edgar	University of Western Ontario, London, Ont.
H. J. Greenwood	University of British Columbia, Vancouver, B. C.
E. H. Nickel	Mines Branch, Ottawa, Ont.
V. S. Papezik	Memorial University of Newfoundland, St. John's, Nfld.
G. G. Perrault	Ecole Polytechnique, Montreal, Que.
P. L. Roeder	Queen's University, Kingston, Ont.
G. B. Skippen	Carleton University, Ottawa, Ont.
A. C. Turnock	University of Manitoba, Winnipeg, Man.

REVIEW OF CURRENT RESEARCH

The following summary is based on the Survey of Current Research in the Geological Sciences in Canada, 1967-68 (Geol. Surv. Can., Paper 68-54).

Category	Number of Research Projects 1965-66	1966-67	1967-68
Mineralogy			
Specific minerals	28	29	28
General problems	23	27	34
Geochemistry			
Experimental phase equilibria	*	*	42
Other	116	108	92
Petrology and petrography	113	110	101
Geochronology	28	20	26
TOTALS	308	294	323

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

The total number of projects has not changed significantly for 1967-68. However, the nature of research is in the process of change with the development of two trends, namely, 1. an increase in the study of general problems in mineralogy and 2. an increase in experimental phase equilibrium studies. The later trend is so marked that it seems justified to separate these studies, some of which rightly belong under petrology, into a distinct category.

TRENDS IN RESEARCH AND TEACHING

This subcommittee began its work by reporting on a questionnaire submitted by the Chairman, which sought opinions on trends in research and teaching. Half the members of the subcommittee have only recently begun their teaching careers and have come to their present positions from well-known research laboratories in the United States. They are at a disadvantage in commenting on teaching trends in Canada but they are well able to report on research trends — in some aspects of research, better able.

It is ironic but perhaps of little consequence that the term geochemistry has no common meaning for members of this subcommittee. To about half of the members, geochemistry is concerned with the study of all chemical processes in the earth and its environments; and with the distributions of all types of chemical species in nature. An accepted definition would, if nothing else, give more meaning to statistical data collected in questionnaires on geological sciences.

Trends in Research

The members of the subcommittee agree that the science of geology is experiencing a change towards more fundamental research but are not in agreement on the intensity of this change at present; remarks ranged from "extremely rapid" to "perceptible". One member observed that our (rightful)

preoccupation with exploration geology and the nation's economy has tended to retard fundamental research.

The members see an increase in the application of the principles and techniques of the basic sciences and mathematics, and an increase in instrumental sophistication as significant trends in Canadian research in mineralogy, geochemistry and petrology. As noteworthy developments they refer particularly to phase equilibria studies in petrology, the introduction of crystal-field and ligand-field theory to mineralogy, the widespread use of data storage and retrieval and the growing importance of the electron microprobe analyzer. They point to the increase in experimental and theoretical studies, the growing concern with general problems (rather than problems in a particular field area) and the search for fundamental explanations as indicators of desirable trends in research in mineralogy and petrology.

The members see a need to bring the quality of laboratory research in Canada to the level of our field work which one member believes is unsurpassed in the world. He also believes that many of the important scientific discoveries in geology will be made in the field in the next ten years by theoretically-competent geologists. Several members point to the need to improve the integration of field and laboratory studies. The science of geology is rooted in the field. It may seem trite to state that a laboratory study in geology should seek to elucidate a geological problem. Equally, field research in the university context should offer the prospect of providing a clearer definition of a geological problem in terms of basic principles, or should attempt to test the validity of a theoretically-feasible model.

Trends in Undergraduate Teaching

The last decade has seen the geology curriculum in many universities change to include more basic science and mathematics. Members generally approve this trend which is compatible with the trend in research in mineralogy, geochemistry and petrology. There is need, according to one subcommittee member, to "bridge the wide gap between what a student learns in his chemistry and physics courses and the classical mineralogy and petrology courses"; the geology professor must apply the principles and methods of the basic sciences and mathematics in both field and laboratory courses in geology.

Members observe that geology courses should be less descriptive and offer more fundamental explanations (based on scientific theory and experiment) of geological phenomenon. The undergraduate material should be integrated under relatively few classical headings (such as mineralogy and petrology) to give the student a deeper knowledge of the broad concepts of geology.

The inclusion of more basic science and mathematics, and the reduction in student contact hours which is a developing trend in university teaching are factors that will influence the undergraduate curriculum. In the effort to present the various facets of an increasingly complex science, the geological content may be spread too thinly and become superficial. The universities must counter this influence and actually increase the depth of learning by the reduction of trivia. Many teaching departments of geology will see two alternatives for the design of the undergraduate curriculum of the future:

1. Stream the curriculum at least in the later years, thereby gaining extra depth in certain fields of the student's choice at the expense of others. One member suggests streaming in two ways — perhaps first according to basic

science (biological as against physico-chemical) and then according to the purpose of the training (that is preparation for graduate school, industry or non-specialist vocation).

2. Maintain the policy of a "well-rounded" curriculum at the expense, relative to the first alternative, of variety and depth in certain fields.

Conclusions

The trends we observe in mineralogy, geochemistry and petrology forecast an increasing pressure to found new research laboratories in universities, in government and in industry and to stock them with sophisticated instruments. The laboratories will require technicians; few if any geology departments in Canada have an establishment of technicians, or workshops to service research laboratories that would be considered adequate by their physics and chemistry counterparts. The science has benefitted greatly as a result of steadily increasing research grants. The rate of increase must be maintained, perhaps even accelerated, if the laboratories are to be built, stocked and staffed.

It seems certain that there will be great difficulty in finding the scientific staff to direct these laboratories. It requires from 10 to 12 years to transform a raw high school graduate into a newly appointed assistant professor with 3 years of post-doctoral training. Thus students who enrol in the universities in 1968 will be the young professors in 1980. We will look to them for innovations in teaching curricula and research programs and it is reasonable to ask if they will receive a proper beginning in 1968. Many Canadian geology departments that profess strength in undergraduate mineralogy and petrology do not require courses in physical and inorganic chemistry and do not offer courses in crystal chemistry and phase equilibrium studies in their own departments. It is discouraging to realize that students now entering these programs may be judged to be not qualified when they apply for admission to graduate schools in the mid-1970's or may be required to undertake an inordinate amount of undergraduate work to prepare themselves for proper graduate courses and research.

How can the quality of undergraduate training in mineralogy, geochemistry and petrology be improved, likely with fewer student contact hours, while maintaining the Canadian tradition of a "well-rounded" under-graduate program? The chairman of this subcommittee offers three suggestions based on a study of the answers to the questionnaire. Actually the suggestions overlap but it is convenient to separate them here.

1. Increase the basic science content. The mere addition of more chemistry, physics and mathematics will have only a limited effect. The important need is for the geology professor to apply in his courses the principles and methods his students learn in the basic science departments.
2. Decrease the descriptive content of geology lectures. Traditionally, lectures in geology include relatively much descriptive material which the student can read equally well in his free time. Probably the quality of undergraduate teaching could be improved in all geology departments by dwelling more on generalizations and less on details.
3. Modify the concept of a "well-rounded" graduate. The Canadian concept of the well-rounded graduate stresses a familiarity with the various fields of geology, perhaps more applied than pure. Hopefully the definition will be

modified to stress grounding in the basic principles or generalizations and methods of geology and its associated sciences in the belief that such a graduate has the basic equipment to enable him to move into any field of geology or adapt to any geological environment with ease.

THE ASSOCIATION OF CHAIRMEN OF ONTARIO GEOLOGY DEPARTMENTS

In January 1967, representatives of nine Ontario universities with established or probable future departments of geology met at the University of Toronto to discuss a variety of topics of mutual interest. The group arranged to meet twice a year thereafter and meetings have now been held at Carleton (May 1967), McMaster (October 1967) and Western Ontario (April 1968). The number of participating universities has grown to twelve. The group will have an influence on teaching and research in mineralogy, geochemistry and petrology and therefore its work should be of interest.

The development of graduate research potential is a topic of much interest to members of this group, whether they represent a well-established or a newly-created department. It has become evident to participants of the meetings, that there is already considerable strength in some fields of geology (e. g. igneous and metamorphic petrology) in Ontario universities and a need to develop more potential in other fields (e. g. sedimentary geochemistry, clay mineralogy). The meetings have had the effect of causing the departments to look at their offerings in the whole Ontario context. It seems certain that this will influence them (perhaps particularly the emerging departments) to move into poorly represented areas of the science and thereby broaden the scope of teaching and research in Ontario geology departments.

SYMPOSIUM ON EXPERIMENTAL METHODS IN PETROLOGY AND ORE DEPOSITS AT THE UNIVERSITY OF WESTERN ONTARIO

An event which is indicative of some of the trends in Canadian research referred to above, was a two-day symposium on experimental petrology and ore genesis staged by the University of Western Ontario in January 1968. The symposium was financed jointly by a number of mining companies and the university. Sixteen papers were presented originating in 9 laboratories in Canada and the United States; an audience of 150 attended from a much larger range of laboratories. The meeting was an outstanding success and should be repeated at intervals. A feature was the large number of graduate and senior undergraduate students who were able to attend and discuss future graduate work with representatives from a variety of universities.

CANADIAN ELECTRON PROBE USERS GROUP

An informally constituted group, known as the Canadian Probe Users, came into being in October 1966 at a meeting in Ottawa organized by Dr. H. Thresh, Mines Branch and Dr. C. D. Williams, Chalk River, to discuss problems in the analysis of alloys using the electron probe technique. A second

meeting was held in April 1967 at the University of Toronto with an attendance of 29 of which 16 declared interest in geology and the remainder in metallurgy. A third meeting will take place at McMaster University in May 1968.

The latest newsletter issued by this group, dated May 1967, lists 15 electron probes in Canada and offers a variety of geological and metallurgical materials for round-robin study.

REPORT OF THE SUBCOMMITTEE ON QUATERNARY GEOLOGY

Presented by W.H. Mathews

Members of Subcommittee

W.H. Mathews (Chairman)	University of British Columbia, Vancouver, B.C.
L.A. Bayrock	Research Council of Alberta, Edmonton, Alta.
W.D. Brueckner	Memorial University of Newfoundland, St. John's, Nfld.
E.A. Christiansen	Saskatchewan Research Council, Saskatoon, Sask.
C.B. Crawford	Division of Building Research, NRC, Ottawa, Ont.
A. Dreimanis	University of Western Ontario, London, Ont.
J.A. Elson	McGill University, Montreal, Que.
Lockhart Gray	Water Control and Conservation Branch, Winnipeg, Man.
P.F. Karrow	University of Waterloo, Waterloo, Ont.
J.D. Keys	Inland Waters Branch, Dept. of Energy, Mines and Resources, Ottawa, Ont.
W.O. Kupsch	University of Saskatchewan, Saskatoon, Sask.
J. Ross Mackay	University of British Columbia, Vancouver, B.C.
R.H. MacNeill	Acadia University, Wolfville, N.S.
Raymond Roy	Department of Natural Resources, Quebec, Que.
A. MacS. Stalker	Geological Survey of Canada, Ottawa, Ont.

A. K. Watt

Ontario Water Resources Commission,
Toronto, Ont.

INTRODUCTION

The deliberations of the Subcommittee on Quaternary Geology were aided by a meeting, held in Ottawa on October 20, 1967, at which 9 of the 16 members, plus 3 alternates for missing members, participated. This provided an opportunity for discussion of problems and possible solutions that was more profitable by far than anything that could have been done by correspondence. The chairman, therefore, recommends a greater frequency of meetings than has prevailed in the past, perhaps aiming at one every year and a half.

ADMINISTRATIVE PROBLEMS

Of problems considered by the Committee several were essentially administrative, but nonetheless of direct concern to Quaternary geologists, quite apart from the operations of the subcommittee.

Of prime importance was the establishment of a working relationship with the newly created National Research Council Associate Committee on Quaternary Research (ACQR). This associate committee has been established to stimulate and coordinate research in Canada in all aspects of the Quaternary record (see attached terms of reference, Appendix 1 to this subcommittee report); to review status of research and training; to maintain contacts with other committees and groups (e. g. the Quaternary Geology Subcommittee); and to serve as the Canadian National Committee for the International Association for Quaternary Research, better known as INQUA. The functions of the ACQR clearly overlap, but do not conflict with those of this subcommittee and our current aim has been to minimize duplication of effort and maximize the combined contribution of the two groups. This objective has been aided by the fact that 3 of the 16 members of ACQR are geologists (J. G. Fyles, its chairman, and W. O. Kupsch and W. H. Mathews of this subcommittee), and by the holding of the ACQR and the subcommittee meetings on successive days so that a joint session could be arranged.

One move to minimize duplication of effort between the two groups was the decision to transfer responsibility for a newsletter on current progress in Quaternary geology, plus progress in other Quaternary fields, to the ACQR. It was agreed that members of this subcommittee would assist the work by serving as local reporters together with scientists in other disciplines. Unfortunately, the editor nominated by the ACQR to coordinate the work is changing jobs and preparation of the newsletter covering the 1967 year has been delayed.

One resolution passed by this subcommittee in considering the transfer of the newsletter was that it should be distributed as widely as possible to anyone (including graduate students) expressing an interest in Quaternary research.

A second problem resulted from the creation of the Inland Waters Branch, within the Department of Energy, Mines and Resources. This branch has taken over some fields, notably groundwater, which had previously been within the Geological Survey as well as within the purview of this subcommittee.

Dr. Ira Brown, formerly handling groundwater for the Geological Survey as well as serving as a member of this subcommittee, was transferred to the Inland Waters Branch; he recommended reconsideration of the position of his field vis-a-vis the subcommittee. However on his appointment to the secretariat of the Canadian National Committee for the International Hydrologic Decade he resigned from this subcommittee. Dr. J.D. Keys of the Inland Waters Branch was asked, at the last minute, to participate; time did not allow any preparation for discussion of this topic at our meeting. It has been pointed out, however, that the National Advisory Committee had been established to represent all aspects of geological research of Canada, and the change in the position of groundwater geology within the federal departmental framework does not alter the responsibilities of the National Advisory Committee or its subcommittees. To assist in clarifying its position the chairman was asked to, and has prepared a draft statement on what is believed to be the scope of this subcommittee (Appendix 2 of this subcommittee report).

Another change within the federal departmental structure that bears on this subcommittee is the creation of a Division of Quaternary Research and Geomorphology within the Geological Survey from parts of the former Geographical Branch combined with the Pleistocene Geology and Palynology and the Engineering Geology sections of the Geological Survey. As before, this change in no way alters the responsibilities of this subcommittee but it does establish a single federal agency which covers much of the field of interest of this subcommittee and may, therefore, simplify some of its work.

REPORTS

Two reports originally promoted by this subcommittee are nearly complete and the subcommittee has considered the most appropriate form of publication.

Engineering pilot studies were first proposed at the Edmonton meeting of the subcommittee in 1962*. Involved were detailed investigation and coordinated mapping in Canada in three representative areas including their topography, bedrock geology, surficial geology, soils, groundwater, and engineering geology. The objective was to demonstrate the inter-relationships of these properties, to encourage greater use of geological maps by engineers and promote appreciation by geologists of those geological characteristics which are of concern to the engineer. Three such areas were to be investigated: one each in the Prairies, Ontario, and Nova Scotia. The coordinated mapping of Edmonton and vicinity is now complete and maps and text are reported to be ready for editing. The subcommittee urges the National Advisory Committee to promote and assist the publication of the Edmonton pilot study.

As originally recommended by this subcommittee in 1962** the report on Guide to the Description of Till by J. Scott and D. St. Onge of the Geological Survey appeared in preliminary form and is to be published in its final form by the Geological Survey. Recognizing the importance of the subject to foundation engineers as well as to geologists, and the need for both groups

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*National Advisory Committee on Research in the Geological Sciences, Annual Report, 1962-63, pp. 58-59.

**Op. cit., pp. 57-58.

to have common definition of terms, it is recommended that this report be prepared also as a pocket book of the National Research Council series (which also includes Guide to the Field Description of Soils and Guide to the Field Description of Permafrost) for most effective exposure to Canadian engineers. As further recognition of the importance of this report it is recommended that either the GSC or the NRC version of the report, or both, be inexpensive, readily available, and widely distributed, and that its existence be publicized through the Canadian Journal of Earth Science and the Canadian Geotechnical Journal.

EDUCATION

A report on the problem of education and public information in Quaternary Geology has been presented by L. A. Bayrock (Appendix 3 of this subcommittee report) and discussed by the subcommittee as a whole. This clearly sets down some of the difficulties which beset geology in general and Quaternary geology in particular.

The presentation of the subject in secondary schools throughout Canada is unsatisfactory; content is meager and too often erroneous, and the mode of presentation, commonly under the guise of history or social studies, distressing. The appreciation of Quaternary geology and its economic significance at the university level is also deficient; indeed too many Canadian universities have no person specializing in this field. The lack of recognition of the subject in many engineering schools is also disturbing, as is the lack of public awareness.

Possible remedies include: 1. provision for better training of secondary school teachers in geology; 2. having a Quaternary geologist on each university geology department; 3. wide distribution of literature on Quaternary geology; 4. provision of more and better Quaternary geology displays in museums across the country; and 5. conscious efforts by qualified geologists across the country to interpret Quaternary geology to the general public.

In assessing the available resources to improve communications in the schools, the universities, and with the lay public, a list of 16 mm sound films was compiled covering aspects of geology and particularly of geomorphology and Quaternary geology (Appendix 4 of this subcommittee report). Dr. R. E. Kucera, University of British Columbia, who assembled the major part of the list and members of the subcommittee have not seen and judged all the films listed and hence the films are not rated. However, the compilation reveals an unexpectedly large supply of films some of which are ideal for purposes of instruction.

A film designed specifically for instruction at the high school level on the Quaternary history of Canada is needed. The animated diagrams showing extent of ice cover of Canada appearing in the 16 mm film "The Continuing Past" could form a vital, if brief, nucleus for a film of, say, 10 minutes duration to this end. It is recommended that the National Advisory Committee request the Geological Survey to explore the possibility of preparing such a film in the near future.

NATION-WIDE COMPILATIONS

The compilation maps by Dr. V. K. Prest, Geological Survey of Canada, showing ice-marginal positions at various stages of Wisconsin time have aroused interest; the subcommittee requests that Dr. Prest be encouraged to publish them.

The subcommittee recognizes a need for, and recommends that the Geological Survey be urged to prepare an index map of Canada on a single sheet, showing the distribution of published surficial mapping by the GSC and other agencies keyed to bibliographic references in the margin.

The subcommittee also recognizes a need for compilation maps of Canada covering a wide variety of subjects including eolian features (already underway by P. P. David), postglacial uplift (with part of the Canadian Arctic already covered by J. T. Andrews), radiocarbon dates, distribution of glacial lakes, physiographic units (such as covered by Holland for British Columbia and Bostock for the northern Cordillera) and bathymetry and modern sediments of the continental shelves and slopes. Additional regional and provincial maps showing glacial geology with appropriate special legends are also needed.

EMPLOYMENT PROSPECTS

An effort was made in February 1968 to assess the employment prospects in Quaternary geology and allied fields in Canada by means of a questionnaire. This received fairly full response from federal government agencies, but for many of the provincial agencies the query preceded the announcement of budgets and the response was rather uncertain. Response from industry and consultants were even more uncertain as the extent of summer work was not then clearly foreseeable. For these reasons a statistical report is inappropriate. Demand for groundwater geologists seems strong and for Quaternary geologists and geomorphologists about the same as last year. The demand for engineering geologists appears weak but this may stem from the timing of the questionnaire and the fact that most engineering geologists are employed by industry and consultants. Three new university appointments in Quaternary geology were being advertised at that time.

RESEARCH WORK AND PUBLICATIONS - 1967

In keeping with the decision to transfer to the Associate Committee on Quaternary Research the reporting of investigations and findings over the past year, this part of the annual report of the subcommittee has been much contracted compared with those of past years. This should not be interpreted as signifying a reduction in research; reference to annual compilation of current research* reveals no diminution in activity in the fields covered by this subcommittee and indeed a continued marked increase in groundwater studies. However, in urban geology the subcommittee must report continued and lack of activity.

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*Current Research in the Geological Sciences in Canada, 1967-68; Geol. Surv. Can., Paper 68-54, 1968.

Publications of note in the past year include:

Life, Land, and Water, I. Meyer-Oakes ed., Univ. of Manitoba press - A review of the environmental studies of the Glacial Lake Agassiz region, with contributions by Elson, Zoltai, Kupsch, et al.

A Review of Quaternary Paleobotany and Palynology in Canada, by J. Terasmae.

Geology of the City of Edmonton, pt. 1, Central Edmonton, Res. Council of Alta., Rept. 66-1.

Geology of Saskatoon.

Pleistocene Geology of the Scarboro Area, Ont. Dept. Mines, Geol. Rept. 46, by Karrow.

Several papers in the Canadian Journal of Earth Sciences by Andrews, Ayers, et al., Bayrock, et al., Dreimanis, King, Klassen, Middleton, Mott and Prest, Nasmith, et al., Roed, et al., Rozkowski and Westgate, et al., and in the Journal of Hydrology, vol. 5, by Lissen, Meyboom, and van Everdingen.

SUMMARY OF RECOMMENDATIONS

1. Frequency of subcommittee meetings - the chairman recommends a greater frequency of meetings than has prevailed in the past, perhaps aiming at one every year and a half.
2. Distribution of the ACQR Newsletter on Quaternary Research - the newsletter should be distributed by the ACQR as widely as possible to anyone (including graduate students) expressing an interest in Quaternary research.
3. Promotion of publications:
   a. Edmonton pilot study on mapping of geology, soils, engineering properties, etc. - the subcommittee urges the National Advisory Committee to promote and assist the publication of the Edmonton pilot study.
   b. Guide to the Description of Till - it is recommended that this report be prepared also as a pocket book of the NRC series (which also includes Guide to the Field Description of Soils and Guide to the Field Description of Permafrost) for most effective exposure to Canadian engineers. As further recognition of the importance of this report it is also recommended that either the GSC or the NRC version or both be inexpensive, readily available, and widely distributed, and that its existence be publicized through the Canadian Journal of Earth Sciences and the Canadian Geotechnical Journal.
   c. Maps of ice marginal positions - the compilation maps prepared by Dr. Prest showing ice-marginal positions at various stages of Wisconsin time aroused interest and the subcommittee requests that Dr. Prest be encouraged to publish these.
   d. Index map of surficial mapping - the subcommittee recognizes a need for, and recommends that the GSC be urged to prepare an index map of Canada, on a single sheet, showing the distribution of published surficial mapping (by GSC and other agencies) keyed to bibliographic references in the margin.
4. Educational film on Quaternary history - the animated diagrams showing extent of ice cover of Canada appearing in the 16 mm film "The Continuing Past" could form a vital, if brief, nucleus for a film, of say, 10 minutes duration for high school instruction. It is recommended, therefore, that

the NAC ask the Geological Survey to explore with National Film Board the possibility of preparing such a film in the near future.

5. Needed compilations - the subcommittee recognizes a need for compilation maps of Canada covering a wide variety of subjects including eolian features (already underway by P. P. David), postglacial uplift (with part of the Canadian Arctic already covered by J. T. Andrews), radiocarbon dates, distribution of glacial lakes, physiographic units (such as covered by Holland for British Columbia and Bostock for the northern Cordillera) and bathymetry and modern sediments of the continental shelves and slopes. Additional regional and provincial maps, with appropriate special legends and conventions, showing glacial geology are also required.

APPENDIX 1
TO THE REPORT OF THE
SUBCOMMITTEE ON QUATERNARY GEOLOGY

Terms of Reference
NRC Associate Committee on Quaternary Research
October 30, 1967

Scope

This Canadian Committee represents approximately the same field as the International Union for Quaternary Research (INQUA). It is concerned, primarily, with the study of environment on the earth and its history during the latest or Quaternary geological period, which extends to the present and includes the "ice age" as well as the interval of man's existence. Facets of this study fall within the disciplines of archaeology, pedology, zoology, and others, but are mutually related within the interdisciplinary field of Quaternary research.

Objectives

To stimulate and coordinate Quaternary research in Canada; to develop an awareness of its interdisciplinary nature; to foster communication between scientists of various disciplines who are engaged in Quaternary research.

To review the status of Quaternary research and training for Quaternary research in Canada; to draw attention to outstanding research and training needs and to needs for cooperation or communication; to recommend profitable avenues of new research.

On behalf of the interdisciplinary Quaternary field, to maintain close liaison with committees and organized groups within Canada that involve important elements of Quaternary research.

To serve as the Canadian National Committee for the International Association for Quaternary Research.

APPENDIX 2
TO THE REPORT OF THE
SUBCOMMITTEE ON QUATERNARY GEOLOGY

Scope of the Subcommittee on Quaternary Geology-Background

by W.H. Mathews

The National Advisory Committee on Research in the Geological Sciences was established in 1950 to coordinate geological research throughout Canada; to suggest worthwhile research projects; and to aid such research by securing finances and arranging that appropriate problems are undertaken by qualified personnel. At that time the National Research Council had no direct concern with, nor was it granting research funds in the geological field, although some of its Associate Committees were indeed involved with subjects peripheral to geology, e.g. in soil and snow mechanics and in geodesy and geophysics.

The National Advisory Committee, to facilitate its work, established a series of subcommittees, one of which was the Subcommittee on Pleistocene, Glacial, Water Supply, Engineering Geology, and Geomorphology. This unwieldy title was almost immediately shortened to "Subcommittee on Pleistocene Geology". In 1965 a proposed change to "Subcommittee on Quaternary Geology, Groundwater (or Hydrogeology), Geomorphology, and Engineering Geology" was not accepted by the NAC; instead the name was changed simply to "Subcommittee on Quaternary Geology". During the 18 year period since the NAC and its subcommittees were founded, new fields of interest, such as marine geology, have arisen and others already in existence, such as glaciology, have been found to have real pertinence to geology. Some of these fields, notably marine geology, are clearly of interest to more than one subcommittee of the NAC, and others can be of interest to both a subcommittee of the NAC and to an NRC associate committee or subcommittee. In reviewing the present field of interest of this subcommittee it is considered that overlap with that of another subcommittee or associate committee is less of a concern than an omission.

In the light of past development, both within the National Advisory Committee and within the field of geology, and of present needs, it is recommended that the Subcommittee on Quaternary Geology should be concerned with the following subjects in Canada and the floors of the adjoining seas, sharing in some cases responsibilities with other subcommittees and associate committees:

1. Quaternary stratigraphy, paleontology, and geological history.
2. Geomorphology, including
    a. the development of modern topography through both Quaternary and pre-Quaternary time, and
    b. geomorphic processes, involving any of the geological agents shaping the ground surface.
3. Groundwater geology (also known as hydrogeology) for both Quaternary and pre-Quaternary rocks, and
4. Engineering geology (including urban geology) for both Quaternary and pre-Quaternary rocks.

APPENDIX 3
TO THE REPORT OF THE
SUBCOMMITTEE ON QUATERNARY GEOLOGY

Quaternary Geology: Education and Dissemination of Information

by L. A. Bayrock

Report presented to NAC Subcommittee on Quaternary Geology, October 20, 1967.

INTRODUCTION

During the 1966 meeting of the Subcommittee on Quaternary Geology held in Ottawa, members realized that there is insufficient dissemination of information on Quaternary geology in Canada with a consequent adverse effect on research in this field and the economics of the whole country.

For this purpose a Subcommittee to the Subcommittee on Quaternary Geology was formed consisting of A. MacS. Stalker (Chairman), P. F. Karrow, and L. A. Bayrock to study the problem and perhaps to produce material for a booklet which would present information on Quaternary geology and which could be widely distributed.

The following is a short analysis of the problem of education and dissemination of information on Quaternary geology in Canada and some suggestions concerning major problems. In general the subject may be divided into four parts; 1. education of secondary school students on Quaternary geology and opportunities of employment; 2. the importance of studies of Quaternary geology in institutions of higher learning; 3. informing other branches of science of the importance of a detailed knowledge of Quaternary deposits; and 4. dissemination of information among the general population of Canada.

SECONDARY SCHOOLS

Little, if any, information on Quaternary geology is given to students of secondary schools. In high school some students are told that some thousands of years ago our country was covered by glaciers but no mention is made of the economic importance of surficial deposits. This is unfortunate, because it is at this time that young people select their careers, if not in particular, then in general. Among the factors influencing high school students in selection of careers are a general interest in a certain field of study and opportunities for employment in this field. Geology, if it is taught in high schools at all is limited to descriptions of the age of dinosaurs and flying reptiles or to finding gold and oil and in most cases, Quaternary geology is treated as part of geography; the fact that there are opportunities for employment in Quaternary geology across Canada is generally not mentioned.

To remedy this situation geology should be taught in high schools by qualified teachers with geological training, and surficial geology should be given fair coverage stressing not only its historic but also its economic importance. Occasional lectures or speeches to students by Quaternary geologists are not

effective. In 1965 about 10 guest lectures were delivered to different high schools in Edmonton and surrounding area, but the enrollment in Quaternary geology at the University of Alberta did not increase, nor was any additional interest stimulated in Quaternary geology.

A new approach is being tried in Edmonton with the cooperation of the Extension Department of the University of Alberta and the Edmonton Public and Separate School boards, whereby a program to stimulate student interest in research has been initiated. For this program a number of scientists from the University of Alberta and the Research Council of Alberta have volunteered to spend five evenings with high school students to show them some phase of research and how it is actually carried out. About fifty of the best students in the City of Edmonton are chosen each year; of these, about ten receive instruction in Quaternary geology. A small project is explained to the students in detail and then approximately three quarters of the time allotted is spent on the actual problem; field trips are also taken. At least one student of every group that took Quaternary geology subsequently has chosen Quaternary geology as his major field of study at university. As a result at least 5 bright students have been channeled into Quaternary geology in the last 5 years.

Such programs require much time and effort and cannot be set up in all major cities across Canada. Nevertheless, if a few more such programs were instituted across Canada, and Quaternary geology stressed, a higher enrollment of Quaternary geology students at our universities could be expected.

UNIVERSITY EDUCATION

Metals and oil have captured the imagination of most professional geologists in Canada. As a result, at many universities mineral exploration and exploitation is considered of utmost importance and consequently surficial geology, doesn't attract students. This may be because many geologists across Canada are not aware of the potential value of surficial geology studies and the economic aspects of surficial geology are not stressed sufficiently. It is not generally realized that the value of sand and gravel processed in Canada is 70 per cent greater than that of coal and only 25 per cent less than that of gold, and that in bulk, sand and gravel production far exceeds that of all other mineral products.

In spite of this the number of geologists engaged primarily in sand and gravel exploration in Canada is essentially zero not because there is no need for geologists in this field, but because there is an extremely low demand for trained personnel. The low demand in turn is the result of ignorance or misinformation, which can be traced back to our education institutions and particularly our universities.

This means that the importance of Quaternary geology in all of its aspects, both economic and academic, must be made more widely known to professional geologists teaching at universities throughout Canada. Because of lack of enthusiasm by professors for Quaternary geology and hence no stimulation of students for the subject, the number of Quaternary geologists graduating each year throughout Canada is small.

The teaching of Quaternary geology at university departments other than geology, such as engineering or soils, is inadequate in many universities because of lack of understanding or enthusiasm for surficial geology. A geologist learns to work with inference as well as fact; the engineer is expected to

work with facts alone. The geologist can infer that something may be encountered but the actual fact is not established until the engineer establishes it by drilling or other means. This is the area where misunderstandings exist. A geologist may contribute to, but is not usually expected to solve engineering problems, just as an engineer may contribute to but may leave unsolved problems of a geological nature. Sometimes only a very small amount of time spent on the project by a geologist can save large amounts of time and effort for the engineer, and vice-versa. A geologist may postulate on the basis of scanty data where certain formations are likely to be encountered, which is helpful to the engineer in his investigation of the actual conditions at the specific location. A geologist is often asked to do engineering work, an engineer is often asked to perform work involving surficial geology.

The above discussion points out the need for promotion of understanding of Quaternary geology in other geological sciences and, secondly, an understanding of surficial geology in the applied sciences.

Quaternary geology should receive proper coverage at university levels. The most effective means of accomplishing this would be to have a Quaternary geologist on the staff of every geology department at every Canadian university.

APPLIED SCIENCES

The various disciplines must be made aware of the benefits to be derived from the proper understanding and study of surficial geology; this applies specifically to earth sciences other than geology. It must be stressed that geologists are available in Canada specializing in the study of surficial deposits. Most of this could be done by Quaternary geologists at universities; booklets and publications in Quaternary geology pertaining to specific fields should be freely distributed with appropriate covering letters, specifically in this case to private industry.

A conscious effort should be made to inform those who work in applied sciences dealing with surficial geology of the latest results from research in this field; once the benefits to be derived from surficial geology studies are realized, demands will be made to have certain services performed.

PUBLIC EDUCATION

It must not be forgotten that the general public plays a large role in the promotion of any science. For example, although archaeology in itself has no economic significance, public interest has given it such an impetus that it overshadows Quaternary geology in Canada. One has only to visit any museum to find a large part of its exhibits devoted to archaeological finds, but few, if any, that relate to Quaternary geology. New archaeological finds are publicized immediately which is not the case in Quaternary geology; although the two fields are closely related the information the public receives from one is in no proportion to information about the other. We cannot hope to make much progress in Quaternary geology at high school levels if students are uninformed about it. Public information media such as radio, television and newspapers should be giving the public much more information about new or interesting discoveries such as a new find of a fossil elephant, the fact that Canada was

covered with thousands of feet of ice not long ago, about the number of glaciations and new theories on glaciers, and interesting data derived from detailed research.

The important museums across the country should be urged to include displays about Quaternary geology. Public lectures should be given to different social organizations to make them aware of the potential economic benefit to be derived from Quaternary geology studies. Gravel, sand, and clay deposits, are associated with different surficial deposits which can easily be found by Pleistocene geologists, as may large companies interested in the exploitation of these deposits are aware.

SUMMARY

In summary the following means to aid the dissemination of information on Quaternary geology should be explored:

1. Science teachers in secondary schools should have training in geology including an understanding of Quaternary geology.
2. Quaternary geologists should be on the faculties of all Canadian universities.
3. Quaternary literature should have wide distribution.
4. Museums in Canada should include Quaternary displays.
5. A conscious effort should be made to disseminate information on Quaternary geology to the general public throughout the country. Whether or not an organized effort is made, any marked improvement in the dissemination of information and promotion of education in Quaternary geology must rest mainly on the efforts of individual Quaternary geologists; each should strive to devote some effort to it.

APPENDIX 4
TO THE REPORT OF THE
SUBCOMMITTEE ON QUATERNARY GEOLOGY

Educational Films in Geology

ABOVE THE TIMBERLINE
16 Mins. Snd. (b/w) Colour
National Film Board of Canada (1960)

AERIAL PHOTO INTERPRETATION OF GEOLOGICAL RESOURCES
34 Mins. Colour
U.S. Geological Survey

THE ALASKAN EARTHQUAKE, 1964
U.S. Geological Survey

ARCHAEOLOGISTS AT WORK
14 Mins. Snd. (b/w) Colour
Film Associates of California (1962)
11014 Santa Monica Blvd.,
Los Angeles 25, California.

ASBESTOS . . . A MATTER OF TIME
20 Mins. Snd. Colour
Canadian Johns-Manville Co. Ltd. (1959)
Public Relations Dept.,
P.O. Box 1500,
Asbestos, Quebec.

THE BEACH - A RIVER OF SAND
Snd. Colour
Encyclopedia Britannica Films

BETWEEN THE TIDES
20 Mins. Snd. Colour
Contemporary Films (1958)

BLUE ICE
30 Mins. Colour
Films Officer,
Australian News and Information Bureau,
636 Fifth Avenue,
New York, N.Y. 10020

CANADA LANDFORM REGIONS
National Film Board of Canada

CAVERNS AND GEYSERS
13 Mins. Snd. (b/w) Colour
Film Associates of California (1961)
11014 Santa Monica Blvd.,
Los Angeles 25, California.

CHALLENGE OF THE OCEANS
29 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

CITY OF GOLD
22 Mins. Snd. (b/w)
National Film Board of Canada (1957)

CLAY (Origin of Species)
Contemporary Films

CONTINENTAL GLACIERS
20 Mins. Snd. Colour
Available from library, Division of Building Research,
National Research Council,
Ottawa, Ontario.

THE CONTINUING PAST
20 Mins. Snd. Colour
Geological Survey of Canada
National Film Board of Canada (1967)

CORAL WONDERLAND
Films Officer,
Australian News and Information Bureau,
636 Fifth Avenue,
New York, N.Y. 10020

COSMIC RAYS
20 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

CRYSTALS - AN INTRODUCTION
25 Mins. Snd. Colour
Bell Telephone Co. (1958)

THE DEPTHS OF SPACE - EXTERIOR GALAXIES
11 Mins. Snd. (b/w)
International Screen Organization (1953)
1445-18th Avenue North,
St. Petersburg 4, Florida.

DIALOGUE AVEC LA TERRE
22 Mins. Snd. French and English versions
Ministere des Richesses Naturelles,
Quebec City, Quebec.

THE ECLIPSE OF THE QUIET SUN
28 Mins. Colour
Sterling Movies USA
43 W. 61st. Street,
New York, N.Y. 10025

EROSION - LEVELING THE LAND
14 Mins. Colour
Encyclopedia Britannica Films

ERUPTION OF KILAUEA 1959-60
29 Mins. Snd. Colour
U.S. Geological Survey (1961)

EVIDENCE FOR THE ICE AGE
19 Mins. Colour

THE FACE OF THE HIGH ARCTIC
13 Mins. Snd. (b/w) Colour
National Film Board of Canada (1959)

THE FLAMING SKY
29 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

THE FOSSIL STORY
18 Mins. Snd. Colour
Shell Oil Co. (1953)

FROST ACTION IN SOILS
20 Mins. Snd. Colour
Cold Regions Research and Engineering Lab.
Available from the library, Division of Building Research,
National Research Council,
Ottawa, Ontario.

GALVESTON ISLAND BARRIER
28 Mins. Colour
Modern Talking Pictures
1212 Avenue of the Americas,
New York, N.Y. 10036

GEOLOGY OF YELLOWSTONE
16 Mins. Colour
Western America Films
426 N. 10th Avenue,
Bozeman, Montana. 59715

GLACIATION
11 Mins. Colour
National Film Board of Canada

THE HIDDEN EARTH
29 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

HIGH ARCTIC: LIFE ON THE LAND
22 Mins. Snd. (b/w) Colour
National Film Board of Canada (1959)

IN THE BEGINNING
28 Mins. Snd. Colour
Socony Mobil Oil Co. (1959)
150 East 42nd Street,
New York, 17, N.Y.

THE INCONSTANT AIR
29 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

ISLAND OF THE FROZEN SEA
30 Mins. Snd. (b/w)
National Film Board of Canada (1959)

LIFE BETWEEN TIDES
11 Mins. Snd. (b/w) Colour
Enclyclopedia Britannica Films (1963)
67 Kipling Avenue S.,
Toronto 18, Ontario.

THE MAGIC MINERAL
13 Mins. Snd. (b/w)
National Film Board of Canada (1959)

MAGNETIC FORCE
29 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

MAN WITH A THOUSAND HANDS
33 Mins. or 59 Mins. Snd. Colour
Modern Talking Pictures
1212 Avenue of the Americas,
New York, N.Y. 10036

MEN AGAINST THE ICE
24 Mins. Snd. (b/w)
National Film Board of Canada (1960)

MINERAL EXPLORATION
13 Mins. Colour
Films Officer,
Australian News and Information Bureau,
636 Fifth Avenue,
New York, N.Y. 10020

MINING FOR NICKEL
41 Mins. Snd. Colour
International Nickel Co. of Canada Ltd. (1955)

THE MOUNTAIN MOVERS
11 Mins. Snd. (b/w)
National Film Board of Canada (1952)

MOUNTAINS OF THE WEST
20 Mins. Snd. (b/w)
National Film Board of Canada (1954)

MYSTERY OF TIME
Moody Institute Films
11428 Santa Monica Blvd.,
Los Angeles 25, California.

NAHANNI
18 Mins. Snd. (b/w) Colour
National Film Board of Canada (1962)

OCEAN TIDES - BAY OF FUNDY
15 Mins. Snd. Colour
Encyclopedia Britannica Films (1956)
67 Kipling Avenue S.,
Toronto 18, Ontario.

OUR NEAREST STAR
29 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

THE PETRIFIED RIVER
27 Mins. Colour
Modern Talking Pictures
1212 Avenue of the Americas,
New York, N.Y. 10036

REFINING COPPER FROM THE SUDBURY NICKEL ORES
39 Mins. Snd. Colour
International Nickel Co. of Canada Ltd. (1959)

REFINING NICKEL FROM THE SUDBURY ORES
52 Mins. Snd. Colour
International Nickel Co. of Canada Ltd. (1957)

REFINING PRECIOUS METALS FROM THE SUDBURY NICKEL ORES
29 Mins. Snd. Colour
International Nickel Co. of Canada Ltd. (1960)

THE RESTLESS SEA
N.W. Bell Telephone Co.

THE RICHES OF THE EARTH
18 Mins. Snd. (b/w) Colour
National Film Board of Canada (1954)

THE RIVER MUST LIVE (Water Pollution)
25 Mins. Snd. Colour
Shell Oil Company

RIVERS IN MINIATURE
14 Mins. Snd. Colour
U.S. Army Corps of Engineers (1954)

ROCKS THAT FORM ON THE EARTH'S SURFACE
16 Mins. Colour
Encyclopedia Britannica Films

ROCKS THAT ORIGINATE UNDERGROUND
Encyclopedia Britannica Films

SCHLIEREN COLOR PHOTOGRAPHY - A RESEARCH TOOL
Shell Oil Company

SCIENCE OF THE SEA
19 Mins. Snd. Colour
International Film Bureau (1961)

THE SEA RIVER
13 1/2 Mins. Colour
U.S. Geological Survey

SEARCH BENEATH THE SEA
Shell Oil of Canada

SECRETS OF THE ICE
29 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

THE SHAPE OF THE EARTH
29 Mins. Snd. (b/w) Colour
McGraw-Hill Text-Films (1960)

SNOW
13 Mins. Snd. (b/w)
Film Associates of California (1961)
11014 Sants Monica Blvd.,
Los Angeles 25, California.

SPEAKING OF MODELS
22 Mins. Snd. Colour
U.S. Army Corps of Engineers (1958)

THE SPRUCE BOG
23 Mins. Snd. Colour
National Film Board of Canada (1956)

TIDES AND CURRENTS
18 Mins. Snd. Colour
U.S. Coast and Geodetic Survey (1955)

UNIVERSAL GRAVITATION
32 Mins. Snd. (b/w)
Modern Learning Aids (1960)
1212 Avenue of the Americas,
New York, N.Y. 10036

UNIVERSE
28 Mins. Snd. (b/w)
National Film Board of Canada (1950)

THE UNKNOWN OCEAN
26 1/2 Mins. Colour
Films Officer,
Australian News and Information Bureau,
636 Fifth Avenue,
New York, N.Y. 10020

VOLCANO SURTSEY
26 Mins. Colour
North Shore News Co., Inc.,
Mt. Vernon Street,
Lynn, Massachusetts. 01901

WATER MOVEMENT IN THE SOIL
25 Mins. Snd.
Washington State University,
Pullman, Washington. 99163

WAVES ON WATER
16 Mins. Colour
Encyclopedia Britannica Films

WHAT MAKES CLOUDS?
19 Mins. Colour
Encyclopedia Britannica Films

WHAT MAKES THE WIND BLOW?
17 Mins. Colour
Encyclopedia Britannica Films

WHY DO WE STILL HAVE MOUNTAINS?
20 Mins. Colour
Encyclopedia Britannica Films
WORLD IN A MARSH
22 Mins. Snd. Colour
National Film Board of Canada (1955)

REPORT OF THE SUBCOMMITTEE ON SCHOLARSHIP AND RESEARCH TRAINING

Presented by Robert Sabourin

Members of Subcommittee

R. Sabourin (Chairman)	Université Laval, Quebec, Que.
Jacques Béland	Université de Montreal, Montreal, Que.
L. G. Berry	Queen's University, Kingston, Ont.
W. D. Brueckner	Memorial University of Newfoundland, St. John's, Nfld.
B. J. Burley	McMaster University, Hamilton, Ont.
A. R. Byers	University of Saskatchewan, Saskatoon, Sask.
C. G. I. Friedlaender	Dalhousie University, Halifax, N. S.
W. H. Mathews	University of British Columbia, Vancouver, B. C.
A. L. McAllister	University of New Brunswick, Fredericton, N. B.
E. W. Nuffield	University of Toronto, Toronto, Ont.
H. S. Perdue	Brandon University, Brandon, Man.
R. D. Russell	University of British Columbia, Vancouver, B. C.
G. D. Williams	University of Alberta, Edmonton, Alta.
J. T. Wilson	University of Toronto, Toronto, Ont.
C. G. Winder	University of Western Ontario, London, Ont.

Response to this year's questionnaire to members of the subcommittee was encouraging. A temporary slackening in employment offers at Université Laval prompted an inquiry to find out if this reflected a trend. All universities reported that as in the past, employment offers for graduates in geology were sufficient for all students and in many cases exceeded the number available. The situation is also back to normal at Laval. Most universities report that student enrolment in geology is increasing gradually. One university notes a trend of increasing enrolment in engineering geology and a decrease in honours geology. Student interest is mostly towards "hard rock" fields.

The present survey has brought two important subjects to the attention of this subcommittee. One is the great need, at least in some parts of the country, for properly trained technicians to operate the more and more sophisticated equipment being used by both university and industry. Graduates of good technical schools in chemistry and electronics make excellent laboratory assistants in laboratories using this type of equipment. A listing of the various technical schools throughout the country with the programs or courses each offers would be most useful to potential employers of their graduates in the universities and in industry.

Certain problems in connection with foreign graduate students should be considered. Some type of common clearinghouse for applicants is needed, perhaps through the Commonwealth Geological Surveys group, for processing of all applications, grading of various degree-granting institutions, assuring funds because practically all applicants require financial assistance, and assuring employment in their own country after their graduate work has been completed. Very few foreign students wish to return home because of difficulties in obtaining employment and many are not suitable for the jobs that industry has to offer in Canada. Canada has a moral obligation to the emerging nations. The training of earth scientists is one concrete way of honouring this obligation but every effort should be made to ensure that these nations benefit fully from the training given their nationals. The February 1968 issue of Geotimes (p. 10) describes one interesting method of accomplishing this.

Professor McAllister, submits the following plea for support of education and research in the field of the mineral sciences:

> "May I again return to the problem of enrolment and the position of our geology departments in the university hierarchy. For decades geology departments have been regarded as the poor cousins within science faculties. This has undoubtedly resulted in part from our historical associations with field problems and our relatively recent entry into more-sophisticated laboratory approaches involving large and expensive pieces of apparatus and normal facilities for chemical and physical measurements. I believe that an examination of most university budgets, as well as figures showing disbursement of research funds, will suggest we still have not established ourselves in the position our science warrants.
>
> "The acute shortages of professional personnel in the mineral resources fields, coupled with the importance of the mineral industry to the Canadian economy, makes a compelling argument for a complete new approach to support of education and research in our educational institutions.
>
> "The National Science Foundation in the U.S.A. has already recognized the inability of existing institutions to provide the numbers of

graduates of the quality demanded by the present technological society, and will attempt to up-grade a number of departments to levels previously attained by only fifteen or twenty of the top departments in the country. This is not done by supplying research and equipment grants on a normal scale, but involves pumping large quantities of money, sufficient to cover capital expenditures, equipment, certain operating expenses, etc., into specified departments.

"It might well be reasoned that only by such an approach will the Canadian educational facilities in the mineral sciences be brought to the level where the support warranted by the industry is in fact supplied.

"The National Research Council has recognized the validity of such a principle in the establishment of its Development Grant program. I doubt, however, that this will in the long run affect the programs in geology and mining engineering. These grants are most likely to go to those branches of the university already well established in expensive and sophisticated programs, and most likely not to the relatively underdeveloped departments most in need."

Important federal funds are presently being allocated for water resources research; perhaps the National Advisory Committee could recommend similar development grants for mineral resources research.

DISCUSSION OF REPORT

A lengthy discussion followed presentation of the report on the large proportion of foreign graduate students from the emerging nations in geology departments in Canadian universities; which is probably also true of other science departments.

The concensus was that in general the foreign students brought to Canada under External Aid programs such as the Columbo Plan are receiving valuable and practical training and experience, and are returning to their countries. However, foreign graduate students supported by other means do not wish to return probably because they are not suitably trained for jobs that industry has to offer in their countries. This in turn is because they tend to choose highly specialized fields in which to train.

In regard to the suggestion in the report that a survey be made of the various technical schools throughout Canada and their programs (p. 42), the Secretary of the NAC was asked to explore how readily this could be carried out and made available to geoscience departments across Canada.

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, Calgary, Alta.
N. M. Ediger	British American Oil Co. Ltd., 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.
Stuart S. Holland	Department of Mines and Petroleum Resources, Victoria, B. C.
R. R. Potter	Department of Natural Resources, Fredericton, N. B.
F. Raynes	Cominco, Ltd., Montreal, Que.
S. C. Robinson	Geological Survey of Canada, Ottawa, Ont.
D. R. E. Whitmore	Geological Survey of Canada, Ottawa, Ont.
H. R. Wynne-Edwards	Queen's University, Kingston, Ont.

D. J. Youston (Consultant) D. F. C. Systems Ltd., Toronto, Ont.

INTRODUCTION

On April 25, 1967 the ad hoc Committee on Storage and Retrieval of Geological Data in Canada presented 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. Included in the report is a program for the implementation and continued development of such a system.

The National Advisory Committee adopted the report of the ad hoc Committee and, as recommended in the report, appointed a Standing Committee on Storage and Retrieval of Geological Data in Canada under the chairmanship of Dennis A. Sharp, Department of Energy and Resources Management, Toronto. The name of the Standing Committee was subsequently changed to Subcommittee on Storage and Retrieval of Geological Data in Canada. The Subcommittee was instructed to consider immediately the establishment and method of financing of the proposed secretariat and the implementation of the other recommendations in the report.

The Subcommittee met three times during the 1967-68 fiscal year: at Toronto, June 8, 1967; Montreal, September 27, 1967; and Calgary, February 13 and 14, 1968. In addition a meeting of subcommittee chairmen was held in Ottawa on November 8, 1967. Business and programs discussed at these meetings included responsibilities of the proposed Secretariat; selection of a National Coordinator, Geological Data Systems; publication of the ad hoc Committee report on a National System for Storage and Retrieval of Geological Data in Canada; current developments in electronic data-processing in the earth sciences, both in Canada and abroad; educational and information programs to assist industry, governments and universities in developing computer-processable geological data files; the operating budget for this subcommittee, its subcommittees and the proposed Secretariat; progress reports and objectives of the various subcommittees.

PROPOSED SECRETARIAT

The ad hoc Committee report emphasizes that the National System for Storage and Retrieval of Geological Data can attain its objectives only under the aegis of a continuing organization that would implement the recommendations of the ad hoc Committee. The proposed organization and terms of reference of the Secretariat as envisaged and recommended by this subcommittee are detailed in Appendix 2 of this subcommittee report.

Under the terms of reference for the National Advisory Committee and its subcommittees the role of the Subcommittee on Storage and Retrieval

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

of Geological Data is advisory and not operative; therefore the operations and development of the National System must be carried out by the proposed Secretariat. However, as an interim measure the Subcommittee recommends that it maintain direct supervision and control over the Secretariat until such time as a permanent organizational and financial structure is established. The relations of the National Advisory Committee, the Subcommittee and the Secretariat are depicted diagramatically in Figure 1.

During 1968-69 the Secretariat will be housed by the Geological Survey of Canada in Ottawa; secretarial services etc. will also be provided by the Geological Survey. The Subcommittee is confident that the services provided by and through the Secretariat will be of such value that the continuing organization will be financed by industry and the federal and provincial governments. However, for the present it is recommended that funds for the Secretariat be supplied by the federal government. If such funds are not available through the Department of Energy, Mines and Resources it is recommended that some other appropriate federal agency support this program. The federal and provincial governments should foster the Secretariat until additional direct financial support is forthcoming from industry.

PUBLICATION OF REPORT OF AD HOC COMMITTEE ON STORAGE AND RETRIEVAL OF GEOLOGICAL DATA

The report of the ad hoc Committee entitled A National System for Storage and Retrieval of Geological Data in Canada was published in September 1967. Copies are available from the Geological Survey of Canada at $2.00 each.

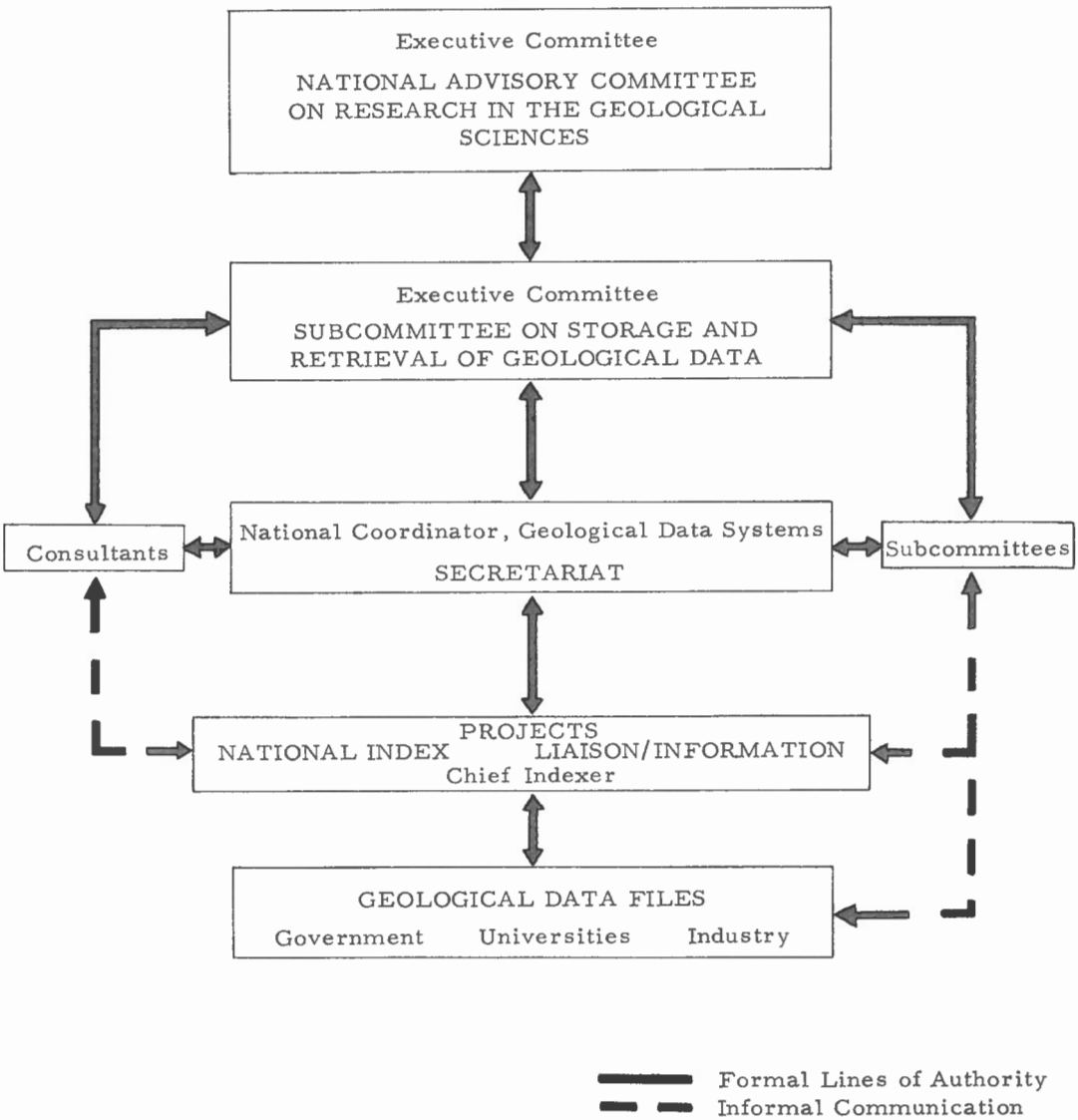
Some 900 complimentary copies were distributed. The complimentary list included the members of the National Advisory Committee, the ad hoc Committee and its subcommittees, government departments, university geology departments, persons having correspondence with the ad hoc Committee, members of the IUGS Committee on Storage, Processing and Retrieval of Geological Data, primary technical and business publications and the Geological Survey of Canada complimentary list. About 300 letters were sent by the Chairman to introduce the report and request comments. A press release was forwarded to most English- and French-language papers and technical publications in Canada and major international papers and technical publications; comments and reviews of the report have been favourable.

The list of those receiving complimentary copies of the report will be used for primary distribution of bulletins from the Secretariat.

SEMINARS AND WORKSHOPS

In an effort to educate the geological fraternity on the work of the Subcommittee and the proposed National System, and to provide a forum for discussion on matters related to data processing in the geological sciences, this Subcommittee is promoting a series of seminars and workshops across Canada. These seminars and workshops, although initiated by the Subcommittee, have been sponsored by a local body or organization wherever practical.

The first of these meetings, held in Toronto on February 7, 1968, was sponsored by the Ontario Department of Mines. The topics discussed



ORGANIZATION OF NATIONAL SYSTEM FOR STORAGE AND RETRIEVAL OF GEOLOGICAL DATA

Figure 1

included: the concept and objectives of a national system for the storage and retrieval of geological data in Canada; development of computer applications in the earth sciences; the role of the provincial governments in developing computer-processable files; system requirements for the resource industries; and a general panel discussion on computer applications.

Ninety persons attended the Toronto meeting, representing a broad cross-section of industry, government and the universities. The general response at the meeting and to subsequent questionnaires distributed by the Ontario Department of Mines indicates that much interest was generated. The need for basic standards such as proposed through continued development of the National System was generally confirmed.

The success of this meeting has encouraged the Subcommittee to promote additional seminars and workshops. More-detailed and specific discussions regarding a particular area of geological data file development are planned for the workshop sessions.

Seminars or workshops are planned in New Brunswick, Montreal, Que., and in Manitoba and Alberta during 1968.

ACTIVITIES OF SUBCOMMITTEES

University Grants

Subsequent to the Geological Survey of Canada agreeing to provide $50,000 for special grants-in-aid of research in the development of computer-processable files of geological data as recommended by the ad hoc Committee on Data Storage and Retrieval, a subcommittee on university grants was set-up by this Subcommittee in September 1967.

Meetings of the Grants Subcommittee were held in October and November 1967. Early in 1968 W. C. Brisbin, Chairman, met with the Director and other members of the Geological Survey of Canada to decide on procedures and draw-up an application form for the special grants. In early February, applications forms were mailed by the Geological Survey to Canadian universities.

The application forms include sections giving the background of the grants, their general objectives and sources of data and scope of the files. As recommended by this Subcommittee it is suggested that:

1. Research supported by the special grants be carried out initially on the development of data files in the fields of mineral deposits, fossil fuels and geological field data; research should include the testing and evaluation of the proposed provincial standards for defining and recording data recommended in the report on the National System for Storage and Retrieval of Geological Data in Canada.
2. The research should include use of data files based on these standards; such research should be planned by the research workers to suit their specific objectives.

The general objectives of the special grants include the testing, evaluating, and modifying or augmenting the recommended standard entries and specifications for computer files.

Applications, open to university academic staff, are received by the Director, Geological Survey of Canada up to March 31st of each year. Applicants are notified early in May whether or not they are being recommended for grants.

Files of Data on Fossil Fuels Deposits

The Fossil Fuels Subcommittee completed its study early in 1967; its report and recommendations are published in the ad hoc Committee report (Chapt. 15, pp. 68-77).

During the latter part of 1967 and early 1968 C. F. Burk Jr., Chairman of this Subcommittee, held discussions with the universities of Alberta and Calgary, the Alberta Oil and Gas Conservation Board and the Institute of Sedimentary and Petroleum Geology regarding the feasibility of initiating a fossil fuels deposits data file. The University of Alberta, the Alberta Oil and Gas Conservation Board and the Institute of Sedimentary and Petroleum Geology have expressed interest in such a file.

Files of Data on Mineral Deposits

The Mineral Deposits Data Subcommittee met twice during 1967-68 to consider means of implementing the recommendations in the ad hoc Committee report (Chapt. 14, pp. 54-58) on mineral deposits data files.

The Chairman of the Subcommittee, D. R. E. Whitmore, with the cooperation of subcommittee members from Saskatchewan, Quebec and New Brunswick, initiated a test file (M file) using a format based on the recommendations in the report. However, it was felt the development of such a file, even on a test basis, was not a suitable subcommittee activity. Further development of the M file will be carried out by the Geological Survey of Canada.

Preliminary steps were taken by subcommittee member S. A. Ferguson toward establishment of a machine-processable mineral deposits index in Ontario. Other provincial departments are expected to take similar action shortly; this subcommittee is prepared to offer every assistance. In particular we propose to demonstrate the application of files of mineral deposits data by holding workshops in 1968 in the Maritimes, Quebec, Ottawa, Toronto and Winnipeg.

The subcommittee as a whole and individually will keep in close touch and assist the mineral deposits data project supported by Geological Survey grants; close liaison will be maintained between these projects and the Secretariat. At the close of a productive and satisfying year of activity, the subcommittees objectives remain to: 1. promote the establishment of a network of files of machine processable data on mineral deposits, and 2. to develop and test formats and potential applications.

Geochemical Data Files

The wealth of data being collected by geochemists and the number of diverse formats presently in use prompted the establishment of a subcommittee on geochemistry in February 1968 with Robert G. Garrett, Geological Survey of Canada as Chairman. This subcommittee will maintain close liaison with the subcommittee on geological field data to ensure coordination in these fields.

Files of Geological Field Data

After publication of its report and recommendations (ad hoc Committee Report, Chapt. 13, pp. 48-53) the Subcommittee on Geological Field Data Files was reorganized to involve more closely those in industry, government and university using recording methods applicable to data processing. Robert Bergeron, Quebec Department of Natural Resources, succeeded Robert Assad as Chairman of the Subcommittee.

At a meeting in Calgary in February 1968, J. A. Roddick and W. W. Hutchison, Geological Survey of Canada presented a summary of the procedures being used in recording data in mapping the Coast Mountains of British Columbia. This project is an excellent example of the potential for collection of field data in computer processable form.

Additional programs for the 1968 field season which will use data processing techniques that follow, in whole or part, the recommendations of the Subcommittee on Geological Field Data include Operation Norman (Geological Survey of Canada) and projects of the Ontario Department of Mines, the Quebec Department of Natural Resources and Canadian Pacific Oil and Gas Limited.

It is hoped that the recommendations contained in the ad hoc Committee Report on the collection of geological field data will be followed where possible. However, the primary objective is to encourage as many pilot projects as possible in a variety of geological provinces during the 1968 field season. The results and problems encountered in such projects will be discussed at a meeting to be held soon after the close of the field season. In the use of the recommended format, emphasis should be placed on the collection of new data rather than on the reorganization of existing field data.

Files of Geophysical Data

Since the publication of the report of the Subcommittee on Geophysical Field Data Files (ad hoc Committee Report, Chapt. 16, pp. 80-81) there have been several developments pertaining to the parameters recommended for inclusion in various geophysical surveys.

The standards in Appendix 7H of the ad hoc Committee report which deals with data required for well logging are being discussed by a subcommittee of the Canadian Petroleum Association and the American Petroleum Institute. The joint CPA-CPI standards are expected to cover both the header data and the curve data. When established, they will be reviewed and probably replace Appendix 7H.

Reviews and checks of the parameter lists have been made with some members of the geophysics subcommittee. Further checks will be made with western Canadian members and with other workers in various fields of geophysics. Extensive changes are indicated in Appendix 7G - Rock Magnetism.

National Index

The National Index Subcommittee met twice in 1967-68. Because it is probable that the National Index will be operational on a limited basis in

late 1968, considerable attention was devoted to deciding on the organization of the National Index within the framework of the Secretariat, and arranging for the modification of the Imperial Oil Limited Streamed Information System programs to meet anticipated computer configuration requirements.

The first step towards making the National Index a reality was taken by the Geological Survey of Canada in August 1967. B. A. McGee was employed by the Geological Survey to set-up an index for the Survey, adopting the Streamed Information System and other recommendations set forth by the National Index Subcommittee. In addition to Mr. McGee, two junior indexers have subsequently been employed.

The first project undertaken by the Geological Survey involves the indexing of geological and geophysical maps published by the Geological Survey of Canada; the results to date have been most encouraging.

The Ontario Department of Mines and the Quebec Department of Natural Resources have expressed an interest in initiating indexes to geological data in their respective provinces. Both provinces wish also to use the Streamed Information System and contribute to the National Index.

Conversion of the existing Imperial Oil Limited Streamed Information System program to an IBM 360 format is well underway. Organizations committed to contribute to this conversion include Imperial Oil Limited, University of Saskatchewan, Geological Survey of Canada and the University of Calgary; the Alberta Research Council and the University of Manitoba are also considering participating in the program. Conversion of the first three stages, which will be equivalent to the existing system, is scheduled for completion by October 1968.

The staff of the National Index will consist initially of a chief indexer and one assistant, with additional staff as required. The Streamed Information System programs will be used and the National Index will require access to computer facilities. This group will be responsible for the maintenance, printing, publishing and distribution of the National Index.

By October 1968, it is anticipated that input documents prepared by the Geological Survey of Canada and at least one other agency will be available to the National Index. However, since the 1968-69 operating budget for the Secretariat does not provide sufficient funds to staff the National Index, the Subcommittee recommends that the Geological Survey of Canada be approached with a view to providing, as an interim measure, part-time assistance to the National Index for the period October 1, 1968 to March 31, 1969. Such assistance, if provided by the Geological Survey indexing staff, will require less than 25 per cent of their time.

It is further recommended that the Minister of Energy, Mines and Resources invite each provincial Minister of Mines to send a man to Ottawa for training in indexing by the Geological Survey indexing staff. Such a program would be limited to one provincial indexer at any one time. The Subcommittee believes that this program would ensure the coordinated development of the National Index.

The Geological Survey of Canada has indicated that if such a training program is undertaken, June 1, 1968 would be an appropriate starting date; a three-month training program could be normally anticipated.

RECOMMENDATIONS

1. That the program of the Subcommittee be approved and that the National Advisory Committee take prompt action to insure that:
    a. Close liaison is maintained between this Subcommittee and the other subcommittees of the National Advisory Committee.
    b. Subject to Canada's acceptance as host for the 1972 Geological Congress, consideration be given to establishing a working committee to undertake a feasibility study on presenting a significant data processing display for this meeting.
2. That the Subcommittee be authorized to investigate all possible sources from which future financial support can be secured for the operation of the Secretariat and, in particular, the National Index.
3. That this Subcommittee, in cooperation with the Geological Survey of Canada, investigate the various implications on the availability of data collected by public agencies in computer-processable form. This study would be concerned with the availability of data both prior to, and after publication of the interpreted results.
4. That the Geological Survey of Canada be approached to provide indexing staff for the National Index on an interim part-time basis for the period October 1, 1968 to March 31, 1969.
5. That the Minister, Department of Energy, Mines and Resources invite each provincial Minister of Mines to send one man to Ottawa to receive training on indexing and the National Index.
6. That the National Advisory Committee maintain close liaison with the Mines Ministers' Conference on matters of common interest.

DISCUSSION OF REPORT

In opening discussion of the report the Chairman pointed out that in 1964 the National Advisory Committee had asked the Geological Survey of Canada to study the need for a National System and Index. The Geological Survey had done this and reported the result of this study in 1965 (S. C. Robinson's report). As recommended in this report an ad hoc Committee has been set-up in 1965 to develop a National System for Storage and Retrieval of Geological Data. In 1966 the ad hoc Committee presented a preliminary report and in April 1967, its final report recommending among other things the establishment of a Secretariat and Standing Subcommittee on the Storage and Retrieval of Geological Data. This Subcommittee was established in 1967 under the Chairmanship of D. A. Sharp, Ontario Department of Energy and Resources Management and instructed to consider the establishment and method of financing of the Secretariat and the implementation of other recommendations in the ad hoc Committee report.

Mr. Sharp, supported by Mr. Buller, emphasized the desire of the members of the Subcommittee to have the Secretariat completely divorced from any Federal organization; the Secretariat should be set-up as a completely independent entity, supported by grants from federal and provincial governments and eventually by industry also.

In a lengthy discussion of the recommendations (p.) several were deleted or revised. Some changes were also suggested in the arrangement and wording of the report. The Committee endorsed the establishment

of a Secretariat for the development of the National System and Index for Storage and Retrieval of Geological Data in Canada and asked the Subcommittee to continue its study of how this may be best accomplished.

Mr. Sharp was asked to convey to the members of the Subcommittee the Committee's appreciation of the report and their accomplishments over the year.

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

Subcommittees of the Subcommittee on Storage and Retrieval of Geological Data

Subcommittee on University Grants

W. C. Brisbin, Chairman,
University of Manitoba,
Winnipeg, Man.

D. A. Sharp,
Department of Energy & Resources Management,
Toronto, Ont.

H. R. Wynne-Edwards,
Queen's University,
Kingston, Ont.

Subcommittee on Fossil Fuels Deposits Data

C. F. Burk, Jr., Chairman,
Geological Survey of Canada,
Calgary, Alta.

J. V. Buller,
Department of Mineral Resources,
Regina, Sask.

S. S. Cosburn,
Department of Mines and Petroleum Resources,
Victoria, B. C.

N. M. Ediger,
The British American Oil Co. Ltd.,
Toronto, Ont.

L. A. Falkenberg,
Oil and Gas Conservation Board,
Calgary, Alta.

Subcommittee on Fossil Fuels (cont.)

M. Houde,
Department of Natural Resources,
Quebec, Que.

S. Kanik,
Department of Indian Affairs and Northern Development,
Ottawa, Ont.

S.A. Kerr,
National Energy Board,
Ottawa, Ont.

H.R. McCabe,
Department of Mines and Natural Resources,
Winnipeg, Man.

J.R. Pow,
Oil and Gas Conservation Board,
Calgary, Alta.

D.A. Sharp,
Department of Energy & Resources Management,
Toronto, Ont.

D.L. Stauft,
Imperial Oil Enterprises Ltd.,
Calgary, Alta.

Subcommittee on Mineral Deposits Data

D.R.E. Whitmore, Chairman,
Geological Survey of Canada,
Ottawa, Ont.

W.C. Brisbin,
University of Manitoba,
Winnipeg, Man.

A.E. Buller,
Consulting Geologist,
Toronto, Ont.

R.L. Cheesman,
Department of Natural Resources,
Regina, Sask.

J. Dugas,
Department of Natural Resources,
Quebec, Que.

Subcommittee on Mineral Deposits (cont.)

*N.M. Ediger,
The British American Oil Co. Ltd.,
Toronto, Ont.

S.A. Ferguson,
Department of Mines,
Toronto, Ont.

W.D. Harrison,
Falconbridge Nickel Mines Ltd.,
Port Arthur, Ont.

S.S. Holland,
Department of Mines and Petroleum Resources,
Victoria, B.C.

R.R. Potter,
Department of Natural Resources,
Fredericton, N.B.

H.R. Wynne-Edwards,
Queen's University,
Kingston, Ont.

*Note: N.M. Ediger was appointed Chairman, effective April 1, 1968.

Subcommittee on Geochemical Data

R.G. Garrett, Chairman,
Geological Survey of Canada,
Ottawa, Ont.

Subcommittee on Geological Field Data

R. Assad, Chairman,
Department of Natural Resources,
Quebec, Que.

K.R. Dawson,
Geological Survey of Canada,
Ottawa, Ont.

N.M. Ediger,
The British American Oil Co. Ltd.,
Toronto, Ont.

J.E. Reesor,
Geological Survey of Canada,
Ottawa, Ont.

Subcommittee on Geological Field Data (cont.)

S. C. Robinson,
Geological Survey of Canada,
Ottawa, Ont.

D. R. E. Whitmore,
Geological Survey of Canada,
Ottawa, Ont.

D. M. R. Wilson,
Northern Alberta Institute of Technology,
Edmonton, Alta.

Note: R. Bergeron, Quebec Department of Natural Resources, was appointed Chairman, effective April 1, 1968.

Subcommittee on Geophysical Data

A. S. Gibson, Chairman,
Imperial Oil Enterprises Ltd.,
Calgary, Alta.

B. K. Bhattacharyya,
Geological Survey of Canada,
Ottawa, Ont.

J. B. Cameron,
Pan American Petroleum Corp.,
Calgary, Alta.

F. S. Grant,
University of Toronto,
Toronto, Ont.

E. R. Kanasewich,
University of Alberta,
Edmonton, Alta.

L. W. Morley,
Geological Survey of Canada,
Ottawa, Ont.

M. S. Reford,
Consultant,
Hull, Que.

Subcommittee on National Index

F. Raynes, Chairman,
Cominco Ltd.,
Montreal, Que.

R. Assad,
Department of Natural Resources,
Quebec, Que.

J.W. Cherry,
Imperial Oil Enterprises Ltd.,
Calgary, Alta.

K.R. Dawson,
Geological Survey of Canada,
Ottawa, Ont.

A.S. Gibson,
Imperial Oil Enterprises Ltd.,
Edmonton, Alta.

J.A.F. Haddon,
Department of Mines,
Toronto, Ont.

S.S. Holland,
Department of Mines and Petroleum Resources,
Victoria, B.C.

J.R. Smith,
Saskatchewan Research Council,
Saskatoon, Sask.

D.R.E. Whitmore,
Geological Survey of Canada,
Ottawa, Ont.

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

Proposed Organization of Secretariat

1. Membership

The Secretariat on Storage and Retrieval of Geological Data shall consist of the National Coordinator, Geological Data Systems, and such staff as are appointed to implement the National System, including the National Index.

2. Terms of Reference

a. Relationship with the Subcommittee on Storage and Retrieval of Geological Data

The Coordinator will:

i. Work under the direction of the Subcommittee to implement its policies.
ii. Report progress in writing to the Subcommittee in advance of each meeting.
iii. Submit such written reports of progress as required by the Chairman of the Subcommittee.
iv. Attend such meetings of the Subcommittee as may be required.
v. Attend meetings of subcommittees, if requested by the subcommittee chairman.

b. Development of the National System

To assist in the continued development of the National System, the Coordinator will:

i. Ensure maximum awareness of the National System, including the National Index, among workers in the Earth Sciences in Canada.
ii. Foster development of the National System, through visits, discussions and correspondence with users and potential users of computer-processable files of geological data.
iii. Supervise the chief indexer of the National Index.

c. Pilot Projects

The Coordinator has particular responsibilities for pilot projects. To develop and test the recommendations of the Subcommittee, the Coordinator will:

i. Coordinate university pilot projects supported by Geological Survey grants for research in the development of computer-processable files of geological data.
ii. Maintain liaison with other projects in industry, government and universities.
iii. Encourage and assist organizations and individuals in establishing and developing geological data files which conform to the principles and standards recommended for the National System.

d. Information Services

The Coordinator will provide an information service on the National System and related activities. In particular, the Coordinator will:

i. Reply to questions from interested individuals and organizations, or refer such questions for answer by the Subcommittee, appropriate subcommittee or consultants.
ii. Prepare and distribute bulletins at regular intervals to interested individuals and organizations, so that they are made aware of developments in the National System.

iii. Distribute copies of reports, papers and articles on aspects of the National System.

e. International Activities

Subject to approval by the Chairman, the Coordinator will:

i. Represent the Subcommittee at meetings and conferences held outside Canada that are relevant to the work in Canada.

ii. Maintain liaison with individuals and organizations outside Canada who are involved in developments of direct interest.

3. Consultants

The Secretariat may have formal access to consultants through the Subcommittee.

REPORT OF THE SUBCOMMITTEE ON STRATIGRAPHY, PALEONTOLOGY AND SEDIMENTOLOGY

Presented by C. W. Stearn

Members of Subcommittee

C. W. Stearn (Chairman)	McGill University, Montreal, Que.
W. J. Braun	University of Saskatchewan, Saskatoon, Sask.
R. P. Glaister	Imperial Oil Ltd., Calgary, Alta.
J. W. Kerr	Geological Survey of Canada, Calgary, Alta.
Jean Lajoie	Université de Montréal, Montreal, Que.
G. V. Middleton	McMaster University, Hamilton, Ont.
J. W. Murray	University of British Columbia, Vancouver, B. C.
P. E. Schenk	Dalhousie University, Halifax, N. S.
C. G. Winder	University of Western Ontario, London, Ont.

INTRODUCTION

The Subcommittee met at the Institute of Sedimentary and Petroleum Geology in Calgary on January 26, 1968 with all members present except Dr. Kerr who was ill. The Subcommittee met alone in the morning but was joined in the afternoon by the Research Committee of the Alberta Society of Petroleum Geologists. In the past, contact with this committee had been maintained by mail, but members found the joint discussions most helpful and recommend that the practice be continued. In addition to meeting, the subcommittee members have corresponded with the chairman throughout the winter.

The report has three parts: 1. a brief account of the deliberations of the Subcommittee meeting, detailing the resulting recommendations; 2. a review of research in sedimentary geology in the 1967-68 academic session; and 3. a summary of the significant events and advances during the year in stratigraphy, paleontology and sedimentology suggested to the chairman by the members of the Subcommittee.

SUGGESTIONS AND RECOMMENDATIONS

Distribution of Sedimentary Rock Suites

In our last annual report (1966-67) we requested that the National Committee set-up an agency for distribution of collections of sedimentary rocks to Canadian universities for use in instruction at the advanced undergraduate and graduate levels. Because the Subcommittee was asked to bring in a more specific proposal in 1968, this matter has since been discussed at length and a survey made of the needs of Canadian universities. The chairman circulated a questionnaire to Canadian universities asking if they would be interested in receiving such collections, if they would be willing to pay enough to cover costs, and what suites they would be interested in. The 16 departments responding favourably to the scheme proposed a long list of suites they could use; details of their responses form an appendix to this subcommittee report (see p. 70). The ASPG University Liaison Committee is distributing a cross-section on plywood of the Swan Hills field with rock samples attached but this project does not conflict with this Subcommittee's proposal.

The Subcommittee therefore asks the National Advisory Committee to endorse the following proposal and recommend its implementation by the Geological Survey:

1. Suites of sedimentary rocks would be collected by university staff who were expert in different parts of the stratigraphic section and supplied free to the Geological Survey in sufficient quantity to make about 20 sets of hand specimens. To start, these collectors would be members of this Subcommittee; possibly the rotation of the Subcommittee membership would introduce enough new members so that an appeal for rocks from geologists outside the Subcommittee would never need to be made. The following members of the Subcommittee have offered to collect sets for distribution: Lajoie - Appalachian flysch; Braun - Swan Hills core, Prairie Mesozoics; Middleton - Niagara Silurian, Devonian at Hagersville; Schenk - Arisaig Silurian, Maritimes Mississippian; Murray - Cache Creek; Glaister - Foothills Cretaceous; Winder - Ontario Huronian, Ontario Devonian. Members of the Quaternary Subcommittee would probably also be glad to cooperate.
2. A student assistant working during the summer at the Geological Survey would receive the bulk samples, break them up into convenient hand specimens, label them, find out which universities wished to receive the suites, pack and ship them, and bill the recipients. We suggest that about $10-$20 per suite of 20 specimens would cover the cost of distribution.
3. Overall coordination of the plan would be the responsibility of the chairman of this Subcommittee but a senior liaison man should be designated at the Geological Survey to superintend the work of the assistant.

Promotion of Symposia and Workshops

At the suggestion of this Subcommittee a symposium and field trip on "Flysch" have been organized by Dr. Lajoie for the Montreal meetings of the Geological Association of Canada in 1969. We hope to establish a more formal liaison with the program committee of the GAC so that in future other symposia on sedimentary geology can be arranged.

It would be advantageous if such symposia were accompanied by informal workshops meeting for a few days before or after the symposium. Dr. Murray will try to organize such a workshop on oceanographic techniques for the 1968 GSC meetings in Vancouver and Dr. Lajoie will investigate the possibilities of organizing a workshop on Flysch before the Montreal Symposium; the National Advisory Committee is asked to support them. To stimulate the holding of such workshops the NAC might consider finding funds to support them (say $1,500 per workshop) and invite university professors who propose to organize them to apply for support.

To stimulate interest in geology among students the Subcommittee suggests the holding of field institutes for undergraduates and even senior high-school students interested in earth sciences. Funds would be necessary to bring students on scholarships from various parts of the country to the field station of one of the universities.

Historical Geology of Eastern Canada

Impressed with the success of the Atlas of the Geological History of Western Canada, this Subcommittee recommends steps be taken to begin the compilation of a similar volume for Eastern Canada. Figures supplies by the Alberta Society of Petroleum Geologists show that the Atlas cost over $63,000 to produce and only after three years showed a profit. Obviously the financial support of a large society is necessary for a project of this magnitude. Either the Geological Association of Canada or an eastern section of the ASPG might promote the publication of such a volume.

This Subcommittee proposes to promote a major symposium on the Geology of Eastern Canada at the 1972 meetings of the International Geological Congress. The major papers in this symposium would form the core of the proposed volume.

Road Maps

The Subcommittee understands that the Alberta Society of Petroleum Geologists is publishing road maps for the use of the geologist in Western Canada and that a set for Ontario is under consideration by provincial government agencies, in preparation for the International Geological Congress of 1972. Quebec is preparing a set of similar road logs on the geology of the Gaspé Peninsula. The Subcommittee recommends that societies and agencies across Canada consider the importance of extending such road log coverage across the nation.

Scientific Grants

The Subcommittee asks the National Advisory Committee to discuss and pass on to the National Research Council a recommendation concerning the differential between the Prairies and Eastern Canada in the amount of money from NRC grants that may be used for travel; at present, maximum allowable amount varies from $300-$500 depending on distance of grantee from Ottawa. Conventions in the earth sciences take place as frequently in the west as in the

east. The differential may be just for other sciences but for applicants in the earth sciences the Subcommittee recommends that a maximum of $500 should be allowable to grantees irrespective of geographic location.

Palynology

The Subcommittee discussed at some length the proposal by the ASPG Research Committee that the group of palynologists at Lille University be asked to desist from modifying the names of spores without reference to the International Rules of Botanical Nomenclature. The Subcommittee considered that such a request might better be presented to the International Commission on Botanical Nomenclature by experts in palynology; members of the National Advisory Committee are not competant to take sides in such a technical matter.

Annual Compilation of Current Research

The Subcommittee recommends that the Secretary of the National Advisory Committee request from the executive of the ASPG a list of addresses of those in the petroleum industry active in research and that forms for the reporting of research projects be sent to them. Although some projects of a secret nature would not be reported, the Subcommittee and the ASPG Research Committee consider this would be a step toward including in the compilation research projects in industry along with university and governmental research*. We also recommend that a special effort be made to include research in progress by Canadian students in American universities and by Americans on Canadian problems. Dissertation abstracts and the lists of graduate students published yearly by NRC would provide some information on the location of graduate students. If these sources did not prove to be helpful, a group of forms could be sent to the major universities in the United States known to attract Canadian graduate students.

Compilation Map of Foothills and Mountains Geology

A joint committee of the Alberta Society of Petroleum Geologists and the Geological Survey of Canada is investigating the possibility of publishing reconnaissance maps of the Rocky Mountains and Foothills using data gathered by both government agencies and the petroleum industry. The ASPG Research Committee has asked this Subcommittee to support its request to the Geological Survey for an assistant to work in Calgary on the compilation of the maps in addition to the technical officer now assigned to the project.

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*Current Research in the Geological Sciences in Canada, 1967-68, National Advisory Committee on Research in the Geological Sciences, Ottawa, 1968; Geol. Surv. Can., Paper 68-54.

International Geological Congress

Members of the Subcommittee suggest the following topics for symposia at the International Geological Congress to be held in Montreal in 1972:

1. Flysch
2. Precambrian fossils
3. Geology of eastern Canada
4. Precambrian sedimentation
5. Continental drift in the northern hemisphere

Review of Current Research

The preliminary results of the compilation of current research projects in Canada for 1967-68* indicates that the pace of research in sedimentary geology has quickened markedly during the past year. The comparison from year to year of the number of research projects listed by investigators making returns must be taken with a grain of salt because respondents are inconsistent; some split their research into many separate projects while others lump it under a single entry. If the kinds of scientists surveyed are comparable each year, the figures should give a rough estimate of research activity in the branches of geological science. This year 291 projects in sedimentary geology were reported compared with 219 for each of the last two years. Projects in stratigraphy and paleontology have increased from 102 to 116, in paleontology from 66 to 81, in sedimentology from 51 to 94, and in coal and petroleum from 14 to 16. Figure 1 illustrates the recent trends in research projects reported and emphasizes the great increase in interest in sedimentology.

Stratigraphy and Paleontology

The separation of projects listed under stratigraphy and paleontology from those that are "pure" paleontology is difficult. This difficulty may account for the apparent stability of research in stratigraphy and paleontology during the past 3 years (Figure 1). Most of the work of the Geological Survey has been listed under this heading because it is concerned with biostratigraphy.

Of the 116 projects listed this year 47 are reported by geologists employed by the Geological Survey and 56 by research workers in the universities. The remainder comprise research undertaken at provincial and other government offices. The investigation of Upper Paleozoic rocks continues to attract most attention; 36 projects are reported. Twenty-nine projects are listed in Lower Paleozoic rocks but only 7 in Precambrian rocks. Mesozoic investigations are reported by 11 university stratigraphers and 19 from government; Cenozoic rocks are receiving scant attention in Canada with only 7 projects listed in all. Although Cenozoic rocks are not extensively exposed in this country, they deserve more attention than they are attracting.

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*Op. cit.

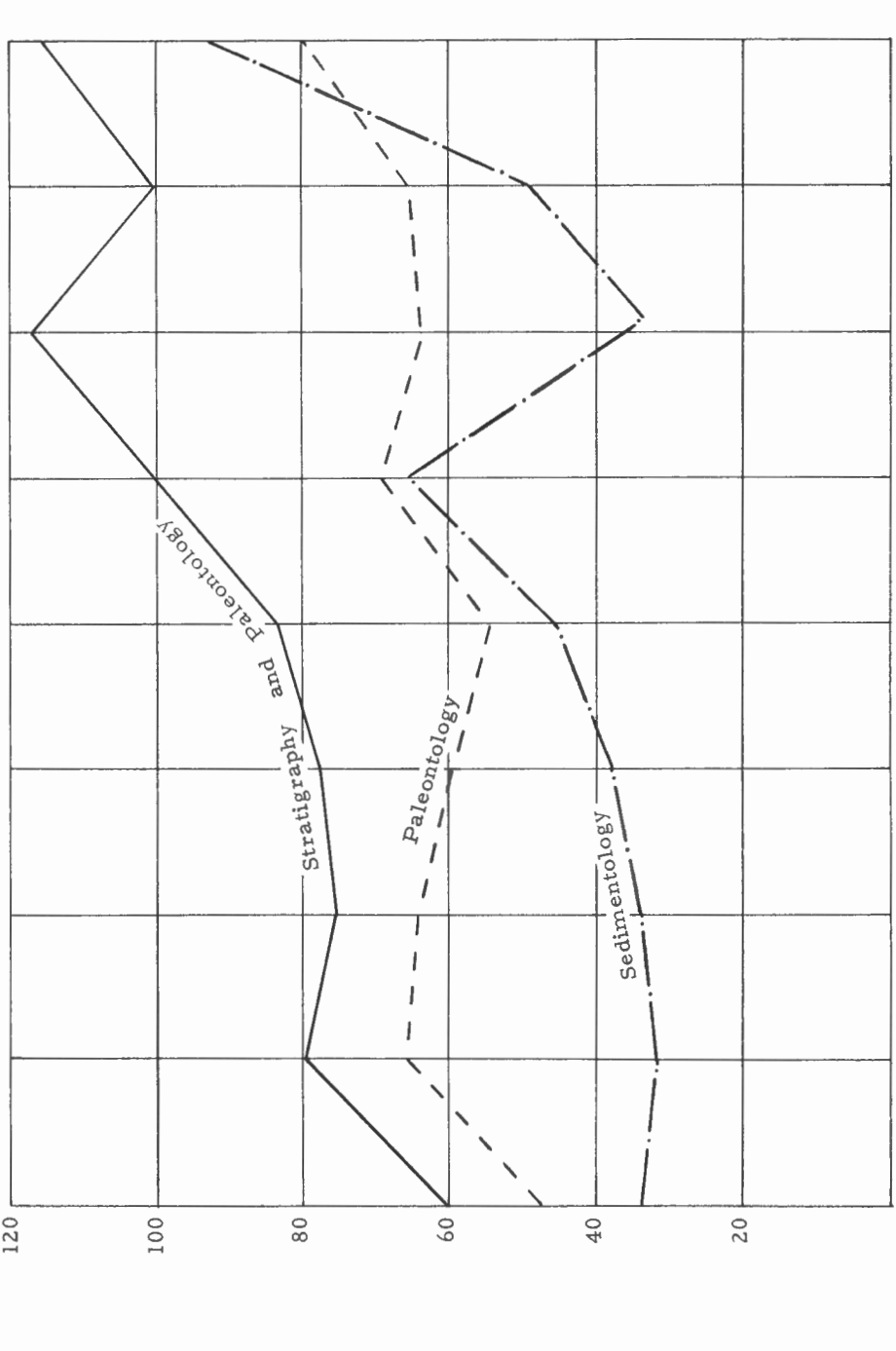

Figure 1 - Projects in Sedimentary Geology Reported to N.A.C.

Sedimentology

Most of the research in sedimentology in Canada is in the universities rather than government agencies. At Dalhousie and the University of British Columbia university staff members work in close cooperation with government scientists. The number of projects in sedimentology has nearly tripled in two years. Research in clastic sedimentary rocks is attracting most attention; 37 projects are reported. Interest in the carbonate and other non-clastic sediments is not far behind.

Eighteen studies of recent sediments are recorded this year. The marine research in this area is concentrated at Dalhousie University and the Bedford Institute. An extensive study of sedimentology in the Great Lakes is being carried on by the Inland Waters Branch, Department of Energy, Mines and Resources. This program will probably expand as the new research station at Burlington, Ont. reaches its full potential. Only a few geologists are interested in the study of stream deposition and the transport of sediments in rivers. Until recently McGill University has been the only institution in Canada with research projects in recent carbonate sedimentation at its Caribbean station at Barbados but this spring, 1968, the Department of Energy, Mines and Resources entered this field by sending the Hudson on a Caribbean cruise.

The neglect by sedimentary geologists of the field of Precambrian sedimentation is shown by the small number (5) of projects reported.

Both the ASPG Research Committee and this Subcommittee believe that the investigation of fluids that occupy pore-space in sedimentary rocks is a field that is being neglected in Canada. Little current research is concerned with hydrochemistry and the role of fluids in depositing cements, influencing porosity and diagenetic processes and mineralization. Geochemists competent in this field are rare although such research has great economic implications. The offering of post-doctoral fellowships by industry might stimulate further research in the universities in this field.

Petroleum and Coal Geology

Most research in these fields is carried on by industry and not reported to the National Advisory Committee. The 16 projects reported this year are largely being carried out by government agencies and a few universities.

Paleontology

The total number of projects listed in 1967-68 shows an increase of about 60% over last year. Of the 81 projects, three are concerned with Precambrian paleontology. A few years ago it would have been surprising for a paleontologist to be concerned with Precambrian rocks but today Precambrian cherts are yielding rich biotas of micro-organisms and Precambrian stromatolites are receiving their first systematic analysis; it is lamentable that only three projects are listed for this exciting field in a country mainly underlain by Precambrian rocks.

Two other branches of paleontology that are neglected in Canada are macropaleobotany and foraminiferal paleontology. Only the coal research

group at the Geological Survey has listed a project in macropaleobotany. The study of forams in Canada is limited to the late Paleozoic and the recent fauna of the Atlantic continental shelf; only 4 projects are listed. The Geological Survey hopes this year to employ new personnel in this field. Vertebrate paleontology is represented by 10 projects most of which are concerned with the mammals. The only paleontologist who was working with fish has left the country, and this field of vertebrate paleontology is now without a senior scientist.

Among the microfossils the conodonts and spores continue to attract the most attention. Seventeen micropaleobotanical projects are listed for 1966-68. Research teams in this field are active at the University of Alberta, the Alberta Research Council, the University of Calgary, and the Geological Survey. Study of the conodonts is centred at the universities of Western Ontario and Waterloo. Again this year the reader is referred to F. L. Staplin's summary of micropaleontological activity in Canada in a recent issue to the journal Micropaleontology.

EVENTS AND ADVANCES

Conferences

The largest conference in sedimentary geology held in Canada in 1967 was the highly successful International Devonian Symposium held in Calgary at the beginning of September. The success of the meeting can be judged by the attendance of scientists from around the world and the high quality of the papers presented. These papers are now appearing in two large volumes published by the Alberta Society of Petroleum Geologists.

The meetings of the International Association of Sedimentologists were held at Reading and Edinburgh in 1967; a large delegation of Canadians attended. Two symposia on Continental Drift held in Canada during 1967 included papers of interest to sedimentary geologists. The larger symposium which was organized by Prof. Marshall Kay, Columbia University was held at Gander, Nfld. in August; the papers are to be published as a memoir of the American Association of Petroleum Geologists. The second symposium was held at the University of Western Ontario in London, Ont. The Eastern Canada Biostratigraphy Seminar was also held at London, in March 1968 and addressed by Drs. Barghoorn, Swinton, Ziegler, and Mamet.

The Eastern Section of the Society of Economic Paleontologists and Mineralogists was organized in 1967; two field meetings were held, one to the Minas Basin, N.S. and the other to examine the Cambro-Ordovician sediments of the Hudson Valley. The annual Conference on Earth Science organized jointly by the ASPG and the University of Alberta was held in 1967 in Banff, Alta. The theme was "Genesis and Accumulation of Petroleum"; the main speakers were U. P. Columbo, G. D. Hobson, and J. M. Hunt. In 1968 the theme of the conference will be "Paleoecology".

For some years a committee under the chairmanship of C. G. Winder has been working on the compilation of data on the subsurface Paleozoic stratigraphy of Ontario and the standardization of names for subsurface stratigraphic units. This committee has now published A Guide to the Subsurface Paleozoic Stratigraphy of Southern Ontario (Ontario Dept. Energy and Resources Management, Paper 67-2). Boundaries of the units are defined and a standard set of

names recommended. The committee will be extending this work in Ontario and hopes similar projects will be initiated in other parts of eastern Canada.

J. D. Aitken has made a significant contribution to sedimentary petrology by recognizing, describing and naming cryptalgal limestones and dolomites from the Cambro-Ordovician rocks of southern Alberta (Jour. Sed. Petrol., vol. 37, pp. 1163-78). E. T. Tozer's A Standard for Triassic Time (Geol. Surv. Can., Bull. 156) is a major contribution to the biostratigraphy of this system.

The exploration activity generated by petroleum discoveries in the Rainbow Lake area of northwestern Alberta has begun to stimulate publication of papers on the geology. Two that appeared in 1967 deal with the Chinchaga and Keg River Formations (J. Craig et al., Can. Jour. Petrol. Geol., vol. 15, pp. 125-137) and Middle Devonian facies relationship in the Zama area (J. G. McCamis and L. S. Griffith, Can. Jour. Petrol. Geol., vol. 15, pp. 383-433).

This has been an important year in application of data processing techniques in the fields of stratigraphy, paleontology and sedimentology. Many of the oil companies are now using it as a tool in exploration and finding it profitable. At first data processing was confined to processing subsurface information but now is being used also to store and retrieve surface data. "Operation Norman" the Geological Survey's reconnaissance study of 125, 000 square miles in the Lower Mackenzie River area will record all field data on cards that can be handled by computer. Among papers written by Canadians in this field those by J. E. Klovan and G. K. Billings (Can. Jour. Petrol. Geol. vol. 15, pp. 313-330) on discriminant function, by F. P. Agterberg on computer techniques in geology (Earth Sci. Reviews, vol. 3, pp. 47-77) and F. P. Agterberg et al. on paleocurrents in the Bjorne Formation (Jour. Sed. Petrol., vol. 37, pp. 852-862) are notable. Roger Walker has attempted to formulate a statistical tool for use on turbidites (Jour. Sed. Petrol., vol. 37, pp. 25-43, and 1012-1022). The publication of G. B. Mellon's study of The Stratigraphy and Petrology of the Lower Cretaceous Blairmore and Mannville Groups, Alberta Foothills and Plains (Alberta Research Council, Bull. 21) marks an important step in our understanding of the Cretaceous of western Canada.

The Hugh Lilly Memorial Volume on the geology of the Atlantic Region published in 1967 by the Geological Association of Canada as a Special Paper No. 4 contains several papers of interest to sedimentary geologists. This volume, and the Canadian Journal of Earth Sciences, contain papers by Lewis King on applying echograms, grab-samples, and continuous seismic reflection to identification of bottom sediments and bedforms of the Scotian Shelf.

Dr. Esther Jamieson's thesis on the Alexandra Reef Complex of northeastern Alberta was judged to be the best contribution in thesis form to the geology of western Canada by the ASPG Research Committee.

In the near future two new instruments may bring about significant advances in sedimentary geology. The scanning electron microscope, which is just coming into use in Canadian laboratories, opens new fields in the study of surface textures of sedimentary particles and microfossils. The deep-diving submersibles now being used in oceanographic research by the United States and other countries will greatly extend man's knowledge of processes of sedimentation in the depths of the sea. Perhaps Canada should be planning to build such research vessels in the near future.

The drilling by Shell Canada of offshore wells from a semi-submersible drilling platform off the coast of British Columbia marks an important

point in Canadian petroleum geology. Three holes have been completed reaching depths of about 16,000 feet in the sedimentary basins of the continental shelf. The samples and logs from those wells will be invaluable to both stratigraphers and geophysicists.

The discovery of manganese nodules on the sea floor of Jervis Inlet has created considerable public interest in marine geological research on the west coast and companies have been formed to explore for minerals on the sea floor.

Members of the Subcommittee have been asked to comment on the proposed International Geological Correlation Project (IGCP) which is being organized by the International Union of Geological Sciences. In general the members consider that Canada should support this project whole-heartedly at the International Geological Congress in Prague so that it can begin in early 1969.

SUMMARY OF RECOMMENDATIONS

1. That the National Advisory Committee ask the Geological Survey to cooperate with this Subcommittee in implementing its plan for distribution of sedimentary rock suites to universities (p. 61);
2. that the National Advisory Committee consider means to support workshops associated with symposia (p. 62);
3. that, to stimulate the holding of field institutes for undergraduate students, and possibly high school students, the National Advisory Committee consider finding funds to support them (p. 62);
4. that the National Advisory Committee forward the Subcommittee's suggestions for symposia at the International Geological Congress, 1972 to the organizing committees;
5. that the National Advisory Committee ask the National Research Council to consider changing travel allowances so that all grantees irrespective of their geographic location, are allowed similar expenditures for travel;
6. that the National Advisory Committee make a greater effort to obtain a record of current research by the petroleum industry by using the offices of the ASPG to direct questionnaires to the areas of research activity; and that the compilation include also research projects on Canadian problems underway in American universities;
7. that the National Advisory Committee support GSC/ASPG project to compile the geology of the foothills and Rockies by requesting the Geological Survey to allot an assistant to work at Calgary on the compilation.

DISCUSSION OF REPORT

In discussion of the report, with respect to the distribution of sedimentary rock suites to universities, the National Advisory Committee endorsed the proposal (p. 61) and will request the Geological Survey of Canada to implement it on a trial basis.

With regard to the promotion of symposia and workshops (p. 62) it was pointed out that the Geological Association of Canada plans to sponsor the "Flysch" symposium in Montreal in 1969, including publication of the proceedings. No action was taken on the suggestion that money be provided for the general support of workshops and field institutes.

With reference to NRC operating grants (p. 62), the Secretary was instructed to write the Awards Officer, NRC, suggesting on behalf of the NAC that the limit of funds that may be used from an NRC operating grant for travel to conferences, etc. be $500 irrespective of the geographic location of the grantee.

With regard to the annual survey of current research in the geological sciences (p. 63) the Secretary agreed to obtain a list of addresses from the Executive of the Alberta Society of Petroleum Geologists of those in the petroleum industry active in research and send these indivíduals forms for reporting their research projects. He also agreed to try to obtain a list of Canadian geological graduate students in the United States to whom the forms would be sent.

APPENDIX
TO THE REPORT OF THE
SUBCOMMITTEE ON STRATIGRAPHY, PALEONTOLOGY AND SEDIMENTOLOGY

Distribution of Sedimentary Rock Suites

In December 1967 a letter was sent to 21 university departments of geology requesting replies to the following questions:

1. If such a distribution system was started, would your department wish to receive such sedimentary rock suites?
2. Would your department be willing to pay for such specimens so that the project would be self-supporting?
3. What specific suites of specimens would your department suggest be distributed?

The following departments responded favourably to the proposal: Western Ontario, St. Francis Xavier, Mt. Allison, Laval, Waterloo, McMaster, British Columbia, Memorial, Windsor, Manitoba, Lakehead, Laurentian, McGill, Alberta, Dalhousie, Carleton, and Montreal. None reported unfavourably but some cautiously.

Proposals for suites to be distributed — Alberta Tar sands, Sandstone reservoirs of Western Provinces, Paleozoics of St. Lawrence Lowlands and Ontario, Precambrian sediments, Permo-Pennsylvanian reefal suites of the NWT, Paleozoic and Mesozoic of Hudson Bay, Precambrian Keweenawan, Huronian, Beltain sediments, Suites from Arctic, Carboniferous of Bay of Fundy, Newfoundland Harbour Main, Conception, Random, Anticosti suite, Mesozoic of Prairies, Vancouver Island sandstones, Ordovician and Silurian graptolitic shales and shelly facies of the Arctic and Yukon, Welded tuffs, Cache Creek fusulinid limestones, Keewatin and Temiskaming rocks, Triassic algal limestomes of Texada Is., Meguma Group, Stephen Formation, Silurian Evaporites, Windsor Group of Maritimes, Lower Paleozoic of Manitoulin Island, Upper Cambrian of Rockies, Late Mesozoic of northeastern British Columbia, Precambrian Hector Shales of Rockies, Edmonton Formation, Late Paleozoic sandstones west of Fort St. John, Palliser suite, Blairmore coal measures, Amaranth gypsum, Modern sediments of Bay of Fundy or Frazer Delta.

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	Dept. 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

The Subcommittee met at the University of Ottawa on March 13, 1968 immediately preceding the Tectonics Research Conference on kink bands and brittle deformation. The meeting made it possible for the Structural Subcommittee to have a thorough discussion of the aims and objectives of structural geology in Canada and how best to achieve them and, as well, to compile the customary commentary on current research.

This report includes a summary of current research under headings denoting the various divisions of structural geology. This complements the Survey of Current Research in the Geological Sciences*. Several committee members offered comments on problems of education and dissemination of information in structural geology; this forms a separate section of the report. Because the year 1967-68 was an important one for symposia on tectonics, these are reported individually.

With the assessment of the current status of structural geology in Canada, the committee has made several specific recommendations, which form a further, and we hope significant contribution to the last section of the report.

SUMMARY OF CURRENT RESEARCH PROGRESS

Studies in the Field

The Geological Survey of Canada

Crustal Geology Division - The principal effort in structural research in the Crustal Geology Division has been directed toward the study of the regional geologic structure of the Canadian Shield and the Appalachian region. In the Canadian Shield, studies in widely separated regions in the central part of Churchill Province have provided new insight into the structural evolution and tectonic implications of previously deformed and metamorphosed rocks that were re-cycled during a phase of plutonism and deformation which apparently corresponds with the Hudsonian orogeny.

Several projects have provided new data on the relation across boundaries between structural provinces in the Canadian Shield, particularly the Thelon Front between the Slave and Churchill provinces east of Bathurst Inlet, and the Grenville Front in the classic region north of Lake Huron, and also in Labrador.

The study of Archaean volcanic belts continues; these studies are adding to our knowledge of the tectonic behaviour of the Archaean crust.

In the Appalachian region, study of the tectonics of the Appalachian system exposed across the breadth of Newfoundland continues. The structural and metamorphic history of the Fleur de Lys Group in northern Newfoundland has been analysed in terms of separate phases of deformation by means of superimposed structural features.

Institute of Sedimentary and Petroleum Geology — The committee draws attention to the creation of a Structural Geology section at the Institute of Sedimentary and Petroleum Geology of the Geological Survey at Calgary. This is an important step. However, the section is concerned with brittle deformation in non-metamorphic rocks; other aspects of structural geology are not included.

With completion of reconnaissance structural and stratigraphic studies in the eastern and northern Cordillera and Arctic Islands, structural research at the Institute of Sedimentary and Petroleum Geology will be concentrated on detailed studies of specific structural types and areas. Current

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*Op. cit. Geol. Surv. Can., Paper 68-54, 1968.

investigations include the structural relations of the Franklinian eugeosyncline and the crust beneath the Arctic Ocean; the control of basement upon the deposition of sediments in the Franklinian miogeosyncline and tectonic significance of the Nares rift valley; the temporal and structural relations of the British, Richardson, Ogilvie and Mackenzie Mountains; the origin and significance in space and time of the Mackenzie and Crowsnest deflections; the mechanics of thrust faulting in the northern Rocky Mountains; the control of sedimentary facies on structural style in the eastern and northern Cordillera; the structural habit in the foothills of the east-central Cordillera; the kinematic and dynamic relations of "normal" faults to thrust faults and folds in the eastern Main Ranges of the Central Rockies; the kinematics and dynamics of emplacement of thrust plates; and the mechanics of accretion of mineral and rock matter on slip surfaces in rock and at interfaces between ice and other rocks.

A start will be made later on physical and computer models of thrusting and folding, and the spatial and temporal relations of these deformations in orogenesis and epeirogenesis; there are plans to employ a physicist and mathematician in the structural geology section of the Institute. Some of the specialized studies in prospect will be carried out as collaborative, comparative programs with Institutes and Geological Surveys around the world, so that, for example, transverse faults of the northern Mackenzie Mountains may be compared with similar features in the Swiss Alps, and the strike-slip faults of the northern Cordillera with those in California and New Zealand.

British Columbia

Detailed structural studies in the western Cordillera are concentrated in the southern part of the region. They have been conducted by students and staff at the University of British Columbia, by the Geological Survey (partly under its "granite" program) and by participants in the Cordilleran Structure project. There has been a large increase in the number of structural studies within the last four years. Most of these are as yet unpublished; most are concerned with the structures in and around granitic and gneiss complexes.

Cordilleran Structure Project — The Cordilleran Structure project was begun in 1964 on the recommendation of the National Advisory Committee, with Dr. J.O. Wheeler as coordinator. Few of the results have been published, but many were presented at the annual meeting of the Geological Association of Canada in Vancouver in April 1968, and will be published as Special Paper No. 6 of the Association.

The main objectives of the first phase of the Cordilleran Structure project were to determine the geometry of the structures, to delineate and describe the mutual relations of the large tectonic units, and to establish the sequence and nature of the various phases of deformation in the southwestern Cordillera. Field mapping at scales ranging from 4 inches to 1 mile to 1 inch to 1 mile permitted considerable attention to mesoscopic fabrics. The principal structural provinces and their subdivisions have been identified and their characteristic structures are being established. Variations in structural style within the provinces have been recognized and can be related to the competency and thickness of rock-units, to structural level, and to metamorphic grade.

The objectives of the first phase have been most nearly achieved in the Rocky Mountains where the exposures are good and the stratigraphy well layered. Structural units are being closely delineated and their mutual relations reasonably well understood, thus providing a sound framework for detailed mesoscopic fabric studies.

In the southern Cordillera the approximate times at which various structures developed cannot be closely defined stratigraphically; reliance must be placed on interpretation of relationships between structures and metamorphic minerals or on cross-cutting granitic plutons that can be dated radiometrically.

Individual contributions to the project are included in the Annual Report on Current Research, 1967-68.

Future work in the western Cordillera would be assisted by application of seismic reflection studies like those carried out in the Rocky Mountains by petroleum companies.

Alberta, Saskatchewan, and Manitoba

Structural work in the petroleum industry is reported separately, but work being done by the universities in Alberta, Saskatchewan, and Manitoba can be placed in three categories: 1. regional structural analyses, 2. detailed study of single structures, 3. experimental studies of deformation. In the first category are 1. a detailed structural analysis of the northern Dogtooth Range and adjacent portions of the Rocky Mountain Trench underway at the University of Calgary, 2. a project to filter structural contour maps from the interior plains of western Canada in order to determine the structure of a number of surfaces at the University of Alberta, and 3. structural studies in the Precambrian Shield at the Universities of Saskatchewan and Manitoba. The Geology Department, University of Manitoba and the Manitoba Mines Branch, Geology Division, are combining their efforts in 'Project Pioneer', an integrated geological, geophysical and geochemical study of the Rice Lake - Beresford Lake area, Manitoba. Almost all are field-type projects involving geometric, kinematic and dynamic analysis of structures. A major portion of the structural work involves computer manipulation of structural orientation data in retrieval and interpretation phases. Considerable emphasis is being placed on the crustal setting and metamorphic environments of deformation. As a result, petrologic and geophysical studies of many types are closely allied to much of the structural work.

The second category includes studies of small-scale structures in the Moose Dome southwest of Calgary by the University of Calgary, an examination of structures in gypsum deposits at Gypsumville, Man., at the University of Saskatchewan, and studies of the tectonic significance of granite diapirs and of the geometric and kinematic properties of rocks deformed by their intrusion, at the University of Manitoba. The only study falling within the third experimental category is a project on ductile deformation at the University of Saskatchewan.

Ontario Universities

Research in structural geology in Ontario universities is slowly increasing. Most of the projects deal with field work and particularly the

geometry and evolutionary sequence in a manner reminiscent of classical paleontology. Little or no effort seems to be devoted to developing new methods of measuring and new ways of interpreting structure although National Advisory Committee reports for several years have urged increased effort in experimental structural studies and greater cooperation between structural geologists and workers in rock mechanics and allied fields. However, there is a minor increase in the number of experimental studies devoted to crystallographic aspects of deformation and recrystallization, but only two university groups — those at Toronto and McMaster — acknowledge active cooperation with engineering or allied departments.

Quebec

Most of the projects underway in Quebec are related to regional mapping, generally for the Quebec Department of Natural Resources. They can conveniently be subdivided by geological province.

In the Appalachian Province, P. St. Julien is completing a study of the nappes of the Quebec area. Three structural projects based on detailed mapping by graduate students are in progress at the Université de Montréal and one at the Université de Sherbrooke.

In the Grenville Province, several structural-petrological studies of the relationships between gneisses and intrusive rocks and of tectonics trends are underway. Work is continuing in the Mouchalagan-Manicouagan Basin.

In the Superior Province, the Otish Mountains are also being studied and in the Churchill Province three projects in the Labrador geosyncline are concerned with detailed mapping, stratigraphy and structure.

Atlantic Provinces

Only a few structural investigations are active in the Atlantic Provinces; most are conducted by university personnel in coastal areas with good outcrops and with limited financial assistance. Appalachian geology is made difficult by poor outcrop and lack of fundamental stratigraphic and paleontologic data. Structural studies will be most significant when closely coordinated with stratigraphic investigations, but we must also find ways of extending the techniques of structural geology to large areas of poor outcrop.

Tectonics and Geophysics

At different points in the scale of structural phenomena, structural geology becomes tectonics, and tectonics becomes geophysics. These points are not defined, and there is therefore some understandable confusion in the classification of structural projects. Tectonics is filed under "miscellaneous" in National Advisory Committee reports, and certain structural projects ultimately fall under the geodesy and geophysics subcommittee of the National Research Council by being part of the Upper Mantle Project. This merely emphasizes that structural geologists are continually appealing to geophysical data in attempting to understand the properties and structure of the gross crustal environment in which deformation has taken place. It is regrettably seldom

that geophysical work has been done that has specific application to a structural investigation; many geophysical projects would yield more significant results if structural geologists had made their working models known to the geophysical research workers. A closer working relationship between these groups would be to everyone's benefit.

Structural Geology and Mineral Deposits

Research specifically into the structural geology of ore deposits forms a very small part of the publicly available research in structural or economic geology in Canada at present. Such studies are limited to a few university thesis projects related to individual mines, and to parts of the integrated governmental studies such as those dealing with the Coronation and Whalesback Ore Deposits and Project Pioneer. Often the structural aspect of a general study of an orebody is restricted to a geometrical description, and no attempt is made to develop the significance of the observations beyond time-worn simplifications. There is also an unassessable volume of research carried on by geologists working for industry. Some of this work is comparable in quality with projects sponsored by institutions, but is unavailable to the public.

Some years ago structural geology was an important exploration tool. In the past decade, however, it has been subordinated to other techniques such as geochemistry, and geophysics. This is logical, as new exploration tools appear, but structural geology has an important role to play in fields other than exploration. Collaboration between mining engineers and structural geologists would undoubtedly produce improvements in mine design and development and in such economically important fields as ground control. On the other side, mining provides a singular opportunity for observation and sampling in three dimensions which structural geologists have been slow to exploit. Such work can only be done effectively by the systematic mapping of working faces as these develop, and mine management would need to be persuaded of its value.

Metallogenic studies are just beginning in Canada. These involve the comprehensive study of the environment and tectonic setting of ore deposits. Many companies are actively involved in metallogenic research but much of this information will never be published. Programs have also been started by the Quebec and New Brunswick departments of natural resources and by the Geological Survey of Canada. The work has created the need for an effective form of tectonic classification, and for some means of describing segments of an orogenic belt.

Structural Geology and the Petroleum Industry

By narrowing the field of research to include only the gathering and interpretation of data for the specific purpose of developing new concepts, about 90% of an oil company's geological effort can be eliminated from the field of research.

Most of an oil company's research is devoted to trying to understand the geometry of particular kinds of oil-trapping structures. The usual method is to make detailed studies to establish the geometry of particular

producing oil fields. In addition to providing pertinent data for the exploitation of that specific field, it also contributes to the establishing of a composite "model" of what a "typical field" of that kind looks like. This typical example is then used as the basis for judging whether a particular suite of geological clues points to another undiscovered structure of that particular kind. Establishing the model is a form of research; using it is exploration.

Companies with a hard-earned understanding are reluctant to educate the opposition. A really first-rate concept eventually seeps into the industry by some kind of osmosis and becomes accepted generally. Only when the concept is widely understood and applied is publication permitted. This means first, that the state of the geological art as reflected in the literature lags considerably behind current thinking, and second, that the research work necessary to justify and demonstrate a concept may have been done independently by six to ten different companies. It is difficult to judge the amount of research in the oil industry by the number of published articles.

In rock mechanics as applied to the petroleum industry, perhaps the most significant work published in the past year was by Powers, "Fluid Release Mechanisms in Compacting Mudrocks and Their Importance in Oil Exploration" (A. A. P. G., July 1967, pp. 1240-1254). This paper strengthens the basic premise of the Hubbert-Rubey paper and should help in the understanding of thrust and decollement phenomena. The significance of supernormal pressures to diapiric and compacting structures is also quite evident so it may be assumed that companies other than Shell are pursuing these lines of investigation.

The value of individual field studies papers is diminished by an inextricable interweaving of observed fact and interpretational inference which makes it difficult to consolidate several such descriptions into a "model" or "typical structure"; one suspects that the structures cannot be as different on the ground as they appear to be in the literature. Published syntheses based upon detailed studies of several fields of the same type are not common. This is unfortunate because the value of a "model" probably increases as the square of the number of examples upon which it is based and which it fits.

In tectonics, the paper by Bally, Cordy and Stewart, "Structure, Seismic Data and Orogenic Evolution of Southern Canadian Rockies" (Bull. Can. Pet. Geol., vol. 14, No. 3, pp. 337-381, Sept. 1966) is representative of the kind of work that has been done by the major oil companies engaged in the search for oil and gas in the Canadian Rockies. It is an excellent resume of the status of structural understanding.

Summaries of progress in paleotopography, historical geology, and tectonics of western Canada are given in a guidebook prepared by Peter A. Ziegler (of Shell) for the Canadian Cordillera Field Trip sponsored by the Alberta Society of Petroleum Geologists during the International Devonian Symposium in 1967; in the Canadian Institute of Mining and Metallurgy Special Volume No. 8 entitled "Tectonic History and Mineral Deposits of the Western Cordilleran"; and in the Alberta Society of Petroleum Geologists' Atlas on the "Geological History of Western Canada".

Experimental Structural Studies in Canadian Universities

Research in experimental structural geology in Canadian universities lies in the future rather than the past. Currie, Lajtai and Clifford have

squeezed some rocks (not many), Ross has studied ice, and the group at McGill University, supervised by Gill, have been deforming sulphides. But all this is recent, and little has appeared in print. Experiments may never give unambiguous answers to apply to a real geologic problem, but because they can set boundary conditions to our speculations about field data they are vital.

To be successful, the experimental research worker must be thoroughly trained in experimental techniques or must have unrestricted access to people who are and can advise on equipment design. The status of current research being what it is, at least two more years will elapse before the first Ph. D.'s with appropriate training appear in Canada. Cooperation must be sought from workers in rock mechanics and other branches of engineering, as well as from materials scientists concerned with the deformation of metals, diffusion studies, recrystallization and grain growth, and properties of materials.

Rock Mechanics

At the Mining Research Centre laboratories of the Mines Branch in Ottawa and Elliot Lake, rock mechanics research is being carried out at three levels: basic research, applied research and advanced technology. Both laboratory and field studies are directed towards obtaining information on ground stresses and rock failure characteristics so that better control may be exercised in the design of mine geometry, selection of support methods and effective breaking or caving of rock.

Five broad areas of interest are currently being investigated, these are: ground control, stability of slopes in rock, blasting, rock properties and rock breakage. The investigation of ground control is concerned with determination of load that is applied to pillars and the strength of pillars, taking into account the various modes of failure; with rockbursts in Nordic and other mines at Elliot Lake; and with residual stresses in rock masses. In Nordic Mine over 300 underground measurements have been completed of residual stresses within the abutments surrounding a large mining area. These indicate high lateral stress but the residual components must be distinguished from those induced by mining and correlated with the geological structure.

The study of stability of slopes in rock may be divided into two categories. The first of these, a slope mechanics program, includes both analytical and model work on stress distributions within slopes of various heights, widths, depths and slope angles. Field studies are being made of the deformation and failure of hard-rock slopes resulting from the deepening of open pits. The second is an engineering approach to the problems of maintaining and increasing rock-slope angles by using artificial supports to maintain the slope angle.

The blasting research program has the objective of determining optimum blasting patterns for excavation in hard rock. Computer studies are being made on the stress distribution and its varition with various parameters around both spherical and columnar charges.

Of more direct interest to structural geologists, are projects to measure strengths of rock masses with systematic discontinuities, such as joints, and with anisotropic properties; and work on the mechanics of rock breakage, including the effects of thermally induced stresses.

Many other projects are in progress in the universities including a basic study, at the University of Alberta, of the application of holography to

the study of strains in rock samples or structures; work, at the University of British Columbia, on the thermal conductivity of rocks under various stress conditions and on the storage and release of strain energy in rocks in relation to the size and nature of the rock mass; an application, at Carleton University, of high current electron beams to the problem of piercing or drilling rock; structural model studies, at Ecole Polytechnique, at McGill University and at the University of New Brunswick, of the stress distributions in mines. Work continues at Queen's University in the fields of blasting research, fatigue fracture of rocks and viscous properties of rocks; at McMaster University on the relation between fabric and mechanical behaviour; and at the University of Saskatchewan on the rheological properties of evaporites at elevated temperatures.

The Canadian Advisory Committee on Rock Mechanics has published the Third Annual Supplement to the Bibliography of Canadian Contributions in the Field of Rock Mechanics, January to December 1966, in the C.I.M.M. Bulletin.

The proceedings of the Fourth Canadian Symposium on Rock Mechanics will be published in 1968. The Fifth Canadian Symposium on Rock Mechanics will be held at the University of Toronto on December 6-7, 1968 and will be preceded by a day of lectures.

Remote Sensing

Remote sensing commonly involves aerial imagery with radiation other than white light (radar, infrared and monochromatic light, for example). As part of the space program in the United States important progress has been made in the development of these techniques which involve in many cases the superposition of images recorded at different wavelengths. There is an obvious application of remote sensing to the delineation of geological features and structures. It is possible that an important opportunity may be missed in Canada, although the amount of work being done by oil companies is unknown because of the triple problem of company and Canadian and American military security regulations. Among the most effective contributions by Canada in the earth sciences have been the development and use of reconnaissance and exploration techniques, and it would be regrettable if this position of pre-eminence were to be lost. It is not essential that the remote-sensing vehicle be a high-altitude one, so this form of research need not be prohibitively expensive.

Data Processing and Structural Geology

This and previous reports of structural subcommittees have shown that almost all structural studies in Canada are based on field work. Field structural geology inevitably involves the systematic collection of numerical data in large quantities. It is thus natural that attention should be given to machine-processable files of structural data and to the use of computers in solving structural problems. The publication in 1967 of the report by an ad hoc Committee of the National Advisory Committee on "A National System for Storage and Retrieval of Geological Data in Canada" and the creation of a subcommittee to implement the report and carry on the work of the ad hoc Committee, have done much to bring the potential of machine-processable data files to the attention of geologists in Canada. The published report does not include

a model input format for structural measurements, but several of these have been and are being designed and used.

The potential of the computer as a tool for structural analysis has not been fully realized by Canadian structural geologists. There is a tendency to think of the application of computers only as a means of accelerating existing techniques, whereas there is clearly a further potential for the development of entirely new concepts. Application of computer techniques will encourage geologists to develop standards for defining and recording structural data which will result in greater consistency in mapping and increased reliability in analysis. Computer techniques using electronic methods for the display and manipulation of data will also provide accelerated means whereby hypothetical structural models can be constructed, tested, modified, and correlated with actual structures.

At a recent seminar in Vancouver, Hutchison and Roddick, Geological Survey of Canada, described a system of computer storage, retrieval and processing of geological data used in their mapping project of the Coast Ranges in British Columbia. Much of the data recorded are structural, and retrieval and processing programs for various types of structural analysis are being developed.

Other structural geologists in the Geological Survey of Canada have been recording structural data in a form compatible with machine processing; several are preparing to do so as part of regional mapping projects. Similarly, the Manitoba Mines Branch and the Geology Department, University of Manitoba are developing a system for computer storage, retrieval, plotting and analysis of structural data primarily for Project Pioneer. Progress to date includes the development of a structural data input document for the computer, and the development of programs for selective retrieval and plotting of data on maps at equal-area orientation diagrams.

At the University of Alberta, Charlesworth and others have developed programs to prepare equal-area orientation diagrams, determine the orientation of the mean vector, determine whether or not a population has a Fisher distribution and evaluate the precision of this distribution, distinguish between low-angle unconformities and disconformities, determine eigenvalues and the best-fit fold axis, determine one- and two-dimensional Fourier transforms, and finally prepare and print correlated isopach and filtered structural contour maps.

The petroleum industry is by far the most advanced segment of the earth sciences in the application of computers, although many companies are just getting started. In addition to their function as mechanized filing cabinets, computers are also linked to plotting machines to provide selected geological data on maps, which in the more sophisticated systems may be automatically contoured. Another use of computers is as model-making machines, a kind of digital pressure box. This is being investigated by some companies. The basic procedure is to establish an assumed process and to determine what effect an alteration of the variables has on the results.

An important facet of computer usage is that the machines have encouraged geologists to make more rigorous use of statistical principles in drawing conclusions from data. The fact that computers are too simple-minded to have hunches or flashes of intuition has frequently proven to be a blessing in disguise by forcing the geologist to state his decision-making procedure in logical, rational terms.

Conferences in 1967-68

The past year has been a significant one for seminars and conferences on tectonics in Canada and it seems logical that these should find a place in our report of activities. The reports of the Structural Subcommittee have repeatedly referred to the need for more national meetings and better means of communication, so that meetings such as those described below are welcomed with enthusiasm. The topics covered have spanned the spectrum of environments of deformation, and the publication of the papers presented will add substantially to the library of structural geological research in Canada.

Age Relations in High-grade Metamorphic Terrains
(Geological Association of Canada, August 1967)

Thirty-two papers were presented by authors from twelve countries at the 1967 centennial meeting of the Geological Association of Canada in Kingston. Starting with a plenary session, the symposium dealt with regional problems of the Precambrian and with problems in post-Precambrian orogenic belts. The symposium examined the problem of distinguishing rocks of different real age in areas that have been overprinted by deep-seated metamorphism and deformation to produce uniform potassium-argon ages and metamorphic mineral assemblages. It included invited contributions from members of AZOPRO*, the European Association devoted to the study of the deep zones of the Earth's crust. Many examples were presented where basement complexes and stratigraphic series of different ages are being discovered in areas of relatively uniform high-grade metamorphism. The techniques employed are generally structural, and involve detailed field observations, although careful work with various radioactive isotopes is proving to be a useful additional tool. Most of the papers presented in the symposium are to be published by the Geological Association of Canada as Special Paper No. 5, edited by H. R. Wynne-Edwards, who was also Symposium Chairman.

Tectonics Research Conference: Kink Bands and Brittle Deformation
(National Advisory Committee, March 1968)

For the first time, the National Advisory Committee sponsored a Tectonic Research Conference in connection with the work of the Structural Subcommittee. The conference was organized by A. J. Baer, P. M. Clifford, W. K. Fyson, and D. K. Norris and was held at the University of Ottawa. The conference, or workshop, consisted of papers presented by invited speakers who were specialists in the field of brittle deformation and kink bands. Two sessions were held, the first on brittle deformation, the second on kink bands, each followed by periods of informal discussion; preprints of the papers were available at the meeting. The proceedings of the Conference, including the discussions, will be published on behalf of the National Advisory Committee by the Geological Survey of Canada (Geol. Surv. Can., Paper 68-52).

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*Association pour l'étude géologique des zones profondes de l'écorce terrestre.

Meeting of the Structural Subcommittee
(National Advisory Committee, March 1968)

The Structural Subcommittee met for the first time in 1968, and thus was able to undertake detailed discussion of aims and objectives in a manner hitherto impossible. The meeting was held at the University of Ottawa in March with the following members present: K. Barron, W.C. Brisbin, P.M. Clifford, C. Dahlstrom, E. Dimroth, H. Morris, R.R. Potter, R.A. Price, P.S. Simony, J.O. Wheeler, and H.R. Wynne-Edwards.

The Subcommittee discussed a draft of its report to the National Advisory Committee, and long-range aims and objectives of structural geology in Canada. The recommendations arising from this meeting are presented in this report.

Structure of the Canadian Cordillera
(Geological Association of Canada, April 1968)

The 1968 meeting of the Geological Association of Canada, like that of 1967, featured a symposium on tectonics, this time embodying the results of the Southern Cordilleran structure project reviewed earlier (p. 73). The symposium consisted of a morning and an afternoon session at which papers were presented dealing with the five major structural provinces delineated by the project. These and other papers, 18 in all, will be edited by J.O. Wheeler, the Symposium Chairman, for publication by the Geological Association of Canada as Special Paper No. 6.

PROBLEMS IN EDUCATION AND COMMUNICATIONS

Professional Obsolescence and Retraining

Technical obsolescence is an ever-increasing problem in the propagation of research and in exploiting it. Except for a limited period immediately after his schooling a professional geologist cannot keep abreast of the science, unless there are the facilities and the opportunities to attend reviews by experts and courses specifically designed for retraining. In the realm of structural geology there are several recent developments which are little known or used among economic geologists in the mining industry, for example the ability to decipher polyphase deformation. Faced with the same problem, several oil companies have instituted educational programs to distribute structural knowledge more widely among their employees (e.g. Chevron, Shell, Humble(Imperial), and Pan American). The usual procedure is to send representatives of operating units to seminars conducted by company-employed specialists in structural geology.

The Structural Subcommittee believes that technical obsolescence has now reached serious proportions. It puts forward the recommendation in the last section of this report that the National Advisory Committee investigate the feasibility of establishing a centre for continuing education in earth science and technology as outlined in an appendix to this subcommittee report.

University Instruction

As structural geology acquires precision, and as the importance and significance of experimental results become apparent, more rigour is needed in instruction in structural geology in universities in Canada. More mathematics and physics appear to be necessary in the curriculum if the theoretical and experimental approach to structural geology is to be a vital and integral part of research in Canada. A possible solution may be the joint appointment of professors in, say, civil engineering and geology, physics and geology, or metallurgy and geology.

Several members of the Subcommittee expressed concern that a hiatus might develop between the experimentalist and the field geologist. Dahlstrom recognized the evolution of several species: the "mathematicians, temperature-pressure rock squeezers, the photoelasticists and pressure-box modellers, and the hairy-chested field geologists". The latter group gather data on "the way things really are" and apply to these "real" data some form of statistical or other inductive reasoning to produce geometric generalities which can be used for geological prediction. The other groups try to determine the fundamental laws of rock deformation to provide a solid body of theory from which geological predictions can be made by deductive reasoning. Both of these methods are legitimate avenues of structural research and, ideally, might ultimately produce identical conclusions, but until one has established a "normal" model of a particular structure in the field, and an accurate idea of the deviations which may occur on either side of that norm, one is in a poor position to offer any useful explanations as to origin. This implies that much more time could profitably be spent in defining structural problems precisely in the field. In structural geology there is a danger of going from the initial areal mapping stage directly to the advanced laboratory stage without spending enough time in the intermediate evolutionary stage of studying what de Sitter called "comparative structural geology". A sensible conclusion from this is that the training in structural geology in Canada should be preponderantly directed at producing geologists able to undertake detailed geometric investigations of critical types of structures.

AIMS AND OBJECTIVES

Structural geology in Canada is presently on a threshold between a phase dominated by systematic reconnaissance regional geologic studies and an emerging phase of specialized field and laboratory work. Until recently, structure played an incidental role in the regional geological investigations, yet these studies outlined the basic structural character of the Canadian Shield and of the younger orogenic belts around it, and established some details of the type of deformation. New techniques have become popular in the analysis of structural phenomena and the simulation of geological structures and processes is being attempted.

This Subcommittee agrees that structural geology is concerned with the form and other physical characteristics of structures in the rocks of the Earth's crust, and with their geologic evolution, the process of deformation by which they were developed and the causes of this deformation. Attaining each of these objectives is, in turn, contingent on the realization of the preceding one and hence systematic regional studies still constitute the most fundamental category of research in structural geology. As work progresses,

however, more specialized, detailed, and careful field work will become increasingly necessary, and geologists should be quick to test experimental results in the field. This subcommittee has given some consideration to long-range objectives in structural research in Canada, but has postponed further discussion for another year, in the hope that some long-range goals and a five-year plan can be defined.

RECOMMENDATIONS

Education

The Structural Subcommittee considered a proposal for continuing education for professional personnel in the earth sciences, which forms an appendix to this subcommittee report, and adopted the following recommendation:

> "That the National Advisory Committee establish a committee composed of representatives from industry, university, and government and reflecting geological, geophysical, and engineering disciplines to investigate the desirability and feasibility of establishing a centre for continuing education in earth sciences and technology."

The Committee makes this recommendation in the belief that major steps are necessary to combat obsolescence and that a demand exists for such an institution.

The Committee favours the introduction of more mathematics in undergraduate programs in geology, but makes no specific recommendation. Training in mathematics is now essential; the fear of mathematics courses among geology students may be combated by designing appropriate courses in which their relevance and applications are made clear.

Data Storage and Retrieval

The Subcommittee notes the progress towards a national system for storage and retrieval of geological data in Canada, and of advances in computer-based techniques in structural geology, and recommends:

> "That the National Advisory Committee convey to the Subcommittee on Storage and Retrieval of Geological Data in Canada the need for the development of standards for the description and recording of structural data, and the willingness of the Structural Subcommittee to provide assistance in establishing and advising an effective body to develop such standards."

Research

Southern Cordilleran Structure Project — The Structural Subcommittee is satisfied that the results of concerted effort on the Cordilleran

Structure Project are impressive and worthwhile. Ten to twelve man-years of work are still required to achieve the objectives of the first phase of the project, to determine the geometry of the structures and delineate large tectonic units. The project depends on participation by university staff and their graduate students, and to be successful requires a significant proportion of the total effort in structural geology in Canada. The Structural Subcommittee is strongly in favour of this type of concerted effort, and therefore recommends:

> "That proposals for research projects which fall within the domain of the Cordilleran Structure Project receive high priority from the National Advisory Committee among grant applications for geological research."

Northern Cordilleran Structure Project — The Subcommittee considered the suggestion that a Northern Cordilleran Structure Project be initiated, but recommends no action at present so that support can be concentrated on the Southern Cordilleran Project.

Appalachian Ribbon Structure Project — The Structural Subcommittee favours initiation of a project similar to the Southern Cordilleran Structure Project being undertaken in the Canadian Appalachians; such a project would make use of personnel in eastern Canada and so not conflict with the Cordilleran Project. The Structural Subcommittee therefore recommends:

> "That an Appalachian Ribbon Structure Project similar to that proposed by W.H. Poole in 1965 be started in the future modelled after the Cordilleran Structure Project."

Tectonic Styles in Canada — The Structural Subcommittee notes with pleasure that the Geological Association of Canada has approved holding a symposium in 1972 on the "Variation in Tectonic Styles in Canada" under the Chairmanship of Dr. R. A. Price; the symposium will mark the quarter-centenary of the Geological Association of Canada. The scale of the symposium and nature of the support it will need will depend on its relation to the International Geological Congress which meets in Montreal in 1972. The symposium will draw on the diversity of tectonic regimes represented within Canada and will compare these regimes and outline differences and similarities pertinent to problems such as the degree of uniformity in the evolution of orogenic belts through time and space, and the changing patterns in the behaviour and evolution of the crust. The symposium offers an opportunity to draw upon the large volumes of data built up in various parts of the country and in various fields of specialization, and to appraise our current state of knowledge of changing patterns in the deformation of the Earth's crust in Canada. The success of this symposium will depend on the amount of support and participation the project evokes, and on the research and compilation undertaken between now and 1972. Recognizing again the need for concerted action, the Structural Subcommittee recommends:

> "That the National Advisory Committee endorse the symposium on 'Variations in Tectonic Styles in Canada' as a worthwhile opportunity to further structural research in the country."

Geologic Map of the Eastern Cordillera — The Structural Subcommittee notes that the Alberta Society of Petroleum Geologists is investigating the possibility of initiating a joint project by oil companies and the Geological Survey of Canada to compile a geological map of the Eastern Cordillera on a scale of perhaps 1:250,000 embodying data from company files and Geological Survey and other publications. The Subcommittee supports this cooperative project, and believes it would produce a map of value and high quality.

Communications

Publication of Structural Data on Detailed Maps — The Structural Subcommittee notes that an increasing and now significant part of geological field work in Canada is done outside the provincial and federal government agencies. Structural geologists in particular are faced with the problem that much 'hard' structural data can only be portrayed on large-scale maps which are expensive to publish and not acceptable to research journals. It feels that these restrictions could be countered by the implementation of the following recommendation:

> "That the National Advisory Committee make provision for granting funds to subsidize publication of basic structural data, accurately portrayed, on large-scale lithographed maps, published in journals which do not normally accept such maps for publication; and further that consideration be given to creating a repository for field map sheets and structural measurements which constitute basic data that cannot be accommodated in published maps."

Specialized Abstract Service and Annotated Bibliography — This Subcommittee discussed problems of communication and disseminating information, and considers some type of bibliography and abstract service might become necessary. Subcommittee members have agreed to undertake a short trial in which each member will contribute abstracts from one journal, so that the value of such a service may be assessed.

Future Work of the Subcommittee

The members of the Subcommittee are unanimous in their opinion that the work of the Subcommittee can be properly carried out only by meeting and discussion. The great success of the conferences on Kink Bands and Brittle Deformation has encouraged the Subcommittee to foster a similar workshop in 1969, and to meet on that occasion. The Chairman has agreed to form a committee to plan and conduct such a workshop, probably with the topic "Plastic Deformation - Experimental and Field Studies"; the Geology Department, McMaster University has offered to act as host. In view of the benefits to be derived by fostering improved communications among structural geologists, the Subcommittee has agreed to attempt to meet annually and conduct a workshop in some phase of current research in structural geology; and recommends:

> "That the National Advisory Committee approve the intention of the Structural Subcommittee to meet annually to

prepare a report and to conduct a workshop in some phase of current research in structural geology, and that it grant some financial support to enable the subcommittee to carry out this intention."

APPENDIX
TO THE REPORT OF THE STRUCTURAL SUBCOMMITTEE

A Proposal for Continuing Education for Professional Personnel in Earth Sciences

Prepared by C. Dahlstrom

Maintaining a full grasp of even a relatively restricted professional speciality is becoming increasing difficult. Partially, this is due to the volume of new information which is being generated and partially because many technological advances are based upon knowledge or skills which the professional was not taught at school or which he has lost since school through lack of practice. The individual, his employer and the professional societies to which he belongs, have all begun to recognize the problem and each has made tentative but uncoordinated steps toward a solution. It is fairly evident that these steps are inadequate and are likely to remain inadequate unless a concerted cooperative effort is made. The following memorandum is a proposal that the National Advisory Committee on Research in the Geological Sciences establish a committee to investigate the feasibility of establishing a centre of continuing education in earth sciences and technology.

Many professional people have begun to realize in the last few years that their technical education is much like an automobile - it actually deteriorates with time and it also suffers by contrast with the newer models which have undeniable functional improvements as well as an attractive modern styling. For a while, obsolescence was a popular topic of casual conversation which didn't really apply to anyone specifically. That time has passed; obsolescence is an ugly fact of modern life which applies to most professional people.

For most individuals, the certainty of eventual obsolescence has not been strong enough to drive them to serious educational effort. There are many reasons for this, most of them quite valid. Those who usually need education most are those longest out of school and they are the very ones who are least apt to have the time because of increased responsibility and demands on their time from business, home and community. Such spare time as is available seems hopelessly inadequate when compared to the ever growing stacks of new texts and new journals, many of them couched in an unfamiliar jargon of recent manufacture. The lectures sponsored by technical societies provide some relief but they are usually brief and infrequent so that the relief is more to the individual's conscience than to his real problem of creeping obsolescence. Most professional people are concerned about obsolescence but they haven't done anything about it and apparently the aren't likely to do anything about it of their own volition.

The gradual deterioration of its technical staff is a problem of serious concern to larger companies who have a stable work force wherein an individual's company career may span 20 to 40 years. Obviously, something

must be done with such employees to make sure that they at least remain abreast of technological developments. In the past, when change took place at a more leisurely pace, it was possible to put the onus on the employee by saying that any professional man worth his salt would be expected and required, on his own time and by his own effort, to maintain his technical competence. While this attitude still prevails in many quarters, it is a fossil attitude left over from another age. There is little point in debating the morals or ethics of the situation either. The simple facts are that self education for most technical people is lagging sadly behind technical advances.

For the companies who hire these people, the question posed is very simple - either accept technical deterioration or do something about it. For most large organizations this is no choice at all, since diminishing efficiency is unacceptable and the people cannot be replaced. The result is a growing trend toward in-service or in-house education for employees. If this trend continues, we can look forward to a time when most major organizations will have their own internal teaching staff.

The problem of educating professional employees is common to many organizations, but let us use the oil business as a specific example. Let us suppose that the present trend continues for another five or ten years and there are ten internal oil company "universities" in existence. Each of them has its own man teaching structural geology, carbonate petrology, marine geology, geological applications of computers, and so on. Of the material being taught, perhaps 80% of it will be exactly the same, whether it's Chevron, or Shell or Imperial. The other 20% will be proprietary techniques and data which are believed to be unique to that company. With this system there is much duplication of effort; a detached observer would point out the obvious solution of a cooperative venture with all the common data taught by a central agency and the in-house teaching restricted to proprietary data.

While this suggestion is logical, it ignores the central fact that oil companies are large, distinctly bureaucratic organizations conditioned to competition, not cooperation, with one another. Some of the larger companies view education as a competitive field wherein they can obtain an advantage over their competitors by instituting more effective teaching systems. This, coupled with the normal "go-it-alone" attitude of the major integrated oil companies and their inherent antagonism toward the smaller independent, almost guarantees that a cooperative educational system cannot originate from within the oil industry itself. On the other hand, the oil industry is, and has been, quick to take advantage of externally sponsored educational activity, such as the currently popular, university-run, short computer courses. One can conclude that the industry would patronize a system for upgrading their technical people if one were available but that they are unlikely to develop it by themselves.

One question that should be considered is whether such educational facilities are already available. Many organizations do sponsor courses of one kind and another. The courses that are given are useful but they are intermittent and unpredictable as to location, timing, quality and subject matter. The most extensive are those sponsored by universities as a public service, using the spare time of normal university staff. Necessarily, such efforts are bound to be limited. Moreover, the universities are naturally catering to the areas of principal demand and they are doing it without consultation with one another. Consequently, it is pretty easy to find a short course in computers or rock mechanics and, maybe, even carbonate stratigraphy, during

the months of May and June, but less popular topics at other times of the year are not available. There is no way that a technical man can obtain "brush-up" or "upgrading" courses in his particular profession when he needs them except by taking leave of absence from his job to go back to university. Even then he would find the courses unsuited to his specific needs.

I have been speaking of the oil industry, but the same general problem exists in mining as well as in the various branches of the engineering profession. What these groups need is an institution where a man could go for three months every four or five years to take three or four courses which he particularly needs. This institution would be a university specifically catering to adults with an obsolescent technical education. The curriculum would need to be fairly extensive in order to meet the diverse requirements of one man who may need a refresher course in calculus, a basic course in statistics and an advanced course in structural geology, while another may need a basic course in carbonate petrology, a course in geological computer applications, and a refresher course in micropaleontology. The basic courses in a subject might not be too different to those presently being taught to undergraduates, but the refresher and advanced courses would have to be specifically designed for a mature audience. A broad span of subject matter (as well as the three grades of presentation) would be necessary in order that the material available would be close enough to what a man actually needs to make it worth his (or his company's) while to take three months away from his job. The variety of subject matter demands the diversity of a university but it is too big a venture for an existing university to take on as a spare time activity. A happy arrangement would be for a newly developing university operating on the quarter system to decide that it would devote 50% of its effort toward adult continuing education and 50% toward the normal undergraduate and graduate program.

I believe that a demand for such an institution exists and that the number of company-sponsored Canadian students would justify the facility. Since no such facility exists in Canada or the United States, there is no precedent from which to make a simple decision. I believe that the proposal has sufficient merit to warrant very serious consideration and fairly extensive investigation to determine its feasibility. Consequently, I suggest that the National Advisory Committee establish a committee composed of representatives from industry, university and government, and reflecting the geological, geophysical and engineering disciplines. The purpose of this committee would be to investigate the desirability and feasibility of establishing a centre for continuing education in earth sciences and technology. While the committee is specifically directed toward earth sciences, the members should bear in mind that the problem they are considering is common to most lines of professional endeavor and that the solution may involve inter-discipline cooperation.

DISCUSSION OF REPORT

In a lively discussion of the recommendation in the report dealing with continuing education for professional geologists (p. 84) several members objected to the wording of the recommendation. It was felt that the proposed Committee should be instructed to consider ways of overcoming obsolescence rather than investigating the feasibility of establishing a centre for continuing education in the earth sciences; there were other ways of overcoming obsolescence than by establishing centres and some might be preferable to the

proposed centres. It was decided to set-up a Committee "composed of representatives from industry, university and government and reflecting geological, geophysical and engineering disciplines to investigate methods and means for continuing education in the earth sciences and technology".

APPENDIX

GEOLOGICAL SURVEY OF CANADA RESEARCH GRANTS TO CANADIAN UNIVERSITIES 1968-69

General Grants

Name & University	Project Title & Amount
C. D. Anderson Manitoba	Geophysical investigation of the Lake Saint-Martin area of Manitoba. ($1, 095)
D. T. Anderson Manitoba	Photogeology, geomorphology and stratigraphy of a selected portion of the Assiniboine Delta. ($1, 500)
G. M. Anderson Toronto	Water pressure in under-saturated magmas. ($2, 000)
L. M. Azzaria Laval	Géochimie du mercure dans l'exploration minérale. ($1, 615)
H. Baadsgaard Alberta	Fundamental research in geochronology. ($2, 000)
J. R. Beerbower McMaster	Geology, paleontology, and paleoecology of earth Mesozoic carbonate banks, Canadian Cordillera. ($1, 615)
J. Béland Montreal	Purchase of a varityper headliner - Model 820 plus accessories. ($1, 615)
J. Berard Ecole Polytechnique	La porosité en tant que facteur d'alterabilité des roches. ($1, 615)
A. R. Berger Toronto	Geochronological studies, Notre Dame Bay - Bonavista Bay area, Nfld. ($1, 615)
L. G. Berry Queen's	Publication of "The ore deposits of Cobalt, Ontario: their mineralogy and geochemistry". ($2, 000)
W. K. Braun Saskatchewan	Biostratigraphy and microfauna of the Middle Devonian Keg River and Winnipegosis formations of Alberta and Saskatchewan. ($1, 615)
W. C. Brisbin Manitoba	A study of deformational environments within the granitic crust of the Precambrian Shield of northwestern Ontario and eastern Manitoba. ($1, 000)

Name & University	Project Title & Amount
R.L. Brown New Brunswick	Structural studies in northern Appalachians. ($1,615)
B.J. Burley McMaster	Study of petrology's residua system at 6kb H_2O pressure. ($1,615)
M.A. Carson McGill	The long term stability of natural slopes. ($2,500)
G.Y. Chao Carleton	Studies of minerals from the Desoudry Quarry, Mt. St. Hilaire, Que. ($1,615)
H.A.K. Charlesworth Alberta	1. Study of the anisotropy of magnetic susceptibility of rocks. 2. Seismological study of crustal loading along the Peace River. ($3,200)
A.H. Clark Queen's	Comparative study of the mineralogy, geochemistry and environment of formation of strata-bound lead-zinc-silver and pyritic copper deposits, southern Iberia. ($1,615)
L.A. Clark McGill	Geochemical subdivision, stratigraphic correlation, and genesis of rhyolitic volcanic rocks, N.W. Que. ($1,615)
W.B. Clarke McMaster	Inert gases in meteorites. ($1,615)
P.M. Clifford McMaster	Structural and metamorphic geology: a. across the Grenville Front near Sudbury; b. in Keewatin-type assemblages of the Lake of the Woods area. ($1,615)
J. Colwell (Miss) Alberta	Late Cretaceous and Early Tertiary micromammals from southeastern Alberta. ($4,000)
P. Copper Laurentian	Evolution, ecology, morphology of Paleozoic spire-bearing brachiopods. ($300)
J.H. Crocket McMaster	Electron microprobe studies of the Cobalt, Ont. silver ores. ($1,615)
W.R. Danner British Columbia	Stratigraphy and paleontology of Cache Creek group, ($1,615)
R.G. Darling Ecole Polytechnique	Geochemical exploration in the Preissac-LaCorne area, Que. ($1,615)

Name & University	Project Title & Amount
P.P. David Montreal	A study of selected dune areas in Canada. ($1,615)
J.A. Donaldson Carleton	Study of heavy minerals in Proterozoic sandstones of the western Canadian Shield. ($1,100)
R. Doig McGill	Petrologic and Rb/Sr isotopic studies of alkaline rocks. ($1,615)
J.A. Elson McGill	Problems of Glacial Lake Agassiz. ($1,615)
R.M. Farquhar Toronto	Age determinations and isotope studies of Precambrian terrains in the Canadian Shield. ($3,200)
E. Farrar Queen's	Potassium-argon and fossil fission track age determinations. ($1,615)
J.J. Fawcett Toronto	Stability of the muscovite-chlorite-quartz assemblage. ($1,615)
R.C. Fox Alberta	a. Early Tertiary microvertebrates from southern Alberta. b. Geographic and vertical distribution of dinosaurian taxa, Oldman Formation, Late Cretaceous, Alberta. ($1,615)
W.K. Fyson Ottawa	1. Relation of minor to major structures in the Maritime Provinces. 2. Structural analysis of Lower Paleozoic rocks, Mt. Albert area, Gaspé Peninsula. ($1,615)
R.A. Gees Dalhousie	Sedimentology of the near shore environments of Nova Scotia. ($1,615)
A.J. Gordon New Brunswick	Comparative provenance of Cambrian and Carboniferous basal conglomerates in the vicinity of Saint John. ($2,500)
G.J.S. Govett New Brunswick	Geochemical orientation, St. Stephen nickel occurrences. ($5,000)
H.D. Grundy McMaster	The crystallography of natural ion-exchanged and synthetic cancrinite and scapolite. ($1,615)
W.E. Hale New Brunswick	Mineral zoning and geochemical orientation associated with a Devonian granite stock in New Brunswick. ($5,000)

Name & University	Project Title & Amount
P.A. Hill Carleton	Distribution of hexagonal and monoclinic pyrrhotite and troilite in sulphide assemblages of known economic importance. ($750)
D.D. Hogarth Ottawa	1. Igneous history of rocks of the southern Gatineau region. 2. Metamorphism of certain sulphide deposits in the Mattagami region. ($3,000)
R.W. Hutchinson Western Ontario	Comparative studies of lithium-bearing pegmatites. ($1,615)
D.E. Jackson Alberta	Graptolites of western Canada. ($3,000)
P.F. Karrow Waterloo	Study of fossil remains in interglacial deposits of the Toronto district and palynology of late-glacial bogs in southwestern Ontario. ($4,000)
M.J. Kennedy Memorial	Structural profile through the eastern margin of the Newfoundland Appalachians from west of Gander to Glovertown. ($2,500)
A.F. King Memorial	Collection from Wabana iron ore deposit. ($2,300)
O. Knop Dalhousie	Structural studies of minerals. ($2,000)
T. Koulomzine Ecole Polytechnique	Comparative study of electrical and electromagnetic methods of geophysical prospecting applied to the search of sulphide deposits concealed under heavy glacial drift. ($1,615)
J.R. Kramer McMaster	Weathering of silicate rocks. ($2,000)
R. Kretz Ottawa	Chemical petrology of some metamorphic rocks of the Lake St. John area, Que. ($1,615)
H.R. Krouse Alberta	Isotopic studies of western Canadian springs. ($2,000)
E.Z. Lajtai New Brunswick	Dispersion of indicators by glacial transportation. ($1,615)
G. Leblanc Laval	Etude préliminaire de la micro-séismicite de la région située au nord-ouest de la ville de Québec et étude séismique de la croûte. ($700)

Name & University	Project Title & Amount
R.L. Ledoux Laval	Etude de la décomposition de la muscovite, de la phlogopite et de la biotite. ($1,015)
E.I. Leith Manitoba	Pleistocene stratigraphy and sedimentation of southeastern Manitoba. ($3,300)
A.C. Lenz Western Ontario	Upper Silurian and Lower Devonian biostratigraphy of the Royal Creek-Wind River region, Yukon. ($1,800)
J.F. Lerbekmo Alberta	Correlation and sedimentation studies in Continental Upper Cretaceous and Paleocene formations of central-western Alberta. ($800)
P.J. Lespérance Montreal	Biometrie de trilobites ordoviciens. ($1,615)
W.G. Libby British Columbia	A tectonic study of the Wark and Colquitz gneiss complex of southern Vancouver Island. ($2,000)
B.A. Liberty Guelph	Southern Ontario mapping. ($2,000)
W.H. Mathews British Columbia	Properties of Late and Post-glacial clays, Fraser Delta area. ($1,600)
A.L. McAllister New Brunswick	Study of Bathurst ores. ($1,615)
D.J. McDougall Loyola	An investigation of ultraviolet light excited "tunnelling" processes in Canadian fluorites. ($1,615)
A. McGugan Calgary	Permian stratigraphy, sedimentation and paleontology, southeast and northeast British Columbia, Yukon and N.W.T. ($2,000)
R.H. McNutt McMaster	A study of the rare earth elements in rocks and minerals. ($1,615)
K.C. McTaggart British Columbia	a. Chilliwack batholith. b. Glaucophane schist belt, Pinchi Lake, B.C. ($1,990)
K.C. McTaggart British Columbia	Publication of papers dealing with the Cordilleran Structural Project. ($6,000)
G.C. Milligan Dalhousie	Investigations in George River series, Cape Breton. ($1,500)

Name & University	Project Title & Amount
R.G. Moore Acadia	Biostratigraphic units in the upper part of the Windsor Group, Nova Scotia. ($3,000)
W.W. Moorhouse Toronto	Studies of basic rocks. ($1,615)
R.D. Morton Alberta	Studies on the nature and origin of certain ore deposits from the Yukon, N.W.T., Saskatchewan, and Norway. ($1,615)
E.W. Mountjoy McGill	Petrology and stratigraphy of Upper Devonian reef complexes, Alberta Rocky Mountains. ($1,615)
J.W. Murray British Columbia	Investigation of the black sands on the west coast of Vancouver Island beach sands of Wreck Bay, Vancouver Island, B.C. ($2,000)
A.J. Naldrett Toronto	Study of the $Fe_{1-x}S$-$Ni_{1-x}S$ solid solution. ($2,000)
E.R.W. Neale Memorial	Form, origin and tectonic significance of the silicic porphyry body between Nippers Harbour and Confusion Bay, Burlington Peninsula, Nfld. ($3,200)
S.J. Nelson Calgary	1. Historical geology of western Canada. 2. Paleozoic corals. ($5,000)
G. Norris Toronto	Palynology of the Mesozoic of western Canada. ($1,500)
G.E. Pajari New Brunswick	The mineralogy and petrochemistry of the St. George Complex, New Brunswick. ($1,615)
G. Perrault Ecole Polytechnique	Mineralogy and petrology of Mount St. Hilaire, Que. ($1,615)
A.R. Philpotts McGill	Investigation of Monteregian rocks. ($1,615)
G. Pouliot Ecole Polytechnique	Petrology and tectonics of Grenville rocks of the Pipmuacan area (east). ($1,615)
D. Rankin Alberta	Magnetotelluric studies of deep crustal structure in southern Alberta. ($1,615)
J.C. Rucklidge Toronto	Structural and chemical investigation of montbrayite. ($1,615)

Name & University	Project Title & Amount
L.S. Russell Toronto	Computer analysis of dental structure in early fossil mammals. ($2,200)
B.R. Rust Ottawa	The sedimentary history of the St. Clair River delta, Ontario. ($1,700)
P.E. Schenk Dalhousie	Paleocurrent and basin analysis of the Meguma Group (Lower Palaeozoic), Nova Scotia. ($1,500)
H.P. Schwarcz McMaster	Uranium isotope disequilibrium studies of cave minerals. ($1,615)
J.E.G. Schwellnus McGill	Study of the development of rock fabric patterns in three dimensions. ($1,615)
W.M. Schwerdtner Toronto	1. Kinematic significance of hornblende lineations in metamorphic tectonites. 2. Reconstruction of strain directions in mylonites. ($2,000)
M. Seguin Laval	Effect du magnétisme rémanent sur l'electromagnétisme. ($1,000)
D.M. Shaw McMaster	Trace element geochemistry. ($1,615)
P.S. Simony Calgary	Geology of the Rocky Mountain Trench. ($4,600)
F.G. Smith Toronto	Grain growth in metamorphic rocks. ($3,000)
W.G. Smitheringale Memorial	1. Applied geochemistry. 2. Geothermometry of some Newfoundland zinc occurrences. 3. Mineralization in the Coppermine district, N.W.T. 4. Application of atomic absorption spectrophotometry to analysis of silicate rocks. 5. Analysis of Hg by atomic absorption spectrophotometry. ($1,615)
C.R. Stelck Alberta	Palynological studies in the Upper Cretaceous of Alberta. ($2,750)
G.R. Stevens Acadia	Analysis of texture and petrologic variability in Triassic basalt flows and dykes, Nova Scotia. ($3,000)
D.W. Strangway Toronto	Paleointensity of the Earth's field as recorded in Tertiary volcanics. ($1,615)

Name & University	Project Title & University
J.L. Talbot Lakehead	Development of retrograde cleavage in basement complexes. ($2,000)
W.M. Tupper Carleton	Mineral deposits and metallogenesis of the Grenville province. ($1,615)
A.C. Turnock Manitoba	Metamorphism and igneous intrusion in the Precambrian of eastern Manitoba. ($1,615)
J.E. Udd McGill	Model studies of structural phenomena. ($1,615)
J.C. VanLoon Toronto	Development of a rapid scheme of silicate analysis based on atomic absorption spectrophotometry. ($1,615)
J.B. Waterhouse Toronto	Permian brachiopod faunas of the Arctic and Yukon. ($1,615)
D.H. Watkinson Toronto	Experimental study of relationships between niobium mineralization and carbonatites. ($1,615)
G.F. West Toronto	Lake Superior seismic survey. ($1,615)
G.D. Williams Alberta	Groundwater geology of Alberta and adjacent areas. ($1,615)
H. Williams Memorial	Carboniferous rocks of the Red Indian Lake basin. ($1,615)
H.D.B. Wilson Manitoba	The composition, age and low grade metamorphism of the "Keweenawan" lavas (Lake Superior). ($1,615)
H.R. Wynne-Edwards Queen's	Geochemical correlation across the Grenville Front. ($1,615)
R.W. Yole Carleton	Petrology and microfacies analysis of Ordovician rocks, eastern Ontario. ($1,615)
G.M. Young Western Ontario	Stratigraphy and sedimentation of some Huronian formations, north shore of Lake Huron. ($1,615)

Special Grants for Research in Development of Computer-Processible Files

Name & University	Project Title & Amount
F.F. Langford Saskatchewan	Development of mineral deposits data file for a Precambrian area of Saskatchewan. ($3,000)
P.G. Sutterlin Western Ontario	Development of a computer-processible file of mineral deposits data. ($10,000)
G.D. Williams Alberta	Characteristics of oil and gas pools relative to the structure and stratigraphy of Alberta. ($6,500)
H.D.B. Wilson Manitoba	The geologic, geographic and temporal significance of the distribution of base metal and precious metal deposits of the world. ($11,000)
H.R. Wynne-Edwards Queen's	Electronic processing of field data from the Grenville province in Quebec. ($12,500)