NATIONAL ADVISORY COMMITTEE ON RESEARCH IN THE GEOLOGICAL SCIENCES

SIXTEENTH ANNUAL REPORT
1965-66

ANNUAL REVIEW AND
REPORTS OF SUBCOMMITTEES

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601 Booth Street,
Ottawa, October 17, 1966.

The Honourable Jean-Luc Pépin,
Minister of Energy, Mines and Resources,
Ottawa, Ontario.

Sir:

I have the honour to submit to you the Sixteenth Annual Report of the National Advisory Committee on Research in the Geological Sciences covering the period September 1, 1965, to August 31, 1966.

Respectfully submitted,

Y.O. Fortier,
Chairman.

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Professor C. W. Stearn	McGill University, Montreal, Quebec.
Professor C. R. Stelck	University of Alberta, Edmonton, Alberta.
Dr. C. J. Sullivan	Kennco Explorations (Canada) Ltd., Toronto, Ontario.
Dr. J. F. Henderson, Secretary	Geological Survey of Canada, Ottawa, Ontario.

Meetings:
April 18-19, 1966, Ottawa, Ontario.

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Professor L. G. Berry	Queen's University, Kingston, Ontario.
Dr. P. E. Grenier	Department of Natural Resources, Quebec, P.Q.
Dr. C. S. Lord	Geological Survey of Canada, Ottawa, Ontario.
Professor D. M. Shaw	McMaster University, Hamilton, Ontario.

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Professor R.E. Folinsbee	University of Alberta, Edmonton, Alberta.
Professor W.O. Kupsch	University of Saskatchewan, Saskatoon, Saskatchewan.
Dr. C.S. Lord	Geological Survey of Canada, Ottawa, Ontario.

Meeting:
June 9, 1966, Ottawa, Ontario.

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 this report gives a summary of the work of the Committee over the period September 1, 1965, to August 31, 1966. This is followed by the reports of the subcommittees. These cover the different fields of the geological sciences, record developments in 1965-66 and suggest further problems for study. An appendix lists the research grants to Canadian universities for 1966-67 which were awarded by the Geological Survey of Canada on the basis of the National Advisory Committee's recommendations.

The annual survey of current research in the geological and related sciences in Canada for 1965-66 which in previous years formed Part II of this report is published this year as a separate volume[1]. 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 Interim Report of the Committee on Storage and Retrieval of Geological Data in Canada (Geol. Surv. Can., Paper 66-43, 1966) and the Symposium on Geochemical Prospecting (Geol. Surv. Can., Paper 66-54, 1967).

RESEARCH GRANTS TO UNIVERSITIES

Grants by the Geological Survey of Canada were initiated in 1951 at the instigation of this Committee to stimulate and support geological research in Canadian universities. Applications are received from members of university staffs and must be submitted to the Director, Geological Survey of Canada, before May 1 of each year. They are reviewed by the Projects Subcommittee of the National Advisory Committee in June and the applicants are 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 (earth sciences) on a more substantial scale. Applicants for N. R. C. grants apply by December 1 and are

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[1] Survey of Current Geological Research in Canada, 1965-66, National Advisory Committee on Research in the Geological Sciences, Ottawa, 1966. Geol. Surv. Can., Paper 66-53, 1966.

notified of awards in April of each year. The National Advisory Committee has full knowledge of grants in the earth sciences awarded in April 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 subcommittee of the National Advisory Committee that reviews the applications to the Geological Survey.

For 1966-67, 98 applications were received (compared with 92 in 1965-66) and the total of the grants applied for was $309,292 (compared with $264,263 in 1965-66). Eighty-five grants totalling $150,000 were awarded to 20 universities. The names of the recipients, the titles of their research projects and the amounts awarded are listed in the Appendix (p. 125).

With but few exceptions the applications for grants for 1966-67 were deserving of support. However, because they totalled $309,292, or more than double the funds available, some were rejected with no support and in nearly all cases the grants to the remainder are substantially less than the amounts requested. The National Advisory Committee has recommended to the Geological Survey that the amount to be provided for grants-in-aid to the universities in 1967-68 be increased from $150,000 to $185,000.

COMPREHENSIVE STUDIES OF CANADIAN SULPHIDE DEPOSITS

The cooperative, comprehensive study of the Coronation cupriferous pyrite orebody southwest of Flin Flon, Manitoba has been completed and a final report is in preparation. This report will be a symposium type volume made up of papers written by those who carried out the different projects with only a minimum of editing to ensure consistency in format, illustrations, etc. Dr. D.R.E. Whitmore, the coordinator of the project since its inception will be responsible for assembling and coordinating the many contributions. He will also be the author of a final paper which will summarize, integrate and assess the whole undertaking.

An "Editorial" or "Steering" committee composed of Drs. D.R. Derry, H.C. Gunning, and C.J. Sullivan has been appointed to advise Dr. Whitmore on the content and organization of the report. Dr. Whitmore has prepared a plan or outline of the report which has been approved by this Committee. The manuscript is expected to be completed by April 1967. It will be a publication of the National Advisory Committee.

The cooperative, comprehensive study of the Whalesback Pond deposit near Springdale, Newfoundland was initiated in 1964[1]. In 1966

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1 National Advisory Committee on Research in the Geological Sciences, Fourteenth Annual Report, 1963-64, pp. 4-5.

geological mapping of the volcanic pile in which the orebody lies was continued by D. Bachinski, Geological Survey of Canada; E. R. Deutsch, Memorial University of Newfoundland is investigating the possible use of palaemagnetism to unravel the volcanic sequence; and D. J. McDougall, Loyola College completed a study of thermoluminescence of the ore and wall rocks in a number of sections across the orebody[1].

STORAGE AND RETRIEVAL OF GEOLOGICAL DATA

The ever increasing flow of quantitative measurements of rocks and minerals create growing problems of storing these data so that they are readily available. There seems need for some standard format, or several compatible formats, that would make data in different compilations readily accessible, exchangeable and generally usable.

With this in mind the National Advisory Committee in 1964 asked the Geological Survey of Canada, which was well advanced in the planning of a format for its own use, to assess the possibility of formulating a system, or several compatible systems, for the storage and retrieval of geological data which might come into general use in Canada[2].

S. C. Robinson, Geological Survey, was appointed to carry out this assessment and his report was made available to the National Advisory Committee early in 1965[3].

In presenting this report to the National Advisory Committee in April, 1965, Robinson said that as a result of his inquiries he was convinced that for the first time data-processing techniques offer geologists an opportunity to exchange data rather than hypotheses and the opportunity to test hypotheses on the basis of common data. He suggested the appointment of a committee to provide guidance for organizations considering the use of data-storage and retrieval methods. After discussion of Robinson's report the National Advisory Committee endorsed his findings in principle and recommended that an ad hoc committee be set up to take necessary steps to develop a national system for the storage and retrieval of geological data in Canada;

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1 McDougall, David J., A Study of the Distribution of Thermoluminescence Around an Ore Deposit; Econ. Geology, vol. 61, No. 6, 1966, pp. 1090-1103.

2 National Advisory Committee on Research in the Geological Sciences, 14th Annual Report, 1963-64, pp. 12-13.

3 Robinson, S. C., Interim Report on Possible Applications of Data Processing Techniques to storage and Retrieval of Geological Data, Geol. Surv. Can., January, 1965.

that funds be provided to permit the committee and its subcommittees to meet and to pay for the advice of consultants; and that a report on this system be presented to the National Advisory Committee at its annual meeting in April 1966[1].

These recommendations were implemented and an ad hoc committee empanelled under the chairmanship of Robinson. This committee found it could not complete its work and present a final report by April, 1966, but did present a synopsis of the principal conclusions and recommendations of an interim report to the National Advisory Committee at its annual meeting in April, 1966.

The principal conclusions and recommendations of the interim report are summarized as follows:

> "There is a widespread and growing awareness of the need for machine-processable geological data because of the accelerating rate at which data are being accumulated. Until now however, there has been no uniformity in format or data content in the file systems which have been developed by a number of individual organizations throughout the country for their own particular needs. An increasing number of other organizations are presently considering or planning machine-processable-data-storage facilities and would welcome guidance or advice in so doing.
>
> "... As a result of its work the committee feels strongly that a National System (i.e. a combination of formats, data content, etc.) which could accommodate files of any organization and facilitate the exchange of data throughout the country is most desirable and if set up would be used by many organizations. Therefore it recommends unanimously that such a system be established. The committee believes further that the problem is urgent and recommends that every effort should be made to expedite the establishment of such a National System. It also recommends that this report, if approved, be published at the earliest possible date and given the widest possible distribution, to acquaint all geologists with the committee's purpose and to enlist the active support of all interested persons and organizations."

The 100-page report includes chapters on data processing in geology, storage and retrieval of geological data in Canada, geographic coordinates, reference numbering, digitizing descriptive data, coding of geological names and terms, a National Index to geological data, data on mineral deposits,

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[1] National Advisory Committee on Research in the Geological Sciences, Fifteenth Annual Report, 1965-65, pp. 4-9.

data on fossil fuels and related sedimentary deposits and numerous appendices, tables and figures. It is a compilation of information from many sources and records the findings and recommendations of the committee and its subcommittees on the subject matter covered by these chapter headings.

The National Advisory Committee accepted the interim report and recommended that the ad hoc committee be retained on the same basis for an additional year to:

(1) assist and advise in establishment of the National Index;

(2) carry forward the design of spread sheets for those files for which there is a current demand in Canada, and to seek advice of such consultants as may be necessary to implement related programs;

(3) act as the clearing house for Canadian representation on international committees in this field;

(4) provide representatives of geology on national committees concerned with storage of data in the environmental sciences;

(5) advise on and encourage the application of computer (quantitative) methods to geological data in Canada; and to promote the training of Canadian geologists in the assembly and utilization of machine-processable files; and

(6) bring in a final report to the National Advisory Committee in April, 1967.

The National Advisory Committee also approved the publication of the interim report of the ad hoc committee in its entirety so that its inquiries, studies and resulting conclusions and recommendations may become as widely known as possible. This report was published in September, 1966[1].

The National Advisory Committee expresses its appreciation to Robinson for his leadership as chairman of the ad hoc committee and to the members of the committee and its subcommittees for their contributions of time and effort to what is proving a most worthwhile and valuable study; and to Imperial Oil Enterprises Ltd. for their generous contribution of certain components of their confidential Information Retrieval System for use in the National Index.

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[1] Interim Report of the Committee 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.

GEOCHEMICAL PROSPECTING SYMPOSIUM

Prompted by a suggestion of the Subcommittee on Mineral Deposits, the National Advisory Committee sponsored a symposium on geochemical prospecting in Ottawa from April 20-22, 1966. The Geological Survey of Canada was host to the symposium which attracted 250 scientists, including many from outside Canada. Some 38 papers were presented, nearly all of which were concerned with the application of geochemical methods to exploration for mineral deposits. It was apparent from the papers that methods of geochemical prospecting are becoming more sophisticated and more broadly and successfully applied. The interest with which the papers were received and discussed reflected the interest and enthusiasm of the participants in this field. The symposium seemed highly successful in accomplishing its dual purpose of stimulating the interest of field geologists in geochemistry and in facilitating the exchange of information and techniques among those engaged in the practical application of geochemistry to exploration for mineral deposits.

The papers for which manuscripts were submitted, and the abstracts of all papers presented, have been published in a symposium volume[1].

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES

The International Union of Geological Sciences issues about four circular letters a year containing current information about the I. U. G. S., future international meetings, reports on recent meetings, abstracts of papers presented to symposia, progress reports on international research projects and reports submitted by I. U. G. S. commissions, committees and affiliated organizations.

Circular Letter 15, issued early in 1966, contains summaries of scientific papers presented at the Ottawa Symposium on the Upper Mantle, a report on the U. M. C. -U. N. E. S. C. O. Seminar on the East African Rift System, held in Nairobi in April, 1965, and abstracts of papers read at the U. M. C. Symposium on Geothermometers and Geobarometers held in Copenhagen, September, 1965.

Circular Letter 16, published in June, 1966 contains reports on I. U. G. S. commissions and committees, a report on the New York Symposium on the Origin of Stratiform Deposits of Lead, Zinc, Barite and Fluorite and summaries of national Upper Mantle Project reports. It also

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[1] Symposium on Geochemical Prospecting, Ottawa, April, 1966, National Advisory Committee on Research in the Geological Sciences, Geol. Surv. Can., Paper 66-54, 1967.

contains Contact and Information Bulletin No. 1 of the I.U.G.S. Commission for the Study of Geological Documentation which contains information on future international meetings, new books, reviews prepared or in preparation, etc. The Commission for the Study of Geological Documentation requests the cooperation of all geologists in sending them useful information so that future issues of the bulletin may be more complete.

Circular Letter 17 which is in press will contain information on the activities of affiliated organizations, reports on meetings sponsored by the I.U.G.S. and Contact and Information Bulletin No. 2 of the Commission for the Study of Geological Documentation.

I.U.G.S. circular letters may be ordered from Professor W.P. van Leckwijck, Secretary General, International Union of Geological Sciences, Mechelse Steenweg 206, Antwerp, Belgium. Subscription to the Circular Letters is $5.00 (U.S.) per annum (about four issues) payable to Professor R. Trümpy, Treasurer, I.U.G.S., Schweizerische Kreditanstalt, Filiale Rigiplatz, Universitätsstrasse 102, Zurich 6, Switzerland.

SUMMARY STATEMENTS AND DISCUSSION OF SUBCOMMITTEE REPORTS

The different fields in the geological sciences are covered by seven subcommittees that maintain a continuous survey of developments in their fields and of the problems most in need of investigation. The reports of these subcommittees which were presented at the Annual Meeting in Ottawa in April, 1966 are given in full in this report (p. 14). Summaries of these reports, and of the discussions that followed their presentation, follow.

The report of the Subcommittee on Geophysical Methods Applied to Geological Problems notes that the gap between the supply of and demand for geophysicists is widening. A more widespread introduction to the earth sciences in high schools is suggested as a means of interesting more students in the earth sciences as a career. The Hudson Bay Project and Project Pioneer are described and cited as the type of integrated geological-geophysical project recommended by the subcommittee in previous reports.

Current research in geophysics in Canada of interest to geologists is reviewed in some detail. This includes regional and local gravity surveys and studies; regional seismological crustal studies and more local investigations concerned with detailed investigation of anomalies and exploration for groundwater; electrical methods which include a wide range of investigations; geomagnetism including general surveys, anomaly investigations, areal studies and palaeomagnetic studies; heatflow, including instrumentation, scale modelling and field studies; remote airborne sensing; and research on recent movements of the earth's crust.

In discussion of the report several members pleaded for greater coordination and integration of geological and geophysical work. Geophysics is of extreme importance to geology and gives it a third dimension, yet many geologists have difficulty interpreting geophysical reports and the data in them. Geologists and geophysicists should work together on more joint projects as is being done in Project Pioneer and the Cordilleran Structural Project.

The report of the Subcommittee on Mineral Deposits in a review of current research points out the important bearing fundamental earth structures may have on the location of mineral deposits. Several studies of such structures are being undertaken in Canada including the structure of the Keweenawan Basin of Lake Superior and an integrated geological and geophysical study in Manitoba to gain a three-dimensional picture of a greenstone belt (Project Pioneer). Such studies should be encouraged.

The report stresses the importance of geological and geophysical studies of the basement topography of sedimentary basins. Many ore deposits have been shown to be associated with ancient shorelines; thus former islands now buried beneath hundreds of feet of sediment may be of great significance to the prospector. More research should be concentrated on favourable environments of ore rather than on ore deposits themselves. As a corollary, studies leading to a greater understanding of the genesis of ore deposits should be encouraged.

In an appendix to the report, J. A. C. Fortescue outlines a proposal for a systematic examination of the scope of geobotanical and biogeochemical prospecting for mineral deposits in Canada and asks for the support of the subcommittee in the project. In a second appendix P. E. Grenier outlines and appraises the geochemical sampling program of the Quebec Department of Natural Resources which is being undertaken by its field parties in the course of normal geological mapping.

In presenting the report, Sullivan stressed the increasing recognition of the importance of geophysics in mineral exploration by exploration geologists. Fortescue's submission in Appendix I to the report on the proposed systematic examination of the scope of geobotanical and biogeochemical prospecting for mineral deposits had the subcommittee's full support.

Fyles stressed the need for more attention to the collection of data on trace elements of metals in sedimentary strata, such as could be obtained in cores from wells drilled for oil and gas. By the study of such cores from northern British Columbia one subsurface formation was known to contain appreciable quantities of lead and zinc over large areas. Within it there might well be concentrations of ore grade related to unconformities, buried topography or similar features.

The report of the Subcommittee on Mineralogy, Geochemistry and Petrology notes no significant increase in reported research projects in these fields; slight shifts in the number of projects in each category are not regarded as significant. A plea is made for an increase in the funds provided for research in the geological sciences in Canadian universities. A reevaluation of the role of the National Advisory Committee as regards policy in awarding Geological Survey of Canada research grants is suggested.

Analytical standards are discussed including their purpose, the different types of standards, their preparation and distribution, and the need for the preparation of additional standards not now available. The report concludes that present efforts should be directed mainly to establishment of more rock standards. Available standards of geological materials are listed; it is recommended that an up-to-date list be maintained by the subcommittee. It is further recommended that Canadian geoscientists fully support the Non-Metallic Standards Committee of the Canadian Association for Applied Spectroscopy in its efforts to prepare, distribute and analyse standards of geological materials.

The sharing of costly analytical tools by scientists in universities and government organizations is discussed; the sharing of such tools is favoured whenever feasible.

In its 1965 report the subcommittee proposed that it be charged with arranging a workshop on the chemical analysis of geological materials. This workshop was held in Ottawa on February 16-18, 1966. J.A. Maxwell, the main organizer, describes the workshop in an appendix to the report.

In discussion of the report, in regard to the sharing of costly analytical tools, the chairman said the Geological Survey seemed seldom to have any idle instruments. When they were available the Survey would be glad to cooperate with other organizations in their use. In past years some mass spectrometric work had been done at the Survey by McMaster University; and the Survey had made C-14 determinations for outside organizations and for individuals when possible to fit them into the Survey's own program.

The report of the Subcommittee on Quaternary Geology discusses the need for an N.R.C. Associate Committee on Quaternary Research to bring together and ensure communication between the varied disciplines that deal with the different facets of the Quaternary and which include geologists, botanists, glaciologists, geographers and engineers. The subcommittee requests the National Advisory Committee to support in writing to the National Research Council the request of the Canadian delegation to the 1965 INQUA Congress for establishment of an N.R.C. Associate Committee on Quaternary Research.

Publication of data on Quaternary geology and education of students are discussed and the support of the National Advisory Committee is requested in the dissemination of information on economic and other aspects of Quaternary geology.

In discussion of research in Quaternary geology and of projects that should be undertaken, a plea is made for an isotope-enrichment laboratory for radioactive dating. Field work is regarded as basic to Quaternary geology and certain regions, including some largely unsettled areas, suffer from lack of attention. The glacial geology and stratigraphy of the Rocky Mountains are mentioned specifically. The mapping of the Niagara Falls area of Ontario is suggested also to take advantage of the vast amount of engineering information that is available from past hydro-electric highway projects and the widening of the Welland Canal.

The report notes some progress in urban geology studies but also that some of our major cities are not being mapped. It recommends that the geology of Toronto and Montreal be studied continually, preferably by resident personnel.

A comprehensive review of current research in Quaternary geology, by province and territory, covers both laboratory and field projects carried out in 1965 by governmental agencies and universities. An appendix lists 64 papers published in 1965 on Quaternary geology and related fields.

In discussion of the report, the National Advisory Committee agreed to the subcommittee's request for support in the establishment of an Associate Committee on Quaternary Research and has written to the National Research Council recommending its formation[1]. It was agreed that the N.A.C. Subcommittee on Pleistocene Geology should continue to function after the Associate Committee on Quaternary Research was set up. Pleistocene geology was but one facet of Quaternary research and there would be little or no overlap in the functions of the two committees.

C.J. Sullivan suggested that since Quaternary deposits cover the greater part of Canada, more attention should be given to their trace element content as a means of tracking down ore deposits. W.O. Kupsch agreed and pointed out that some work of this kind was being done by H.A. Lee, Geological Survey, A. Dreimanis, University of Western Ontario, and by the Research Council of Alberta. The chairman said the Geological Survey was contemplating applying such studies to the great system of eskers northeast of Great Slave Lake.

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[1] The National Research Council considered this request at a meeting in June, 1966 and agreed in principle to the establishment of an Associate Committee on Quaternary Research.

The report of the Subcommittee on Scholarship and Research Training discusses replies to a memorandum directed to university departments of earth sciences in Canada. A proposal is made that the subcommittee prepare a Canadian version of the A.G.I. booklet on careers or opportunities in geology. In regard to student registration in the geological sciences, most schools recorded small numerical increases. Several respondents suggested that teaching of geology in high schools should be more widespread. Replies to queries on the supply of funds for support of promising students and on postdoctorate fellowships are discussed.

In presenting the report L.G. Berry noted that members of the subcommittee were nearly unanimous in recommending production of a Canadian booklet on careers or opportunities in geology. However, consideration should be given to whether such a booklet would succeed in attracting more students to geology as a career and, since registration of geological students seems now on the upswing, whether we may be soon again in the position of the late 1950's of having too many graduates in geology for the jobs available.

After considerable discussion the Subcommittee on Scholarship and Research Training was asked to proceed with the preparation of a booklet on careers in geology.

The report of the Subcommittee on Stratigraphy, Palaeontology and Fossil Fuels reports no great difference in the number of research projects reported over the last two years and suggests that a plateau is being approached. The unreported research by geologists of oil and mining companies may be assumed to include a comparable number of projects.

Oil-company projects on the Atlantic Shelf and off-coast exploration of the Pacific Margin and Mackenzie Delta Basin, when integrated with the work of the Bedford Institute of Oceanography, are considered the most important developments in 1965. They suggest that we are on the threshold of important discoveries in the fields of micropalaeontology, basinal- and continental-shelf concepts and continental-margin studies.

In a discussion of data processing the report points out that data-processing machines can unravel many stratigraphic problems of correlation, but primary observations to feed the machines must be made by geologists and the demand for broadly trained men will continue to rise.

New developments are discussed and projects are suggested for each of the geographic regions of Canada. The section on Western Canada highlights the research in the Cordilleran and Plains regions and suggests many stratigraphic and palaeontologic problems that need attention. E. Mountjoy reports on research under way and proposed in Eastern Canada, including Ontario-Quebec and the Maritimes regions, and includes suggestions for many worthwhile projects that should be undertaken.

In conclusion the report recommends that "Sedimentation" be included in the name of the subcommittee; that Geological Survey of Canada reports be published more promptly than at present; that the Geological Survey continue the present practice of sampling salt shafts in Saskatchewan; and that future volumes of the G. S. C. Economic Geology Series reports on Petroleum in Canada be broken into a series of reports covering a number of areas.

In presenting this report C. R. Stelck suggested that "Sedimentation" be substituted for "Fossil Fuels" in the name of the subcommittee. Fossil fuels were of only indirect concern to the subcommettee but sedimentation was an integral part of stratigraphy and studies related to it were of increasing and direct concern.

In regard to the recommendation that the Geological Survey continue to sample the strata exposed in potash mine shafts in Saskatchewan, the chairman said the Survey planned to continue this practice.

The report of the Subcommittee on Structural Geology notes greater emphasis on structure than a few years ago, with more integrated studies aimed at determining the structural history of regions, and more universities with professors actively engaged in structural research.

Current structural studies are discussed in turn under the categories of field studies, both regional and detailed; integrated studies involving other branches of the geological sciences, mainly geophysics; and theoretical and experimental studies. In regional studies the understanding of the structure is more or less incidental to geological mapping. Among these are several projects in the Coast and Rocky Mountains, in the Arctic and in Labrador as well as many projects of the provincial departments of mines in Quebec, Ontario, Manitoba, Saskatchewan and British Columbia. Detailed field studies are divided into those aimed at determining the structure and structural history of an area and those aimed at determining some new structural principles or techniques. Renewed interest is noted in the tectonics of the northern Appalachians in the Atlantic Provinces. Among the relatively few detailed field studies aimed at establishing structure principles or developing new techniques are studies of principles of folding and data-collecting techniques in the Rocky Mountains, an analysis of folding and cleavage in Newfoundland and studies of the structural significance of hornblendes in metamorphic tectonites. New quantitative methods of analysis of basic field data are discussed.

Among the structural studies involving other branches of the geological sciences more than a dozen important integrated studies involving geophysics are mentioned. Several studies of the deformation of sulphides have been prompted by the theory that many orebodies have undergone deformation. Currently popular theories about volcanic and sedimentary sources for

base-metal deposits have reduced the emphasis on their structural control, but structural control cannot be neglected because most orebodies are strongly influenced by deformational structures.

Except in the field of rock mechanics, experimental and theoretical structural studies have played a minor role in structural research in Canada. However, experiments on deformation using natural or synthetic materials or models have been initiated at several universities. V.A. Haw, Secretary of the Canadian Advisory Committee on Rock Mechanics, describes the research in rock mechanics currently in progress in Canadian universities and in the Mines Branch, Department of Energy, Mines and Resources.

A second season of field work on the Southern Cordilleran Structural Project was completed in 1965. A table summarizes the projects currently under way.

In presenting this report J.T. Fyles noted that to promote liaison between the subcommittee and the Canadian Advisory Committee on Rock Mechanics, V.A. Haw, Secretary of the Advisory Committee, is a member of the subcommittee and that he in turn is a member of the Advisory Committee on Rock Mechanics.

CHANGES IN PERSONNEL OF COMMITTEE

A.M. Goodwin, H.C. Gunning and J.T. Wilson retired from the Committee in 1965. 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 to succeed those who have retired are: J.E. Blanchard, Department of Physics, Dalhousie University, Halifax, Nova Scotia; S.A. Ferguson, Geological Branch, Department of Mines, Toronto, Ontario; and W.H. Mathews, Department of Geology, University of British Columbia, Vancouver, B.C. C.W. Stearn, Department of Geological Sciences, McGill University has been re-appointed for a second term.

SUBCOMMITTEE REPORT

REPORT OF THE SUBCOMMITTEE ON

GEOPHYSICAL METHODS APPLIED TO GEOLOGICAL PROBLEMS

Presented by W.C. Brisbin

Members of the Subcommittee

W.C. Brisbin (Chairman)	University of Manitoba, Winnipeg, Manitoba.
A.R. Barringer	Barringer Research Ltd. Toronto, Ontario.
A.E. Beck	University of Western Ontario, London, Ontario.
G.D. Garland	University of Toronto, Toronto, Ontario.
D.H. Hall	University of Manitoba, Winnipeg, Manitoba.
M.J. Keen	Dalhousie University, Halifax, Nova Scotia.
L.W. Morley	Geological Survey of Canada, Ottawa, Ontario.
R.D. Russell	University of British Columbia, Vancouver, British Columbia.
V.A. Saull	McGill University, Montreal, Quebec.
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INTRODUCTION

All geophysical research, whether in the categories of geophysical theory, instrumental development, interpretation theory, or the collection of field data, is ultimately of importance to earth science. During 1965 geophysical research in Canada included all these categories, but in this report only those projects that have a more immediate application to geologic problems are discussed. The subdivision is an artificial one and not intended to minimize the importance of the geophysical research that is not included. Readers are refferred to the Canadian Geophysical Bulletin Vol. 18, 1965, published by the National Research Council, and to the International Upper Mantle Project Report No. 3, April, 1966 (pp. 26-40) for a more comprehensive review of both fundamental and applied geophysical research in Canada.

Financial assistance for most university research has come from the National Research Council, the Geological Survey of Canada, the Defence Research Board, the Meteorological Service, the Department of Northern Affairs and Natural Resources, and the Mines Branch. As well, a few universities received grants from United States governmental agencies.

SUPPLY AND DEMAND OF GEOPHYSICISTS

Several subcommittee members have noted that the gap between the supply and demand of geophysicists is becoming greater. The difficulty goes beyond filling available positions in industry; graduate schools and research in geophysics will soon suffer. This situation is a reflection of the trend noted in Geotimes (July-August, 1965), and in the Bulletin of the A.A.P.G. (Dec. 1965). The latter publication, in its projections to 1967 in the United States, notes that geophysics graduates available for employment will be no more than 10 per cent of the number of job opportunities. The same trend is probably true in Canada and will certainly be aggravated by the condition in the United States.

One step that might be taken to interest more students in geology and geophysics would be a more widespread introduction to earth sciences to students in high schools. In the United States the National Science Foundation and the American Geological Institute have organized the "Earth Science Curriculum Project" and produced an earth science textbook, teacher's guide and laboratory manual for ninth-grade educational level. These were used in 75 schools in 15 test centres during 1964-65, and a revised, second edition is now available. These publications would form an excellent foundation for earth-science studies in Canadian high schools.

INTEGRATED GEOLOGICAL-GEOPHYSICAL PROJECTS

In view of previous recommendations of this subcommittee for the initiation of more integrated geological-geophysical studies, it seems appropriate to mention two such projects initiated in 1965.

The Hudson Bay Project, conducted during August and September, 1965, was an extensive and comprehensive survey of the Bay encompassing the fields of geophysics, geology and oceanography. Bottom sampling, bathymetry, shallow seismic profiling (Sparker), shipboard and bottom gravity and magnetic observations and shallow and deep seismic-refraction profiling were included in the program. The expedition was organized by the Bedford Institute of Oceanography and the Geological Survey of Canada. Participating groups were the Observatories Branch, the Polar Continental Shelf Group, and Dalhousie, Toronto, Western Ontario, Manitoba and Saskatchewan universities. Preliminary results of some of the geophysical aspects of the project are referred to in the review of current research which follows.

Project Pioneer, organized by the Manitoba Department of Mines and Natural Resources and the Geology Department, University of Manitoba, is an integrated geological, geophysical and geochemical study of the Rice Lake-Beresford Lake volcanic-sedimentary belt. During 1965 several geophysical programs were started in the area (gravity, deep seismic and magnetic); geological and geochemical investigations will be initiated in the summer of 1966. Careful consideration is being given to the deliberations of the National Advisory Committee's ad hoc Subcommittee on Storage and Retrieval of Geologic Data (see p. 3); this group is providing useful guide lines for the handling of the vast amount of geological and geophysical data that will be forthcoming from this project during the next three years.

A REVIEW OF CURRENT RESEARCH

Gravity

As in previous years, the major gravity research in Canada has been carried out by the Gravity Division, Observatories Branch. In addition to the field investigations referred to in the following section, the Gravity Division has been engaged in fundamental research on sea gravimeters, theoretical studies of methods of analysis of gravity data, earth-tide studies and in control surveys.

The 1965 gravity field projects which may be of interest to geologists are as follows:

Regional Surveys

The Observatories Branch has extended regional gravity coverage in the following areas and is presently working on the interpretation of the data: (The present extent of gravity coverage in Canada is illustrated in Canadian Geophysical Bulletin, Vol. 18, 1965).

(a) Northern Manitoba, Ontario and Saskatchewan: In northern Manitoba and Saskatchewan, gravity stations were established with an 8-mile spacing within the large area bounded by latitudes 54° north and 60° north, longitudes 92° west and 104° west. More detailed information, to study the Churchill-Superior boundary, was obtained in the form of 650 stations at intervals of 4 miles covering the Nelson River gravity high. In addition, 700 gravity stations, at intervals of 2 miles or less, were observed in the Stony Rapids area of northern Saskatchewan to investigate the norite intrusions of this area and their extension beneath the Athabasca sandstone. This work was performed in cooperation with the Saskatchewan Department of Mineral Resources.

In Ontario, surveys with a station spacing of 8 miles were done in the following areas: Ignace-Fort William, Chapleau-Sudbury Michipicoten-Sault St. Marie.

(b) Polar Continental Shelf: 750 regional stations were observed at intervals of 6 to 8 miles over Somerset and Prince of Wales Islands to study the Boothia Arch and neighboring sedimentary basins. Approximately 500 stations were observed also on sea ice over the continental shelf and slope of the Arctic Ocean.

(c) Quebec and Newfoundland: With the exception of the area north of latitude 55° north and east of longitude 63° west, regional gravity mapping has been completed in these provinces. A comprehensive structural interpretation of the gravity anomalies in Quebec and Labrador is now proceeding. More detailed information has also been acquired in the Cape Smith, Goose Bay, Payne Bay, and Magpie Lake areas for study of the basic intrusions and anorthosite bodies.

(d) Hudson Bay: As part of the cooperative oceanographic and geophysical program with the Bedford Institute of Oceanography and the Geological Survey of Canada, the Observatory carried out a reconnaissance gravity survey of Hudson Bay during the summer of 1965. Approximately 800 stations with a station interval of 8 to 10 miles were established along a number of traverses. As well as establishing a hitherto unknown gravity field, these data will undoubtedly

contribute to the statistical analysis of gravity and elevation data around Hudson Bay and James Bay which is being carried out by the Observatory to study the isostatic effects of glacial loading and rebound.

(e) Northwest Territories: The results of regional gravity work over 30,000 square miles of the Bear geological province south of Coronation Gulf are being analyzed. The rocks of this area include the Coppermine basalt flows and the Muskox ultrabasic intrusion. The major feature of the gravity field is a north-south trending positive anomaly which does not correlate with the surface exposure of the basic rocks. The anomaly has been interpreted as a result of a deep-seated basic intrusion originating from a crustal depth of not less than 20 kilometres.

The sea gravimeter of the Bedford Institute of Oceanography was used for 161 days at sea collecting gravity data across several areas which include Hudson Bay, Ungava Bay (where a large negative free-air anomaly was observed) and the mid-Atlantic ridge. The Bedford Institute interpretation of combined gravity and seismic observations across the Nova Scotia continental margin suggests a possible density variation in the upper mantle.

In New Brunswick 1322 regional stations were established in the vicinity of Moncton, Woodstock and Edmundston. Except for the Cambellton area, all accessible roads in the province have been surveyed and evaluation of the data is proceeding. In Nova Scotia gravity surveys were conducted on Cape Breton Island and in Cumberland County.

At the University of Manitoba regional gravity interpretations of the English River gneissic belt are being refined as a result of regional crustal seismic studies across this structure.

A gravity profile was established along the Hanson Lake Road by the University of Saskatchewan group to provide additional control in the interpretation of seismic crustal refraction measurements in this area.

Local Investigations

The gravity division of the Observatories Branch has continued field investigations of possible fossil craters. Field investigations in 1965 were centred at Pilot and Nicholson Lakes in the Northwest Territories. A gravity survey over Nicholson Lake outlined a circular negative Bouguer anomaly similar to those recorded at other Canadian craters. The Observatory group considers these to be of meteoric origin.

The Geological Survey of Canada studied thirteen aeromagnetic anomalies by gravity methods in the Kapuskasing-Moosonee area of northeastern Ontario. The field data are now being interpreted.

At the University of Manitoba a detailed gravity investigation of the Rice Lake area has begun. This work is designed to determine the depth and structure of a greenstone belt and the form and size of granite diapirs which have intruded the greenstone. The gravity investigation is one the geophysical studies forming part of Project Pioneer.

In Saskatchewan the Department of Mineral Resources has chosen the exploration for potash as a target for gravity research. Specifically, it is applying Hammer's gravity-stripping method to an area where good gravity, seismic, and pre-middle-Devonian well control is available. The Saskatchewan Research Council has been involved in studying gravity fields in three areas: between Amisk Lake and the Manitoba boundary, in the vicinity of Stenan, and 15 miles west of Saskatoon where the objectives are anomalies associated with buried sand and gravel deposits.

The University of Alberta reports that a small detailed survey has been completed between Brooks and Vulcan, Alberta, to provide additional control in interpreting deep crustal reflection data.

Seismology

Crustal Studies

The largest of the experiments in this category was the one in Hudson Bay which took place during August 1965 as part of the Hudson Bay Project. The study consisted of two lines of shots, one from the Ottawa Islands to Churchill, the other from Chesterfield Inlet to join the first line at the centre of the Bay. The nine recording crews were located at the Ottawa Islands, Povungnituk, Coats Island, Chesterfield Inlet, Eskimo Point, Churchill and Winisk. Each of the different recording agencies is processing its own records.

In the 1966 continuation of the International Lake Superior Crustal Seismic Study approximately 40 large shots were to be fired off the Keeweenaw Peninsula by the U.S. Geological Survey in July. At least 12 agencies and universities in the United States and Canada were to provide crews to record these shots out to radial distances exceeding 2500 kilometres.

Crustal-refraction studies at the University of Alberta include two profiles; one between Swift Current, Saskatchewan, and Vulcan, Alberta, and the other from Suffield, Alberta, west to the Rocky Mountains and Purcell Mountains. As well, investigations of near-vertical-incidence

reflected waves continued in 1965; it has now been established that reflected events are obtainable from depths of 25 to 48 kilometres over much of southern Alberta. Correlation is possible over short distances and the indicated structure fits well with gravity anomalies. The technique appears to be useful in determining the structure and nature of the lower crust, but the technical and interpretational difficulties are not to be underestimated.

At the University of Manitoba crustal-refraction work over the English River gneissic belt has been extended to include stations along the road from Vermillion Bay to Red Lake, Ontario, and from Lac du Bonnet to Manigotogan, Manitoba. Converted head-waves have been identified on the records and have been used in the analysis of crustal structure. The structure on the Conrad and Mohorovicic discontinuities has been outlined and is presently being correlated with the regional gravity, regional magnetics, and surface geology. This project was to continue during 1966.

The geophysical group at Dalhousie University has obtained detailed information about the crust and upper mantle from seismic refraction work over the Atlantic continental shelf, slope, rise and ocean bottom. By combining these with sea-gravity observations, several models of the crust and upper mantle have been constructed. As mentioned earlier in this report, the results suggest that density contrasts between oceanic and continental mantle material extend to depths in excess of 40 kilometres. This group has also traced the roots of the Appalachian system from the Gulf of St. Lawrence to northeast of Newfoundland by seismic-refraction measurements.

The Observatories Branch seismic group has been active in crustal studies, particularly in the north and on the west coast. In the Yellowknife area experiments are determining crustal and mantle structure and velocities in the Bear and Slave geologic provinces. In the Arctic Archipelago the Observatory has been doing crustal-refraction work and surfaces-wave studies. In the west it has been conducting a program of refraction work to outline the major crustal and upper-mantle features of the Cordillera. Observations parallel to the west coast have been published and a reversed profile from Merrit to Quesnell completed.

Local Investigations

The Bedford Institute of Oceanography and the Geological Survey of Canada were involved in shallow seismic profiling and conventional marine-refraction programs as part of the Hudson Bay project. The Sparker survey outlined mud thicknesses that may be more than 100 feet in some areas, whereas other bottom areas have been scoured clean by currents. In the eastern part of the Hudson Bay basin, seismic velocities suggest that there may be a considerable thickness of Proterozoic sedimentary rocks overlying the basement, the westerly limit of which is unknown. In the central part of the basin the seismic velocities indicate the probable existence of Mesozoic

overlying Paleozoic sedimentary rocks. The estimated thickness of post-Proterozoic strata is 7,000 feet. The results also indicate the presence of considerable structure within the sedimentary section of the central part of the Bay.

Shallow-refraction studies with a hammer seismograph were conducted in two areas by the Geological Survey of Canada: the Moose River area over the Moose River magnetic anomaly, and at Suffield, Alberta, over a proposed blast site. Preliminary reports on these projects appear in the G.S.C. Paper 66-1. Two-ship marine-refraction work was conducted by the Geological Survey in October, 1965, to investigate the thickness, nature, and attitude of the sedimentary rocks underlying a portion of the Gulf of St. Lawrence. The results of this study are also reported in preliminary form in G.S.C. Paper 66-1.

Queen's University reports a combined seismic-resistivity study in the vicinity of Kingston to evaluate the Precambrian-Paleozoic interface as a possible control in the quality and quantity of groundwater in the area.

Extensive refraction work has been done in the Stavely area of Alberta by the Alberta Research Council as a means of exploring for buried channels. A test-drilling program has also been conducted as an aid in the evaluation of this technique.

The Saskatchewan Research Council reports a program of underground seismic measurements in a potash mine as a means of measuring the thickness of the salt beds.

Electrical Methods

Work by the Geological Survey of Canada in this category covers a wide range of investigations which include field studies, scale-model studies, instrumental-development and laboratory studies of electrical properties of rocks and minerals. One field trial, of special interest to geologists, was the airborne measurement of the resistivity of surficial deposits in four areas of Saskatchewan and Manitoba using a pulsed electromagnetic source (Barringer INPUT System). In the Winkler area of Manitoba the survey took three hours flying time as opposed to a three-month period to collect the equivalent data on surface. The results of the airborne work compare favourably with those obtained on the ground. In the other three areas resistivity anomalies were detected that will require follow-up work on the ground. The method can definitely detect near-surface anomalies with a two-times resistivity contrast.

The Geological Survey of Canada has also been doing surface resistivity work to determine the location of the buried pre-glacial Missouri channel in Saskatchewan and Manitoba.

At the University of Toronto a project is under way to determine the cause of electro-conductivity in serpentine.

The Polar Continental Shelf Group, along with the University of the Sorbonne and the National Research Council, has been making measurements of the electrical resistivity of polar ice masses. This work should provide important fundamental information on the electrical properties of large crystalline masses.

Geomagnetism

General

The Geological Survey of Canada continued publishing new aeromagnetic sheets; 476 sheets were published as a result of the Federal-Provincial Aeromagnetic program and 152 sheets as a result of surveys done by the G.S.C. Two hitherto unknown magnetic features were revealed and have caused much interest - the Moose River magnetic feature running southwest from Moosonee, and a sizeable magnetite iron-ore prospect in the Grenville subprovince 35 miles northeast of North Bay.

Theoretical and laboratory studies on magnetic instrumentation, new techniques of analysis, and magnetic properties of rocks are continuing at the Geological Survey, the Mines Branch, and at the Universities of Toronto and Western Ontario.

Computer use in reducing, filtering and plotting aeromagnetic data is receiving considerable attention from the Geological Survey and the University of Manitoba. The areas to which these techniques are being applied are listed in the next section.

The University of Toronto has continued its program of measuring natural magnetic variations to test the hypothesis that high electrical conductivity is related to high temperature. The work during 1965 was extended from Iceland to the Azores.

A magnetotelluric profile was initiated in Southern Alberta by the University of Alberta and is being interpreted in cooperation with the University of British Columbia. The results are outlining changes in resistivity in the crust and upper mantle.

During the summer of 1965 the University of British Columbia carried out a rather extensive field program of geomagnetic depth soundings in British Columbia and New Mexico. On the basis of the records, studies are proceeding concerning the possible existence of areas of anomalous inductive effects in the earth's upper mantle and crust.

Anomaly Investigations and Areal Studies

The Geological Survey of Canada is using computer methods for reducing, filtering and plotting magnetic data over a large area covering approximately 100,000 square miles of the Precambrian shield in northwestern Ontario to determine the depth and extent of magnetized bodies in the crust of the earth. Interpretation of aeromagnetic anomalies in areas north of Lake Superior and Lake Huron is proceeding.

The University of Manitoba is doing somewhat similar work in a large area of the shield between Lake Winnipeg and Red Lake to determine features of crustal structure; the work is closely correlated with the program of seismic, gravity, and regional geologic studies in the same area. The Manitoba group is also studying local anomalies, and induced and remanent magnetization of surface samples.

As part of the comprehensive Hudson Bay project the Bedford Institute of Oceanography made surface-magnetic observations over a large part of the Bay during the summer of 1965. Anomalies up to 4,000 gammas were observed on the east and west flanks of the Bay, with a relatively uniform magnetic field in the central two-thirds. Preliminary analyses of the results indicate that the depth to crystalline basement rocks is greatest in the west-central area, where it reaches about 3,000 metres. A special aeromagnetic survey was carried out by the Geological Survey of Canada over the central part of Hudson Bay. The orientation of the anomalies suggests that the belt of high-amplitude magnetic anomalies observed near Owl River, Manitoba, probably swings to the south or else dies out before it reaches the area of the survey. Large-amplitude anomalies were also observed approximately 60 miles north-northwest of Churchill. These have been interpreted to be caused by magnetic iron formation which underlies approximately 7 square miles of the Bay.

The Geological Survey of Canada completed another special aeromagnetic survey over the Flemish Cap off Newfoundland. Short-wave-length anomalies were observed and have been interpreted as due to basic igneous intrusions buried at shallow depths below the ocean bottom.

The Bedford Institute of Oceanography made magnetic observations in connection with an oceanographic and geophysical study of a portion of the mid-Atlantic ridge. Results of this work indicate a model in which steep contacts parallel to the median valley of the ridge separate blocks of different magnetization; the blocks may extend to depths of five kilometres below sea level.

The Moose River magnetic anomaly in northeastern Ontario which has been the subject of much interest was studied in some detail by the Geological Survey of Canada during the summer of 1965. A preliminary report on the work is to be found in G. S. C. paper 66-1, 1966.

Paleomagnetic Studies

An active program of paleomagnetic studies is under way at the University of Western Ontario. Investigations of Precambrian rocks include the Nipissing diabase, the Gowganda Formation and the lavas and sills of Keewanawan age from the Lake Superior region. A number of gabbro-syenite intrusions from the Grenville and Superior provinces are also being studied. Paleomagnetic work is also being carried out on late Triassic basalt from Nova Scotia and Mississippian-Devonian andesites from Cape Breton Island. Paleomagnetic investigations of Mesozoic and Cenozoic rocks from Africa and South America are also under way.

Paleomagnetic studies at the Geological Survey of Canada concern diabase dykes of the Canadian shield; the Whitehorse and Laberge map areas in the Yukon; the Sudbury irruptive norite (a joint project with the International Nickel Company of Canada); and the vicinity of Rouyn, Val d'Or and Sudbury.

Paleomagnetic work at Memorial University of Newfoundland is accompanying geologic examination of the high shoals of the Great Bank off Newfoundland and the shoals of the Gulf of St. Lawrence.

Heat Flow

Heat-flow instrumentation, scale modelling, and field studies are being extended at the University of Western Ontario. Field work in Western Canada has established that thermal data correlate with two basement intrusions; this work is being continued and the location of a third intrusive body has been predicted. Data obtained from oil company boreholes suggest that the method may be used to show the interconnection of reservoirs. A similar program in southwestern Ontario indicates that the Algonquin Arch is reflected in the heat-flow data. Detailed thermal measurements of the Lake Dufault orebody, Quebec, have progressed considerably, but interpretations of the data are not yet complete. Heat-flow studies of the Muskox intrusion are close to completion and will be published shortly.

The program of the Observatories Branch to measure heat flow in Canada has now established fifteen thermal gradients at widely separated locations across the country. Measurements have been made in special holes drilled by the Observatory in addition to commercial holes drilled originally for other purposes.

At McGill University an interesting study of the effect of post-Wisconsin climatic changes on thermal gradients in the Quebec lowlands is under way. Conductivity determinations are also being made on rocks from the Observatories' heat-flow hole at St. Jerome, Quebec.

The University of Toronto is continuing investigation of possible improvements in the measurement of temperature gradients and thermal conductivities in place. Measurements of heat flow at new localities are being made in the course of this study.

Radioactivity

Interest in radioactive geophysical methods is apparently decreasing. The only project reported is the joint study of the Geological Survey of Canada and the University of Western Ontario in the Elliot Lake area. Here the G.S.C. portable gamma-ray spectrometer was used to complete a survey of the exposed rocks in part of the Huronian basin and its basement. The results of the survey will be correlated with the geology and ore deposits.

Remote Airborne Sensing

There is growing interest in remote airborne sensing. During 1965 the Geological Survey of Canada established a Remote Sensing Section in its Geophysics Division. This section is concerned with the development and use of various sensing devices that measure electromagnetic radiations ranging in frequency from microwaves through the visible spectrum to gamma rays. Research is directed toward the remote measurement of various physical properties of rocks and minerals and the geological interpretation of these measurements. During 1965 an airborne infrared-scanning experiment was carried out in the vicinity of Vaudreuil, Quebec, Carleton Place, Ontario, and along the Lake Ontario shoreline from Port Hope to the Niagara River. The results are presently subject to military security regulations, but there is evidence that the method will be of value in hydrogeologic research. Infrared imagery may also have high potential for finding oxidized orebodies.

Recent Movements of the Earth's Crust

M. J. S. Innes, Observatories Branch, has prepared an excellent summary of projects to study recent vertical and horizontal movements of the earth's crust in Canada, for International Upper Mantle Project, Report No. 3, 1966, pp. 28-30.

Investigations of vertical movement involve a trans-continental relevelling program which will permit comparison with previous precise-level lines, tidal gauge measurements, geologic and oceanographic methods of estimating the maximum extent of marine submergence and subsequent crustal uplift, and gravity studies. A long-term program is also under way to determine vertical movements in response to future loads of water at three hydro-electric reservoirs: the Peace River reservoir in British

Columbia, the South Saskatchewan River reservoir in Saskatchewan, and the Manicouagan 5 reservoir in Quebec. Earth-tide measurements have been initiated by the Observatory and by Dalhousie University; the latter is studying the effects of crustal loading by large oceanic tides in the Bay of Fundy.

Long-term studies to detect possible horizontal movements of crustal blocks have begun in widely separated areas in Canada. The Geodetic Survey of Canada is providing a control network as a base for future studies of possible horizontal movements across the Logan Fault. The same organization has carried out preliminary work to select station sites for precise horizontal measurements across the north end of Robeson Channel between Ellesmere Island and Greenland to test the possibility that Greenland and Canada are moving apart.

At the University of British Columbia reconnaissance has been completed for proposed horizontal control from the mainland to Vancouver Island. This control is to be used to check for possible movement of the island with respect to the mainland.

RECOMMENDATIONS AND PROPOSALS

1. The chairman of this subcommittee had the privilege of attending the March 1966 meetings of the Associate Committee on Geodesy and Geophysics of the National Research Council as an official representative of the National Advisory Committee. As a result of the considerable interest shown by the Associate Committee members in the National Advisory Committee and its functions, it is recommended that, in future, Associate Committee members be sent the annual reports of the National Advisory Committee.

2. Meetings of the subcommittees of the National Advisory Committee are regarded by members of this subcommittee as most worthwhile. Although circumstances prevented a meeting of this subcommittee in 1965, it is recommended that at least one meeting take place during the three-year term of each chairman.

3. With reference to the supply and demand of earth scientists in Canada the subcommittee suggests that the National Advisory Committee consider methods to encourage the introduction of earth science curricula in the high schools. A possible starting point might be to approach the Geological Association of Canada which is making a survey of earth science teaching in high schools. A well-prepared combined G. A. C. - N. A. C. submission to the 1966 Mines Ministers Conference might be appropriate.

REPORT OF THE SUBCOMMITTEE ON MINERAL DEPOSITS

Presented by C. J. Sullivan

Members of Subcommittee

C. J. Sullivan (Chairman)	Kennco Explorations (Canada) Ltd., Toronto, Ontario.
R. L. Cheesman	Department of Mineral Resources, Regina, Saskatchewan.
J. F. Davies	Department of Mines and Natural Resources, Winnipeg, Manitoba.
A. M. Goodwin	Geological Survey of Canada, Ottawa, Ontario.
P. E. Grenier	Department of Natural Resources, Quebec, P. Q.
Walter Holyk	Texas Gulf Sulphur Company, Toronto, Ontario.
C. S. Ney	Kennco Explorations (Canada) Ltd., Vancouver, British Columbia.
J. P. Nowlan	Department of Mines, Halifax, Nova Scotia.
J. E. Riddell	Consulting Geologist, St. Andrews, New Brunswick.

REVIEW OF RESEARCH

Fundamental Earth Structures

It is believed that fundamental earth structures have a major bearing on the location of important types of Canadian mineral provinces, and knowledge about them is thus important in prospecting. Penetrating studies of the earth's crust are being undertaken in Canada, and it is recommended that these be encouraged.

Among these important contributions is the study of the structure of the Keweenawan Basin and the earth's crust in the vicinity of Lake Superior by G. F. West and H. Halls, University of Toronto. The margins of this tectonic basin may contain valuable deposits of iron, bedded copper ores, volcanic copper ores, and copper related to granitic intrusives.

A study of similar importance is Project Pioneer, being supervised by J. F. Davies, Manitoba Department of Mineral Resources, and H. D. B. Wilson, University of Manitoba. Integrated geological and geophysical data are being obtained to provide a three-dimensional picture of a greenstone belt. It is within such belts that many large ore deposits are found and greater understanding of their nature is of great significance for prospecting.

Similar commendable work has been carried out by the Observatories Branch and the Geological Survey of Canada in the James Bay lowlands of Ontario, and in the Nelson River region of Manitoba.

J. P. Nowlan recommends "a detailed study of the graben that extends on land between Chedabucto Bay and Minas Basin and which has been traced several hundred miles east. I think there is a fair possibility that this may turn out to be a structure of depth similar to, say, the Kirkland-Cadillac break. A basin like this, cut by post-Mississippian basic intrusives, may be host to many ore deposits at depth."

Sedimentary Basins

It is recommended that in addition to the study of faults and continental boundaries, research into the basement topography of sedimentary basins be carried out by geological and geophysical means. This is standard procedure in oil exploration but would be useful also in prospecting for many types of metals. Lead-zinc deposits of the Pine Point-Missouri type; the bedded copper ores of Rhodesia-Katanga; the Irish lead-zinc and copper deposits - these are associated with ancient shorelines, abutting against basement highs. Former islands, now buried by hundreds of feet of sediment, are thus of great prospecting significance.

J. P. Nowlan suggests that the Windsor basin of Nova Scotia-New Brunswick would be suitable for palaeogeographic studies. In addition to lead and copper, this basin contains large evaporite deposits.

Other mineralized beds occur in the Palaeozoic rocks of southern Ontario and Quebec, in the late Precambrian north of Lake Huron, and in the late Precambrian basins of the Port Arthur-Nipigon region. Prospecting for lead, zinc, copper and uranium in these beds would be greatly aided by palaeogeographic knowledge.

In the Hudson Bay region, new knowledge of prospecting significance has recently been obtained. In such work geological research cannot be separated from geophysical research.

The Environment of Ore and its Genesis

This subcommittee in its report for 1965 recommended that more research be concentrated on the environment of ore[1], rather than on ore deposits themselves. As a natural corollary, investigations leading to genetic understanding of ore deposits should be encouraged.

Bedded Ores

Work under the direction of R.E. Folinsbee, University of Alberta, gathered new facts concerning the Pine Point lead ores. In the light of the results, these researchers conclude that the lead possibly migrated to its present position at the margin of the basin from sources deeper within the sedimentary pile.

S.A. Jackson, University of Toronto, is investigating the palaeoecological aspects of the Presqu'ile dolomite, Pine Point.

At the University of Alberta research is proceeding on the distribution of lead, zinc and other metals in relation to dolomitized reef fronts and to other facies changes. Similar studies are reported by the British Columbia Department of Mines. This type of research may be very fruitful; it should be encouraged.

Beales, Edhorn and Moorhouse, University of Toronto, are studying the Precambrian fossils of the Animikie and their relationship to iron deposition. Copper also has recently been found in association with these algal-like forms, near Lake Nipigon and near Lake Mistassini, repeating a pattern found elsewhere in the world. Studies of this empirical association could be significant. Such work is proceeding at Queen's University under the direction of F. Mendelsohn.

Massive Sulphides

Canadian metal production has been largely derived from massive sulphide ores, and the recent discovery of a large deposit, near Timmins,

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[1] National Advisory Committee on Research in the Geological Sciences, 15th Annual Report, Part I, 1965, pp. 27-31.

Ontario, has re-awakened interest in the origin of such deposits and the geological environment in which they should be sought.

R. W. Hutchinson and fellow workers at the University of Western Ontario are investigating these deposits. Their conclusion that the deposits are of volcanic-exhalative origin is of considerable prospecting significance.

Pioneer work on the movement of sulphides under the direction of J. E. Gill, McGill University, continues to throw light on the origin of sulphide ores; and trace-element studies at the University of Manitoba are helping establish consanguinity of some of the ores. Nevertheless much remains to be discovered concerning the environment in which such ores are likely to be found. Without such knowledge, the selection of areas in which to prospect for further deposits is not scientific.

GENERAL COMMENTS

Geological teaching and research should bear a close relationship to fundamental, empirical, field work, especially with reference to the search for mineral deposits. Although every effort within reason should be made to take advantage of new knowledge and techniques of physics, geology is a science proper to itself which cannot be learned with a microscope or electron microscope; a Ph. D. graduate who has spent four years determining the structure of perovskite may not know much about geology!

J. E. Riddell suggests that more geological data collected by mining companies should be reported to the geological profession after it has been in their possession a suitable length of time. This would save duplication of effort by university and government workers.

J. F. Davies comments as follows:

"Historically, the investigation of mineral deposits has involved:

1. General studies of the deposits themselves.
2. More detailed studies of individual aspects of certain deposits and certain types of deposits.
3. Generalized studies of the geological setting of deposits, in restricted regional sense.
4. Broad and generalized interpretations of metallogenic environments.

"Progress is still being made in all of these fields, but two factors have impeded progress, paradoxical as this may appear on the surface; one is over-specialization and the other is overgeneralization. We must team together the specialists and the geological philosophers. I am convinced that little further progress can be made if we treat the problems of geology as separate problems. What is required are integrated, thorough, and penetrating investigations of entire mineralized districts, utilizing all possible geological, geochemical and geophysical techniques. This is the thought behind our Project Pioneer to which I referred last year and which is to be initiated this spring[1]."

A. M. Goodwin comments as follows, mainly apropos the actions of this subcommittee:

"1. I suggest that the government agencies, at the federal and provincial levels, be offered the full encouragement of the subcommittee to proceed with and if possible increase the scale of scientific investigations of mineral deposits both as to nature and origin.

"2. That ways and means be investigated for broadening the basis for liaison and consultation between the geological research agencies on the one hand and the exploration fraternity on the other. One such way might be to increase the number of participants from industry on the Subcommittee on Minéral Deposits.

"3. That advantage be taken of the opportunity to hold a meeting of the Subcommittee on Mineral Deposits prior to the regular session of the National Advisory Committee.

"4. The study of the massive sulphide deposits at the Coronation Mine has given interesting results and these should be published. Studies of the general geological environment in which such deposits occur would be of prospecting value."

APPENDICES

In Appendix I to this report J. A. C. Fortescue outlines a proposal for a systematic examination of the scope of geobotanical and biogeochemical

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[1] Davies, J. F., Project Pioneer - A new approach to the study of Precambrian Geology in Manitoba, Canadian Mining Journal, vol. 87, No. 4, 1966, pp. 86-104.

prospecting for mineral deposits in Canada and asks for the support of this subcommittee in the project. The Subcommittee on Mineral Deposits commends this project and especially to mining companies which may have suitable deposits available for study.

Grenier's appraisal of geochemical sampling for trace metals by the Quebec Department of Natural Resources is of general interest and appears as Appendix II to this report.

Appendix I

Research Program for Examination of Scope of Geobotanical and Biogeochemical Prospecting in Canada

by J.A.C. Fortescue

In 1962 the Geological Survey of Canada began a long-term research program aimed at a systematic examination of the scope of geobotanical and biogeochemical prospecting for mineral deposits in Canada. Research carried out to date has shown that in order to obtain meaningful results field investigations should be carried out in the vicinity of mineral deposits which are drilled, but undisturbed by stripping or mining.

Owing to absence of systematic data on the geobotany or biogeochemistry of Canadian landscapes, our research program has been aimed at producing a number of sets of similar systematic data describing the morphology and chemistry of landscapes of the kind described above. The results of these studies will focus attention on the scope of the plant-prospecting methods in each area studied and also provide a fund of basic information on the distribution of chemical elements which are not major components of the ore. To this end, in the first instance, it is planned to determine nine elements (Zn, Cu, Pb, Ba, Sr, Ni, Ti, Mn, and Cr) in all samples collected. It is hoped to carry out systematic studies in the vicinity of mineral deposits containing one or more of all these elements before the end of the program.

Before any plans of this kind can be carried out, suitable mineral deposits must be located, and it is here that the Subcommittee on Mineral Deposits can assist us. If the subcommittee considers this approach to the systematic study of undisturbed mineral deposits valid then perhaps we may mention that we have the backing of the subcommittee when companies are approached for suggestions regarding the location of areas where investigations may be carried out.

The basic problem which we are attempting to study is brought into focus in Figure 1. The problem of locating buried mineral deposits by indirect methods will always involve the measurement of geological, geophysical and geochemical properties of the landscape. Each point within a landscape can be considered as a prism as shown in the diagram. Indirect prospecting methods measure the properties of the prism. Unfortunately the prism is seldom uniform vertically or horizontally for any significant distance and these variations usually limit the effectiveness of specific geological, geophysical and especially geochemical methods of prospecting. In this proposal we are interested only in the geochemical methods.

Biogeochemical and geobotanical research generally involves investigation of specific mineral deposits at two levels of detail:-

1) Pilot Project: involving examination of data already obtained at a property together with geological and geobotanical investigations made during a brief visit to the property.

2) Main Project: involving detailed geobotanical and ecological studies together with sampling of overburden, soils and plants and determination of the depth of the prism of landscape (i.e. surface to bedrock surface) by a shallow seismic method.

The pilot project is carried out in a number of properties within a specific part of Canada (e.g., the Boreal Forest) during the first summer of a two-year program. During the second year main surveys are carried out in two areas selected on the basis of detailed appraisal of the results of pilot projects carried out the previous year. All results obtained are made available to the company on a confidential basis at the time they are obtained and published within two years of the commencement of field work at the pilot or main level. The results of pilot and main surveys carried out during a single summer will be compiled and prepared for publication during the following winter. The data will be published in a series of reports of progress which appear annually.

It is expected that pilot projects will be carried out on as many properties each year as staff permits. On the basis of these studies, the property most suitable to our main project research will be selected for investigation and, if the company owning it agrees, the main project will be carried out on it in the following year. The principal factors influencing selection of a property for the main project are climate, vegetation, soil conditions, overburden conditions and bedrock geology. An overriding condition is that the property must remain undisturbed long enough for the main project to be carried out.

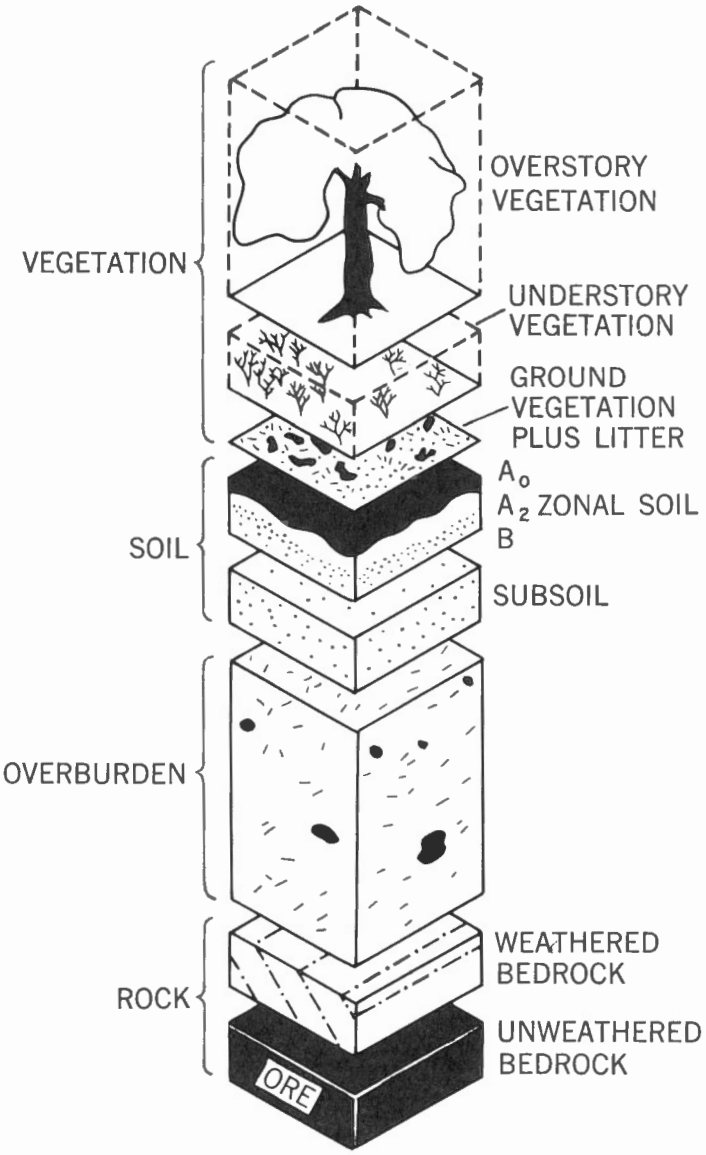

Figure 1. The prospecting prism of landscape extending from the ore to the atmosphere.

A few properties have been drawn to our attention for possible study at short notice, before stripping commences. In cases where these properties offer circumstances of exceptional value to our research we shall try to make a brief summary examination termed a "quick project." These quick projects will not be undertaken if they will delay pilot and main projects.

It should be stressed that the scope of projects of this kind does not require a knowledge of the amount or grade of the mineral deposits selected for investigation. All that is required is that the deposits give rise to a significant geochemical signal in the landscape, which is picked up by the vegetation. As far as the bedrock geology is concerned we need an idea of the area of the sub-outcrop of the mineralized zone and a few hand specimens of typical ore for detailed chemical and mineralogical studies. Owing to the research requirements of the project and the limited staff available, the Survey can only study those deposits that most nearly meet its requirements and must to so at times dictated by limitations of staff.

Appendix II

Geochemical Sampling Program

Quebec Department of Natural Resources

By P.E. Grenier

In 1962, the Quebec Department of Natural Resources assigned a two-man party to collect stream-sediment samples in an area with known copper mineralization. The purpose was to study the feasibility of taking geochemical samples in the course of the normal geological mapping. The following year another pilot area mineralized with molybdenum was investigated.

In 1964 all geological-mapping parties were instructed to take samples wherever their traverses crossed streams. This was not done by many of the reconnaissance parties due to delay in delivering sample bags and various other reasons. In 1965 new sample bags with the different types of required information printed on them were issued to parties. In this way data such as grain size and humus content, etc., could be recorded on the bags by merely checking appropriate items.

All the samples are analyzed for total copper, zinc, lead and molybdenum content at the Department's laboratory. Only a few parties are equipped to perform rapid field tests.

So far these surveys have given positive results in three areas. In the Otelnuk area, New Quebec, several stream-sediment samples collected in the course of a reconnaissance mapping contained anomalous amounts of copper. A detailed follow-up survey traced the anomalous results to a zone of copper mineralization.

In the Mount Ste-Cécile area, Eastern Townships, where two molybdenite-rich zones are known, sediment samples were taken in all streams at 500-foot intervals. One of the mineralized zones gave anomalous results over a sufficient length to show that it would have been detected with a greater sampling interval. The other molybdenite showing was not indicated by the samples, but stream sediments in a swampy part of the area carried high amounts of molybdenum. We believe that in this case the concentration of molybdenum in the stream sediments is due to the lower PH and Eh factors of the environment and does not reflect underlying mineralization. Nevertheless, if these results had been obtained in the course of the normal reconnaissance survey, they would have initiated detailed follow-up work and traced at least one anomaly to the target zones.

The analysis of all the samples taken in the Rivière Lesseps area, Gaspé, is not complete, but the results received so far indicate that the copper zone recently discovered by the Terra Nova Co. is reflected in samples collected in a stream fed by tributaries draining the copper-zone area.

From the results obtained so far we conclude that geological mapping parties should continue to take geochemical samples of stream sediments. We are aware that in work done on the scale of one mile to the inch this may mean as little as one sample per square mile. Nevertheless, the reconnaissance-geochemical results may serve as an excellent orientation survey for future mineral exploration.

In future, we plan to analyze samples from selected areas, such as those underlain by basic gneisses, for cobalt. We hope the cobalt will serve as a pathfinder for copper in cobalt-copper mineralization.

Tests were to be conducted in 1966 on a portable sampling device designed to collect soil samples near bedrock in overburden at depths of 50 feet or more. We hope that such samples may help to establish an order of drilling priority where several geophysical anomalies are known.

Statistical studies of the results from our geochemical sampling have been initiated. We hope that eventually meaningful differences in the distribution of metals will be found. For instance, all the results obtained so far indicate that the trace metals are distributed in near-log-normal populations. The one exception is in the Joutel area, Abitibi, where three major

copper-zinc zones covered by a blanket of at least 50 feet of clay are known. The geochemical survey in this area gave no anomalous results, but the copper and zinc results are distributed in near-arithmetic-normal populations.

REPORT OF THE SUBCOMMITTEE ON MINERALOGY, GEOCHEMISTRY AND PETROLOGY

Presented by G. Perrault

Members of Subcommittee

Guy Perrault (Chairman)	Ecole Polytechnique, Montreal, Quebec.
C. M. Allen	Mount Allison University, Sackville, New Brunswick.
D. M. Baird	University of Ottawa, Ottawa, Ontario.
R. A. Burwash	University of Alberta, Edmonton, Alberta.
L. C. Coleman	University of Saskatchewan, Saskatoon, Saskatchewan.
John Gittins	University of Toronto, Toronto, Ontario.
Robert Ledoux	Université Laval, Quebec, Quebec.
J. E. Reesor	Geological Survey of Canada, Ottawa, Ontario.
P. L. Roeder	Queen's University, Kingston, Ontario.
H. P. Schwarcz	McMaster University, Hamilton, Ontario.
A. J. Sinclair	University of British Columbia, Vancouver, British Columbia.

Members of the subcommittee exchanged abundant correspondence with their chairman; They also met in Ottawa on Friday, Feb. 18, 1966.

All members consider that meeting once a year helps give substance to the work of the subcommittee and we recommend that funds be provided for such annual meetings to discuss research in mineralogy, petrology, geochemistry and geochronology in Canada.

REVIEW OF CURRENT RESEARCH

The following table is based on the Survey of Current Research in the Geological Sciences in Canada, 1965-66, and earlier surveys.

Category	Number of research projects		
	1965-1966	1964-1965	1963-1964
Mineralogy			
(1) Specific minerals	28	30	*
(2) General problems	23	41	*
Total	51	71	48
Geochemistry	116	121	95
Petrology and Petrography	113	141	122
Sedimentation	42	*	*
Geochronology	28	26	25
Grand total	350	359	290

* not reported separately

There is no significant increase in the total number of reported research projects in the current year. Slight shifts in number of projects in each category may not be of much significance. More projects are reported in the fields of structural crystallography, experimental silicate-phase petrology, mineralogical thermochemistry and electron-microprobe analysis, but these are still neglected fields, considering their importance in the earth sciences. There is a slight increase in the number of reported publications.

FUNDS FOR GRANTS

Applications to the Geological Survey for research grants for 1965-66 totalled $264,263, considerably more than the $150,000 available.

Although the funds for grants have been increased over the years the gap between the amount of money applied for and that available has been widening. The state of research in the geological sciences in Canada, the importance of the mineral industry and the needs of university geoscience departments for financial support all suggest a need for a further increase in funds for grants.

Some fundamental examinations of the state of research and development and the role that government should play in supporting and orienting research have been made in recent years. These include the report of the Bladen Commission on financing higher education of which research forms an essential part, the Duff-Berdhall Commission on university administration, the United States Government inquiry into the National Science Foundation, and other similar inquiries. A number of questions on the role of the National Advisory Committee may be asked at this time.

Should funds for Geological Survey grants, which are awarded on the basis of recommendations of the National Advisory Committee, be obtained from Treasury and expended for much-needed support of geological research in the universities? Should these funds be directed to implement a research and development policy defined by the National Advisory Committee? What should govern the amount of money granted--the number of applications or a pre-determined policy? It would be well to compare the Canadian effort in fundamental research in the earth sciences with that of other nations to determine if our effort is in equilibrium with the development of our mineral resources. We suggest re-evaluation of the role of the National Advisory Committee in this light.

ANALYTICAL STANDARDS

Analytical standards were discussed in some detail at the meeting of this subcommittee in February, 1966. We report the following progress.

Purpose

It is desirable that analytical standards of geological materials be available to all analytical laboratories to supply some measure of comparison and provide uniformity in the work done in these laboratories. The need for standards is particularly acute where instrumental techniques are used for the analyses (e g., X-ray fluorescence, flame photometry, atomic absorption spectroscopy, etc.) but they are needed also for classical wet chemical methods of analysis (e.g. determination of volatile constituents).

This subcommittee considers that the most urgent need is for rock-analytical standards. We recommend that efforts should be oriented mainly, at present, towards the establishment of such standards.

There are many other types of standards of geological materials of interest to analysts, including:

a) geochemical standards: representative specimens of geological units;

b) commercial standards: to reference commercial operations (ores, concentrates, etc.);

c) mineral standards: to establish comparisons in the measurement of properties and chemical composition of minerals, e.g., reflectivity, refractive indices, intensity of X-ray diffraction, etc. (microprobe standards, possibly synthetic, of known chemical composition could be included in this group);

d) calibration standards: standards to be used directly in the analysis of geological materials, in numbers large enough to define a calibration curve to fit certain rock-type analyses.

While the preparation of some mineral and commercial standards is contemplated immediately by some groups, this subcommittee proposes to support mostly the development of rock-analytical standards.

Available Standards of Geological Materials

The following list is compiled from recent correspondence and some bibliographic research.

1. The U.S.G.S. rock standards.

   a) Being analyzed:

      G-2 : granite, Bradford, R.I.
      GSP-1 : granodiorite, Silver Plume, Colo.
      AGV-1: andesite, Guano Valley, Lake Co., Oregon.
      PCC-1: peridotite, Cazadero quadrangle, Sonoma Co., Calif.
      DTS-1 : Dunite, Twin Sisters, Washington.
      BCR-1: basalt, Columbia River (Yakima type), Multnomah Co., Oregon.

   b) In process:

      STM-1 : nepheline syenite, Table Mountain, Tidewater quadrangle, Lincoln Co., Oregon.

SCO-1 : shale, Cody, Edgerton quadrangle, Natrona Co., Wyoming.
SDC-1 : mica schist, Rock Creek Park, Washington, D. C.
MAG-1: terrigenous marine mud, Wilkerson Basin, Gulf of Maine, Atlantic Ocean (42°34.6'N, 69°32.6'W).
------: obsidian (field name), Glass Mountain, Calif.
------: quartz latite or dacite (field names), Lake Co., Oregon.
GSM-1 : gabbro, San Marcos; Rancho Santa Fe quadrangle, San Diego Co., Calif.
TLM-1: tonalite, Lakeview Mountain, Perris 7-1/2 minute quadrangle, Riverside Co., California.
------: quartz, mostly optically clear; shipped from Brazil during World War II.
------: garnet, placer; Hampton Creek, White Pine Co., Nevada.

c) Formerly available:

G-1 : granite.
W-1: diabase.

2. Frederick Smith Chemical Company,
P.O. Box 23344, Columbus 23, Ohio.

GFS 450:)
GFS 451:) magnetite concentrate (Minnesota).
GFS 452:)

GFS 453:)
GFS 454:) hematite (Minnesota).
GFS 455:)
GFS 456 - GFS 490: magnetite-hematite blends.

GFS 400: dolomite, Woodville, Ohio.
GFS 401: limestone, Marble Cliff, Ohio.
GFS 402: limestone, Spore, Ohio.
GFS 403 - GFS 419: limestone-dolomite blends.

3. Canadian Association for Applied Spectroscopy.

Chairman, Non-metallic Standards Committee.
Prof. R. Webber, Dept. of Geological Sciences, McGill University.

Sulfide ore -1
Syenite rock -1 (now exhausted).

4. Centre National de la Recherche Scientifique.

Centre de Recherches Pétrographiques et Géochimiques de l'Université de Nancy, B.P. 682, Nancy, France.

Granite

5. Schweizerische Arbeitsgemeinschaft für Steine und Erden.
Attn: Prof. Dr. T. Hügi, Mineralogisch-petrographisches Institut, Sahlistrasse 6, Bern, Switzerland.

"Liste der Referenzproben der Chemischen Abteilung der Technischen Stelle Holderbank der Bestimmung des Mineral-Bestandes".

Offers a wide variety of rocks and minerals: feldspars, silicate minerals, amphiboles, pyroxenes, chlorites and chrysolites, micas, hydrated micas, candites, smektite, carbonates, hydrated oxides minerals, calcium silicate and other Portland cement clinker materials, and others.

6. National Bureau of Standards, Washington, D.C.

Dolomite 88.
Argillaceous limestone.
Fluorspar.
Opal glass 91.
Feldspar 70.
Glass sands 81 and 165.
Soda feldspar 99.
Flint clay 97.
Plastic clay 98.
Phosphate rock 120.
Lithium ores 181, 182 and 183.

7. British Chemical Standards.

Iron ore, BCS 175-1.
Manganese ore, BCS 176-1.
Lincolnshire iron ore, BCS 301.
Northampshire iron ore, BCS 302.
Iron ore sinter, BCS 303.
Grecian chrome ore, BCS 308.
Sillimanite, BCS 309.

8. Professor Kukharanko, Leningrad.

Nepheline Syenite.

9. Tanganyika Geological Survey

Tonalite from Tanganyika.

There are probably many other available standards. It is recommended that this committee should try to establish and to maintain an up-to-date list of available standards of geological materials.

The Preparation and Distribution of Analytical Standards

Many points came up in the discussion of the preparation of analytical standards.

1. Collection of material.

a) The material should preferably be fresh; no weathered surface, etc.
b) If the material is intended for a geochemical standard as well as an analytical standard, it should be representative of a geological unit.
c) If the material is intended as an analytical standard, it should fill the need for a specific chemical composition.

2. Crushing and pulverizing

Most grinding techniques will cause some contamination. It is thus essential that the procedure be clearly known. The following is the procedure used by the U.S.G.S.; some similar procedure might be considered by Canadian geoscientists:

a) Jaw crusher.
b) Roller crusher.
c) Ball mill (high-density porcelain liner and balls).

The final product to be 80% 200-mesh. Impact mills using air jets might gainfully replace the ball mills; however, this remains to be proven.

3. Separation, blending, etc.

The U.S.G.S. recommends:

a) Mixing in a stainless steel blender.
b) Removing sample (about three pints) from the blender and pouring it over the surface of a stainless steel cone into 32 bottles under the periphery of the base of the cone; the samples are identified by the number of the split and the position around the cone; rotate blender and repeat the blending.

With respect to distribution of analytical standards:

a) It would be convenient if the distribution of standards of geological materials were handled through one distribution group.
b) The Canadian Association for Applied Spectroscopy does have a mechanism for distribution of standards; it is well-structured and already has two standards in circulation.
c) No other Canadian standards group or association is willing to accept responsibility for preparation, distribution and analysis of standards of geological materials.

This subcommittee therefore recommends that Canadian geoscientists fully support the Non-Metallic Standards Committee of the Canadian Association for Applied Spectroscopy in its efforts to prepare, distribute and analyse standards of geological materials. At present the C.A.A.S. Standards Committee is chaired by C.L. Lewis, c/o Falconbridge Nickel Mines Limited, Metallurgical Laboratories, P.O. Box 900, Thornhill, Ontario.

The Non-Metallic Standards Committee, one of the working groups of the C.A.A.S., is chaired by Prof. R. Webber, c/o Dept. of Geological Sciences, McGill University, Montreal. The activities of the C.A.A.S. Standards Committee have recently been reviewed (Canadian Spectroscopy, Vol. 10, No. 4, p. 99). The following extract from this article may be of interest:

> "An organization is available whereby interested persons can produce standard samples with C.A.A.S. aid and sponsorship. Application can be made to the Standards Committee; if it agrees on the usefulness of the proposed standard(s), a task group will be formed to operate within the framework of the Non-Metallic or Non-Ferrous committee, as the case may be. The task group, comprising persons having the greatest interest in the standard(s), will obtain the materials, prepare the standard(s), carry out homogeneity testing, and obtain certification analyses. It will also be responsible for publication of results and for any technical correspondence pertaining to the standard(s). The Standards Committee will provide financing, at least to the extent mentioned above, and will advise the task group on procedure for standard preparation, homogeneity testing, and analysis. It reserves the right to withhold permission for issuance of a standard under the C.A.A.S. label if it is not convinced that the material is homogeneous or the certification accurate.
>
> When a standard sample is approved by the Standards Committee for issuance, distribution will be handled by the Mines Branch".

New Standards of Geological Materials:

This subcommittee examined this question and supports the development of the following new standards:

1. alkaline gabbro, Glamorgan Twp., Ontario;
2. leucogranite, Monmouth Tp., Ontario;
3. biotite nepheline syenite, Blue Mountains, Ontario;
4. nepheline feldspar concentrate, Blue Mountains, Ontario.

The above four materials are already being developed as standards for use at the University of Toronto. Professor John Gittins has agreed to make them available to a wider group of geoscientists and might be interested in forming a C.A.A.S. task group to do this. The C.A.A.S. Non-Metallic Standards Committee would be agreeable to this procedure.

Professor Guy Perrault has agreed to investigate development of a pyrochlore standard and to discuss with Professor Webber whether such a standard would serve a gainful purpose. Discussions with St. Lawrence Columbium and Metals Corporation will be initiated to find out under what conditions a sufficient quantity of high-grade pyrochlore concentrate would be available.

Members of the subcommittee favour development of analytical standards of the following Canadian Shield rocks:

1. an amphibolite facies rock,
2. a greenschist facies rock,
3. a basalt.

Miscellaneous Topics on Analytical Standards:

This subcommittee believes further consideration should be given to development of mineral standards; it is proposed to examine this question in the coming year.

Mineral standards should be pure if they are to be gainfully used in almost any type of measurement. They should also be highly homogeneous (e.g. microprobe work).

Some mineral standards could be large, expecially those designed to serve as analytical standards; others could be small (e.g., microprobe standards).

The synthesis of microprobe standards from the melt or otherwise is probably the most promising line of investigation in this direction.

Thought should be given to the development of isotope standards for research on ore genesis and on geochronology.

It is hoped that the National Advisory Committee may be in a position to support financially the development of analytical standards along the program outlined above through its grants for research to universities.

It would be appropriate to solicit financial support from the Department of Industry in the development of commercial analytical standards.

It is hoped that some financial support may be obtained from C.A.A.S. on the development of standards under its name and with its control and distribution.

Members of this subcommittee believe that the development of analytical standards along the lines outlined should be accelerated. This subcommittee proposes to keep in touch with developments during the coming year.

WORKSHOP ON ANALYTICAL TECHNIQUES

In our report last year, we proposed that this subcommittee be charged with arranging a workshop on analytical techniques for 1966 and report on the results and success of the workshop at the annual meeting of the National Advisory Committee in 1966.

A "Workshop on the Chemical Analysis of Geological Materials", was held in the laboratories of the Geological Survey, Ottawa, on Feb. 16, 17, and 18, 1966, as a direct result of the above recommendation. The workshop was organized by John A. Maxwell, was well attended and seemed to respond to a need on the part of analysts of geological materials in Canada. A brief report on this workshop by Maxwell is appended to this report.

SHARING OF COSTLY ANALYTICAL TOOLS

Some members of the subcommittee wished to discuss this question. The principal points that came out were:

1. Instruments for research in the geological sciences are becoming increasingly complex and costly.

2. Departments of geological sciences in universities and government laboratories are being equipped with many of these costly analytical tools. It would be desirable and useful to know what instruments are located where.

3. Access of researchers to these costly tools, either in a university department or government laboratories, probably could be best arranged through personal contacts. Many members of the subcommittee would willingly engage in this type of cooperation if assured of the usefulness of the work. A small amount of cooperative work could be handled in this way. However, major participation in any research endeavour could not be easily arranged; such participation would call for more elaborate arrangements, the sharing of costs, the sharing of decisions as to the orientation of the work, etc.

4. Expensive analytical equipment may be unused at times in universities and/or government laboratories. Would it be feasible for a technician employed on a research project in a university to carry out analyses in connection with such projects with analytical instruments in a government laboratory when these instruments were not otherwise in use? Such an exchange would create special problems including the training of the technician to use the special equipment in the government laboratory, the means of supervising his work and other administrative problems.

SUMMARY AND CONCLUSIONS

This subcommittee recommends:

1. That it be provided with funds to meet each year to discuss research in mineralogy, petrology, geochemistry and geochronology in Canada.

2. That, in the field of analytical standards, the efforts of geoscientists in Canada should, at present, be mainly oriented towards the establishment of rock-analytical standards.

3. That one of the responsibilities of the subcommittee should be to establish and maintain an up-to-date list of available standards of geological materials.

4. That Canadian geoscientists fully support the Non-Metallic Standards Committee of the Canadian Association for Applied Spectroscopy in its efforts to prepare, distribute and analyse standards of geological materials.

5. That further analytical standards of Canadian Shield rocks be developed, particularly an amphibolite facies rock, a greenschist facies rock and a basalt.

This subcommittee favours:

1. The wider distribution of the analytical standards being developed by Professor Gittins at the University of Toronto by the Canadian Association for Applied Spectroscopy. These standards include: alkaline gabbro, leucogranite, biotite nepheline syenite and nepheline feldspar concentrate.

2. The development of a pyrochlore standard by Professor Guy Perrault at Ecole Polytechnique.

3. The acceptance of J.A. Maxwell's report on the Workshop on Chemical Analysis of Geological Materials and the conclusions and recommendations contained therein.

4. The sharing of costly analytical tools amongst geoscientists in Canada wherever and whenever this is possible and desirable.

This subcommittee hopefully requests:

1. That the National Advisory Committee support financially the development of analytical standards along the program outlined through grants to research in the universities.

2. That the Canadian Association for Applied Spectroscopy support financially the development of analytical standards along the lines of the program as outlined with the funds collected for preparation of standards.

ACKNOWLEDGEMENTS

The subcommittee thanks the many officers of the Geological Survey, and in particular, its director, Yves Fortier, and John Maxwell, head of the

analytical chemistry section of the Division of Petrological Sciences for their collaboration in the organization of the Workshop on Chemical Analysis of Geological Materials and the meeting of the subcommittee.

APPENDIX

THE WORKSHOP ON THE CHEMICAL ANALYSIS OF GEOLOGICAL MATERIALS

by J.A. Maxwell

A more detailed report, intended to provide guidance for the organization and operation of future workshops, is in preparation. The following brief outline emphasizes those aspects likely to be of interest to the National Advisory Committee.

Organization

The workshop was held in the Geological Survey building, 601 Booth St., Ottawa, beginning Wednesday evening, February 16, and ending at 5 P.M. Friday, February 18. The opening session was held in Room 117, the coffee party in Logan Hall, and all technical sessions either in the laboratories of the Analytical Chemistry Section or in selected laboratories of the Mineralogy and Geochemistry Sections. A workshop dinner at the Bruce MacDonald Motor Hotel on Thursday evening, February 17, completed the program.

A three-page preliminary notice explaining the purpose of the workshop and giving details about the program, registration and accommodation was mailed about December 15, 1965, to the geological departments of 22 Canadian universities and eleven provincial surveys, research councils and related organizations. Replies were received from 19 organizations from Newfoundland to British Columbia. A final eight-page notice giving the final program, the group assignment code, brief notes on the areas of operation to be covered and a questionnaire to be completed and returned, was mailed to those who signified their intention to attend.

The 37 participants were divided into groups of four or five on the basis of their specialized interests, and for two days each group had the opportunity to observe, in rotation, all areas of operation in the Analytical Chemistry Section, and selected related areas in the Mineralogy and Geochemistry Sections. Section personnel demonstrated and discussed equipment and techniques.

A short meeting was held in Room 117 at 4:30 P. M. on Friday to end the workshop and to collect a second questionnaire which was issued to participants on Friday morning for evaluating the usefulness and effectiveness of the workshop.

Participants

Thirty-seven chemists and geologists represented 13 universities, five provincial mines departments and research councils and one Colombo Plan project.

Evaluation

Thirty-three questionnaires were returned. Participants were asked to evaluate the methods of presentation in the various areas under the heading of "too long", "too short", "too general", "too detailed" or "just right". Evaluation of the different areas could not but reflect the particular interest of the participant, but even so satisfaction with the presentation in the seven areas ranged from 52 to 92%. On the question of the workshop as a whole (28 replies), seven considered it too short, one thought it too general and 20 thought it "just right". Among the comments offered by participants, terms such as "very interesting", "very informative", "beneficial", "well organized" occurred with a frequency that was gratifying to the organizers of the workshop.

The following suggestions for future organization and operation of similar workshops were among those most frequently offered:

1. More 'general' time for discussion of details with staff.

2. A 'blank' period to permit a return to areas of particular interest.

3. A choice of activities in order to allow concentration on specific areas if desired.

4. More round-table discussions with leaders prepared to discuss and compare different methods and techniques.

The following fields were suggested as topics for future workshops:

X-ray microanalysis (6)
X-ray diffraction (2)
Geochemistry (2)
Isotope chemistry (2)
Soil and water analyses (2)
Plus chromatography, synthesis of minerals, mass spectrometry (age determinations), biogeochemistry, geochemical prospecting and mineralogy.

The views of the staff members were sought with reference to the benefits derived from the workshop. These can be summarized as follows:

1. There was little flow of ideas to Survey personnel. In part this is due to the detailed program but it also reflects the fact that, in spite of the emphasis upon practical application, too many of the participants were not practicing analysts.

2. The workshop was an interesting experience for the staff and served to open lines of communication that should be kept open.

3. It was noted that, when the opportunity was given, participants preferred to discuss rather than view instrumentation, and that the discussion tended to become general rather than specialized.

REPORT OF THE SUBCOMMITTEE ON QUATERNARY GEOLOGY

Presented by W.O. Kupsch

Members of the Subcommittee

W.O. Kupsch (Chairman)	University of Saskatchewan, Saskatoon, Saskatchewan.
L.A. Bayrock	Research Council of Alberta, Edmonton, Alberta.
I.C. Brown	Geological Survey of Canada, Ottawa, Ontario.
W.D. Brueckner	Memorial University of Newfoundland, St. John's, Newfoundland.
E.A. Christiansen	Saskatchewan Research Council, Saskatoon, Saskatchewan.
C.B. Crawford	National Research Council, Ottawa, Ontario.
A. Dreimanis	University of Western Ontario, London, Ontario.
J.A. Elson	McGill University, Montreal, Quebec.
Lockhart Gray	Water Control and Conservation Branch, Winnipeg, Manitoba.
P.F. Karrow	University of Waterloo, Waterloo, Ontario.
J. Ross Mackay	University of British Columbia, Vancouver, British Columbia.
W.H. Mathews	University of British Columbia, Vancouver, British Columbia.

R.H. MacNeill — Acadia University, Wolfville, Nova Scotia.

Raymond Roy — Department of Natural Resources, Quebec City, Quebec.

A. MacS. Stalker — Geological Survey of Canada, Ottawa, Ontario.

A.K. Watt — Ontario Water Resources Commission, Toronto, Ontario.

INTRODUCTION

In reports by subcommittee members to the chairman, several topics are dealt with which are to be brought to the attention of the National Advisory Committee on Research in the Geological Sciences. These topics are discussed below under separate headings.

National Research Council Associate Committee on Quaternary Research

A request, drafted jointly by J.G. Fyles (Geological Survey of Canada), J.D. Ives (Geographical Branch, Department of Energy, Mines and Resources), and R.J.E. Brown (Division of Building Research, National Research Council) has been presented to the President of the National Research Council for the establishment of an associate committee under NRC to deal with Quaternary research[1]. Such an associate committee would represent all scientists dealing with the various aspects of Quaternary Research. The present Subcommittee on Quaternary Geology of the National Advisory Committee on Research in the Geological Sciences would continue to represent geologists.

The time has clearly come for geologists, engineers, botanists, zoologists, glaciologists, geographers, and all other scientists interested in the Quaternary to be brought together. The proposed associate committee under the National Research Council would be a suitable vehicle for accomplishing

[1] The National Research Council considered this request at a meeting in June 1966 and agreed in principle to the establishment of an Associate Committee on Quaternary Research.

this. The absence of an organization covering all fields of the Quaternary was felt strongly last year when an official delegation was improvised to represent Canada at the INQUA Congress in Denver. If an organization such as the proposed Associate Committee on Quaternary Research had existed at that time, the matter of representation could have been handled on a much broader basis than was possible under the circumstances. The only solution was to set up an ad-hoc group, and the following scientists were selected as offical delegates:

R. J. E. Brown, Division of Building Research, National Research Council, Ottawa, Ontario.

J. A. Calder, Plant Research Institute, Department of Agriculture, Ottawa, Ontario.

C. S. Churcher, Department of Zoology, University of Toronto, Toronto, Ontario.

A. Dreimanis, Department of Geology, University of Western Ontario, London, Ontario.

J. A. Elson, Department of Geology, McGill University, Montreal, P. Q.

J. G. Fyles, Geological Survey of Canada, Department of Energy, Mines and Resources, Ottawa, Ontario.

J. D. Ives, Director, Geographical Branch, Department of Energy, Mines and Resources, Ottawa, Ontario.

W. H. Mathews, Chairman, Department of Geology, University of British Columbia, Vancouver, B. C.

G. M. MacDonald, Archaeology Division, National Museum of Canada, Ottawa, Ontario.

J. C. Ritchie, Trent University, Peterborough, Ontario.

The above list shows some of the diversity of interest and training of those concerned with the Quaternary, but an NRC Associate Committee on Quaternary Research would cover an even broader spectrum and bring the various disciplines permanently together; such a committee would ensure communication between them. There would still be need for more specialized groups, such as the N. A. C. Subcommittee on Quaternary Geology, to continue to function.

Publication

R. H. MacNeill mentions the need for publication of known data on Pleistocene deposits and the correlation of effort and information in this respect. He adds that beginning in 1966 the Nova Scotia Research Foundation is making available a number of preliminary maps and notes on map sheets of Nova Scotia for limited distribution to departments of government, universities, and interested industries in the Atlantic provinces.

On the same subject, J. A. Elson mentions a useful medium for making Quaternary geology and geomorphology better known and more respected by the Canadian geological fraternary. The medium is the Geological Association of Canada Newsletter which is edited at McGill University and publishes book reviews and reports.

Speed and format of publication as well as the availability and interchange of unpublished data are topics of general importance. P. F. Karrow asks why there is such a long delay in the publication of the annual report of the National Advisory Committee on Research in the Geological Sciences. A. M. Stalker emphasizes the importance of attending professional meetings. He feels it is easier to obtain thousands of dollars for some project, such as drilling, than a few hundred dollars to help train a young scientist to present the results of such a program.

Education

Although no dependable data are available on the ratio of students interested in Quaternary geology to the number of job opportunities for them, it seems evident that there are fewer students at a time when there are more jobs than ever before.

Fully supported field work for Ph. D. candidates including summer employment and winter scholarship support is taken up by students from the United States whither most will return. This work must be done, and if federal or provincial organizations can not find the necessary personnel in this country, they must turn to the United States. This raises questions as to the quantity as well as quality of Canadian geology students in groundwater geology, engineering geology, palynology, etc., within the broad category of Quaternary geology.

Research Projects

P. F. Karrow pleads for an isotope-enrichment laboratory in Canada for radiocarbon dating. He mentions that he has been waiting for results on

three samples from the Toronto area submitted to the Groningen laboratory four years ago. Groningen now seems to be unable to produce any quantity of "old" dates, and as these are very important for the unravelling of the stratigraphy in the Toronto area, Karrow would like to see the Geological Survey take up the matter and thus remove what he refers to as "the bottleneck to progress in early Wisconsinan chronology".

The large number of field-mapping projects relative to other research in Quaternary geology (Table 1) shows that field work is still the mainstay of our profession. That this will continue to be the case is expressed by L. A. Bayrock: "The importance of regional mapping of surficial deposits of Alberta cannot be overstressed. At present only about 1/6 of the province has been mapped. Some of the newer soils maps do have proper designation of surficial materials but are not detailed enough for many practical uses. The lack of surficial mapping makes it difficult, if not impossible, to consult other agencies interested in or dealing with glacial sediments. On the academic level stratigraphic conclusions are questionable. The availability of maps of surficial deposits would immediately and greatly help the following disciplines: agriculture, soil survey, highway research, soil mechanics, construction, forestry, watershed research, groundwater, and many others. Consequently the prime objective of Pleistocene research in Alberta should be regional mapping."

Certain regions, such as the largely unsettled areas, suffer more from a lack of attention than others. In Alberta the glacial geology and stratigraphy of the Rocky Mountains has been neglected; both Bayrock and A. M. Stalker call attention to this, the latter in some detail as follows:

(1) Process studies on active glaciers in the Rocky Mountains. Several easily accessible glaciers offer an outstanding opportunity to study such processes as the formation of till, sedimentation in superglacial lakes, calving phenomena.

(2) Tertiary and early Quaternary gravels in the Rocky Mountain Foothills. Although plenty of data are available, they are little understood.

(3) Mass-wasting studies in the Rocky Mountains. Rock glaciers and talus slopes are suitable for quantitative studies in rate of formation, sedimentation and other factors.

(4) Cordilleran - Continental Ice Front studies. The question of extent and relative time between these fronts is not well known.

(5) Palynological studies, especially of recent (last 4,000 years) glacial activity in the Rocky Mountains.

Bayrock suggests "the deciphering of glacial succession of the Rocky Mountains should prove invaluable for regional stratigraphic conclusions".

Moving from Alberta to Ontario P. F. Karrow suggests the need for mapping the Niagara Falls area to take advantage of the vast amount of engineering information available from past hydro and highway projects and the new information becoming available from the widening of the Welland Canal. This is a classical area and ranks second in importance only to Toronto. Recent publications by Terasmae and MacClintock on the Seaway area show how valuable co-ordinated geological and engineering efforts can be.

J. S. Scott is now preparing the second draft of the Till Manual to incorporate comments on the previous draft.

It is gratifying to report some progress on urban geology by mentioning that the Saskatoon Geotechnical Group received $5,000 from NRC to study and report on the geology of Saskatoon; and a start has been made on a similar study of the geology of Edmonton, Alberta. I. C. Brown stresses that "urban geology has to be a continuing job"; in order to "sell it" an example might be provided by study of the urban geology of a chosen city under sponsorship of the National Advisory Committee similar to its sponsorship of comprehensive studies of the Coronation Mine and the Whalesback Pond base-metal deposits. Karrow asks, Who is going to study the Pleistocene geology of Toronto? There are plans for new subways but none to study the excavations for them, and this in an area that holds the answers to many questions of glacial stratigraphy.

As representative of Canadian Quaternary geologists, this subcommittee is in a position to request support for glaciological studies that fall within the realm of geology. Of particular interest are studies of glacier flow (whether done by physicists, engineers, or others) which contribute to a better understanding of the origin and behaviour of certain metamorphic rocks. A study of glacier flow in the light of Carey's rheid concept is not only of importance directly to Quaternary geologists but indirectly, through analogy, to hard-rock geologists as well.

Projects in Progress

As in previous reports, Table 1 presents an attempt at a quantitative estimate of projects now in progress in various parts of Canada. Again, it must be emphasized that the estimates are only approximate.

REVIEW OF CURRENT RESEARCH

The following presents some highlights of the various regional submissions arranged by provinces and territories. It covers laboratory and

field work done during 1965 by various governmental agencies, federal as well as provincial, and by several universities. Only areal projects which are complete or near completion have been mentioned; others are left for future reports. Current studies of a more general nature are included even though they may not be too far advanced. References to publications are in the appendix to this report.

Northwest Territories

W. Blake, Jr. and F. M. Synge, Geological Survey of Canada, carried out a reconnaissance study of the glacial geology of Baffin Island from Lake Nettilling south, as part of Operation Amudjuak, a helicopter-supported reconnaissance-geological mapping of southern Baffin Island. They found that the ice flow was from the uplands toward the depressions of Hudson Strait, Frobisher Bay, and Cumberland Sound where only a narrow coastal strip shows evidence of marine inundation following deglaciation. On the lowlands facing Foxe Basin, on the other hand, the sea penetrated as much as six miles inland. For a part of postglacial time, southern Baffin Island was separated from the rest of the island. From near Lake Harbour, northwestward along Hudson Strait, the elevation of the limit of marine submergence is 300 feet or more above sea level. Southeastward from Lake Harbour the marine limit decreases in elevation and is less than 100 feet near the southeastern tip of Baffin Island. In Frobisher Bay no evidence of marine action was found above 400 feet. In the Putnam Highlands, west of Lake Nettilling, the marine limit is over 300 feet, whereas throughout the length of Cumberland Sound it appears to be less.

In the district of Mackenzie, H. H. Bostock, Geological Survey of Canada, found that east of Point Lake glacial striae indicate ice movement west to west-southwest. North of this lake the striae are west to west-northwest but east of the north end of Contwoyto Lake, the most prominent direction is northwest.

J. G. Fyles, Geological Survey, carried out preliminary stratigraphic studies of the Quaternary deposits of the Arctic Coastal Plain between Cape Bathurst and the Alaska boundary, an area which includes the Mackenzie Delta region. The Quaternary stratigraphy of the area shows the presence of (1) widespread fluvial, lacustrine, and marine sediments that originated prior to the last glaciation, (2) deposits and landforms attributed to two or more Laurentide glaciations, (3) varied postglacial sediments chiefly of fluvial and lacustrine origin, and (4) a complex of surface materials emplaced by frost and slope processes. Along the Yukon coast, from Blow River 30 miles northwesterly to King Point, interglacial deposits are tentatively assigned to a single stratigraphic unit. The exposed materials are mainly gravel in the southeast part of this area, but farther to the northwest the gravels are replaced by sands which grade in turn into silt. The gravels

TABLE 1 - PROJECTS BY AREAS

Project categories	NWT	YT	BC	Alta	Sask	Man	Ont	PQ	NB	NS	PEI	Nfld	Total
Field mapping, general topics	9	2	6	13	5	5	9	7	1	6	1	4	68
Stratigraphy, sedimentation	-	-	4	3	-	-	4	-	-	-	-	-	11
Paleontology and palynology	-	-	1	3	2	-	2	-	-	1	1	-	10
Geophysics and geochemistry	-	-	1	4	1	-	2	5	-	-	-	-	13
Groundwater	-	-	3	18	6	11	14	2	1	5	1	-	61
Petrography and mineralogy	-	-	1	-	-	-	3	-	-	-	-	-	4
Marine and lacustrine geology	-	-	-	-	-	1	2	-	-	2	-	-	5
Engineering geology, glaciology	5	1	1	2	2	3	5	4	-	-	-	1	24
	14	3	17	43	16	20	41	18	2	14	3	5	196

enclose logs of wood up to a foot or more in diameter, whereas the sands and silts contain smaller pieces of wood, beds of peat and peaty silt, fresh-water shells, rare bones and tusks, local thin beds of marine clay, and, in a few places, fossil ice wedge casts. Thick glacially deformed silts, sands, and gravels are found on Herschel Island and along the coast between King Point and Kay Point. Unconsolidated deposits along the coast and on the lowland south and west of Herschel Island include much silt and clay that, in places, yield marine shells. Because some of the materials show evidence of presumably glacial deformation, they are assumed to be "interglacial". Other deposits which contain stones and boulders are considered to be glaciomarine. A glaciomarine stony silt is also found in exposures along the coast near the Alaska boundary. In this area some material was encountered which may be a true till, suggesting that at one time the Laurentide ice sheet reached the northeast corner of Alaska.

J. Ross Mackay and J.K. Stager, University of British Columbia, continued their Quaternary studies in the Northwest Territories with support of the Geographical Branch, Department of Energy, Mines and Resources. They collected samples of ground ice on Garry Island, in the Mackenzie Delta area, and shipped them to Vancouver for study of their detailed fabric, bubble pressure, and gas content. In the field, a microstudy of surface temperatures of melting ice slumps was undertaken. To accomplish this, 25 plastic tubes were inserted in the ground to a depth of four feet, and their vertical profiles and separations were accurately surveyed. The tubes will be resurveyed in the spring of 1966 to check if any deformation resulting from thermally induced ground changes has taken place. Near Fort McPherson and Arctic Red River wells logged to a depth of 200 and 250 feet were used to make ground-temperature measurements and to determine the thickness of permafrost.

On Garry Island D.E. Kerfoot, University of British Columbia, carried out studies of coastal retreat, hummocks, ablation rates of ice slumps, solifluction, and ground temperatures.

The Polar Continental Shelf Project supported the following programs in cooperation with the Sorbonne University (Paris, France), the National Research Council, the Observatories Branch (Department of Energy, Mines and Resources), the United States Army Natick Laboratories, the Université de Liège (Belgium), the Canada Council, and the Geographical Branch, Department of Energy, Mines and Resources:

Andrieux, P., "Measurements of the electrical resistivity of polar ice masses."

> Careful measurement of the electrical resistivity of ice in two and three dimensions, and its variability with time, temperature, and physical or crystallographic character of the material, have been

made as follows: in May, Penny Ice-cap, Baffin Island (supported by Gravity Division, Observatories Branch); in June, July - Meighen Ice-cap, Meighen Island (supported by Polar Continental Shelf Project); in August - White Glacier, Axel Heiberg Island (supported by McGill University and Polar Continental Shelf Project). The work has provided important fundamental information on the electrical properties of large crystalline masses.

Everette, K.R., "Study of mass-wastage of sedimentary rocks under a high arctic environment."

Detailed study of mass wastage with quantitative measurement of soil movement and the relation of the amount of distribution of precipitation and the development of the thawed layer in soils of various chemical, physical and mechanical characteristics, in various aspects of exposure, slope and vegetative cover.

Kahn, M., "Study of fluctuating non-traditional variables or space-variables affecting chemical reactions, as evidenced by the speed of standard chemical reactions on and within ice caps at different geomagnetic latitudes."

A series of many thousand standard chemical reactions were carried out on Penny Ice-cap (May), Meighen Ice-cap (June and July) and White Glacier (August) at synoptic hours to determine the effect of geomagnetic and geographic latitude on chemical reactions. The same reactions were carried out within the glacier under different thicknesses of ice, to discover the screening effect of ice on these still unknown factors that control the rate and completeness of reactions. The relation between the fluctuations in rate of chemical reactions, and the simultaneous fluctuations of electrical resistivity (see work of Andrieux) are being studied. The large, physically and chemically nearly homogeneous, crystalline mass of cold solar ice-cap is proving to be an admirable environment in which to study subtle aspects of physical and chemical behaviour that are completely masked in the laboratory or in other parts of the earth by extraneous local influences.

Paterson, W.B., "Investigation of the thermal structure and dynamic behaviour of a 'cold' polar ice-cap."

Study of the detailed vertical temperature profile from top to bottom of an ice mass 122 metres thick, and below the pressure-melting temperature; investigation of the flow of geothermal energy into the base of the mass, and of the strain rate and plasticity of ice at depth.

The measurements may help to define the flow law of ice at particular temperatures, pressures and crystal sizes, and may give an indication of the energy balance at the surface of this part of the earth and its relation to geothermal heat flow, present and past climate, and effect of changes of sea level.

Pissart, A., "Study of periglacial features of the Arctic coastal plain."

Included study of pingoes; evolution of slopes and terraces in a periglacial climate; wind action on the Arctic coastal plain; development of periglacial soils on Prince Patrick Island.

Barr, W. (Ph.D. Candidate, McGill University) Geomorphological field work in northern Devon Island.

Dineley, D.L., Rust, B.R., and others. This project concerns the detailed geology and geomorphology of the northern end of the Boothia Arch, ranging from the Precambrian crystalline basement to Quaternary deposits. Structural, stratigraphical and sedimentological studies were included.

Yukon Territory

In the central and southwestern Yukon, O.L. Hughes, Geological Survey of Canada, mapped the limits of successive ice advances. Exposures displaying stratigraphic relationships of deposits of successive advances are few, and therefore reliance has to be placed on geomorphic criteria rather than stratigraphy for differentiating the various advances. Evidence in the form of glacial erratics, moraines, inferred drainage changes, etc., permitted the approximate mapping of the limit of one or more older advances, and an accurate mapping of limits of two younger advances (pre-classical Wisconsin and classical Wisconsin?).

V. Rampton commenced a study of the surficial geology from the snout of Klutlan Glacier, southwestern Yukon, to the limit of glaciation north of Snag. The area probably contains deposits from at least four distinct advances.

E.B. Owen, Geological Survey, carried out engineering-geology investigations of dam sites along the Pelly River in the Yukon. Four potential dam sites suitable for a hydro-electric power development were examined along the river between Hoole Canyon and Pelly Crossing.

British Columbia

The postglacial and glacial deposits of the Kitimat-Terrace area were studied by J.E. Armstrong, Geological Survey, for three weeks in 1965. He finds the withdrawal of Cordilleran ice was followed by an invasion of the sea for a minimum distance of 50 miles from the present shore. Extensive marine deposits containing shells were found up to elevations of 400 or more feet. The marine deposits are overlain by outwash sand and gravel up to elevations of 750 feet; these probably represent marine deltas. In several places glacial till overlies the marine clay, possibly representing a late advance of the Cordilleran ice. The evidence suggests that the land in the Kitimat-Terrace valley was depressed at least 1,000 feet below its present elevation during Cordilleran glaciation.

In the Okanagan Valley, R.J. Fulton, Geological Survey, found ridges of sand and gravel, overlain by till, that rise as high as 400 feet above the valley floor. This valley fill extends to at least 350 feet below the present valley floor, as indicated by water wells at Vernon, B.C. Other major valleys in the Vernon (West half) map area contain similar thick Quaternary fills. In the Salmon River valley till-covered remnants of valley fill are up to 1,000 feet above the present floor. The valley fills indicate a base-level prior to the last ice advance much higher than the present. Raised-shore features at the north end of Okanagan Lake and elsewhere were left by a glacial lake at an approximate elevation of 1,400 feet. Possibly a single late-glacial lake more than 180 miles long extended from southwest of Ashcroft in the Thompson River valley to south of Winfield in the Okanagan Lake valley.

A sedimentologic study at the head of Upper Arrow Lake was undertaken by M.J. Pullen, Geological Survey of Canada, who ran echo-sounder profiles on the deltas of the Columbia and Incomappleux Rivers. In addition, grab samples were taken from the delta surface to a water depth of 100 metres.

The surficial geology of southeastern Vancouver Island was studied by E.C. Halstead, Geological Survey, who completed the mapping of the Sooke area. The surficial deposits were deposited by the last major ice advance or its meltwaters; older Pleistocene deposits are exposed in cliff sections. Peat and wood were collected from the non-glacial deposits lying between the two tills.

G.D. Hobson, Geological Survey, conducted an experimental seismic survey using a hydrosonde instrument developed in Canada on three lakes in the interior of British Columbia to investigate the thickness of overburden in the mountain valleys and to test the marine seismic technique in a freshwater environment. Poor results were obtained.

In 1965, J.G. Souther, Geological Survey, started an investigation of the Tertiary and Recent volcanic centres and related plutons in the Canadian Cordillera. Ten days were spent examining a group of post-glacial volcanoes on the coastal islands of British Columbia. Mount Edziza, a composite volcano, the lower basalt unit of which is overlain by till and glacial-fluvial deposit, was also studied.

D.W. Lawson, Geological Survey, started a hydrogeological study of the Trapping Creek basin, some 30 miles east of Kelowna. E.C. Halstead, in the mapping of surficial deposits of southern Vancouver Island, installed instruments in two small basins for future water-balance studies; he also investigated the water supply for the new Queen Elizabeth Observatory on Mount Kobau.

J.A. McCallum, British Columbia Department of Lands, Forests and Water Resources, began a study of the Quaternary geology of the Prince George area, with supervision by E. Livingstone and W.H. Mathews. K.M. Piel is undertaking, under the supervision of G.E. Rouse, a pollen study of the samples obtained in drilling in the Prince George area under sponsorship of A.R.D.A. E. Livingstone and F.C. Foweraker are mapping, drilling and interpreting the stratigraphy of Quaternary deposits as sources of groundwater in the North Okanagan, in the lower Fraser Valley near Cloverdale, at Massett and Port Clement on the Queen Charlotte Islands, and at Sointula on Malcolm Island.

Studies of soil creep in the alpland area of Garibaldi Park and of snow creep on Mount Seymour are being continued by J. Ross Mackay and W.H. Mathews, University of British Columbia.

H. Nasmith, G.E. Rouse, and W.H. Mathews are studying the age of the Bridge River volcanic ash in southern British Columbia; this involves the coring of a peat bog at Jesmond. Samples have been submitted for radiocarbon dating to the Geological Survey of Canada.

Miss J. Ryder, University of British Columbia, studied the alluvial fans and terraces along the Fraser River between Pavilion and Lytton, and along the Thompson River from Lytton to Kamloops and examined the Quaternary deposits immediately underlying them.

L.S. Evans, under supervision of L. Washburn, Yale University, began study of cirque development and modification in the Bridge River district.

Alberta

Seismic-refraction surveys by G.D. Hobson and J.A.M. Hunter, Geological Survey, over three areas of the Defence Research Board Suffield

Experimental Range, indicate several layers of unconsolidated sediments in the overburden. Subsurface contouring of key horizons indicates a complex series of lakes and rivers in Pleistocene time with three distinct river channels.

D. A. St. Onge, Geological Survey, studied the geomorphology and glacial geology of north-central Alberta in the Iosegun map-area (83 K, East half). The area is heavily forested and contains several bogs, some of which were sampled to investigate climatic fluctuations based on pollen variations. In the higher parts of the area, road cuts commonly expose Cretaceous sands and clays deformed by glacial ice. The high hills rising above 3,900 feet in the south and northeast parts of the map-area are covered by quartzite gravels, lithologically similar to those of the Cypress Hills Formation whose age is conjectural. Granite erratics are found on the top of these hills. Till in the bottom of the valleys of the Athabasca, the Little Smoky, the Iosegun and the Goose Rivers shows that these valleys pre-date the last glaciation. During retreat of the Laurentide ice to the north and northwest, an arm of a large glacial lake occupied the valley of the Athabasca River. While the lake existed the Little Smoky River drained into the Athabasca through the valley now occupied by Marsh Head Creek. At a later stage, following further ice retreat, a large ice-dammed lake was formed north of the divide separating the Athabasca from the Little Smoky. This lake drained into the Athabasca through a large spillway carved into the divide to an altitude of about 2,700 feet.

A. M. Stalker, Geological Survey, studied the glacial geology in southern and central Alberta. He mentions the surprising insignificance of glacial sculpturing in the mountains bordering the lower part of the Kananaskis Valley with general lack of cirques, truncated spurs, and hanging valleys in the tributary valleys, although farther south, near the Kananaskis Lakes themselves, such features are well developed. Recent fan deposits form prominent surface features. Stalker reports further progress in delineating the Foothills Erratic Train which has been traced northward to a point about 20 miles north of Calgary. Because the erratics appear to become smaller and rarer in a northerly direction and because the forest cover increases, they are more difficult to trace than farther south where the Train includes what is probably the largest erratic in North America, the Okotoks "Big Rock".

During three weeks C. S. Churcher, University of Toronto was attached to Stalker's party making a reconnaissance study of certain vertebrate-fossil localities. Results of this study exceeded expectations and fossils were recovered from apparent preglacial sands, and from interglacial, interstadial, and early and late postglacial deposits.

A. Dreimanis and J. A. Westgate, of the University of Western Ontario, continued their investigations of buried soils in Banff National Park,

Alberta. During the course of their field work they found two more or less continuous layers of volcanic ash which may become useful stratigraphic markers.

L.A. Bayrock reports that research and investigations in Pleistocene geology by the Research Council of Alberta during 1965 were numerous and varied. They include the following:

Berg, T.E.
Surficial deposits of the Medicine Hat (72L) area
Periglacial phenomena in Alberta

Carlson, V.A.
Gravity exploration for a buried channel near High Prairie, Alberta

Dunn, D.
Groundwater resources of the Stettler area.

Gabert, G.M. and Roed, M.
Bedrock topography of the Edson area
Groundwater hydrology of the Edmonton area
Groundwater-level fluctuations in Alberta, Canada, caused by the Prince William Sound, Alaska, earthquake of March, 1964.
Groundwater hydrology of a buried-channel aquifer near Devon, Alberta.

Gabert, G.M. and Lennon, D.H.
Analysis of pump-test results

Geiger, K.W.
Groundwater conditions and changes near the Waterton Dam

Geiger, K.W., Brown, R.E., Withers, D.W., de Vries, P.
Tabulation and publication of water-well data

Jones, J.F.
Geology and groundwater resources, Peace River District

LeBreton, E.G.
Groundwater geology and hydrology of the Lamont-Chipman area, Alberta.

LeBreton, E.G. and Vanden Berg, A.
Groundwater geology and hydrology of east-central Alberta

Lennox, D.H., and Carlson, V.
The seismic method of exploring for buried channels near Stavely, Alberta.

Geophysical exploration for buried valleys in an area north of Two Hills

Roed, M.
Groundwater geology and hydrology of the Cache Percotte and Whiskeyjack basins near Hinton, Alberta.

Toth, J.
Development and investigation of methods to determine the groundwater regime in uninstrumented drainage basins.
Investigations for groundwater for the town of Olds, central Alberta.
Investigations for groundwater in the Three Hills and Red Deer areas, central Alberta.

Vanden Berg, A.
Groundwater movement and groundwater chemistry in the Hand Hills-Bullpound Creek area, Alberta.

Of primary importance were projects concerned principally with mapping of surficial deposits, such as those of the Banff area, which was investigated by N. Rutter, Canadian Department of Forestry. The results of his investigations were presented as a Ph. D. thesis, University of Alberta. Rutter also conducted investigations on the susceptibility to erosion of areas covered with spruce-fir forest in the Rocky Mountains Forest Reserve, Alberta.

A. L. Allong completed a study on the sedimentation of the Saskatchewan Gravels and Sands in Alberta, describing all the known outcrops. His work is in partial fulfilment for a M. Sc. thesis, University of Wisconsin; it will be published by the Research Council of Alberta during 1966.

R. J. Clissold is working on a Ph. D. thesis (university of Alberta) entitled "A quantitative study of Alpine landforms, Canadian Rocky Mountains, Jasper, Alberta." T. Gardner is studying "Mass wasting processes in the Alpine Zone of the Canadian Rocky Mountains" (Ph. D. thesis, McGill University).

The surficial geology of the Edson-Hinton area (83 F) is being studied by M. Roed (Ph. D. thesis, University of Alberta). The field work, which will be followed by laboratory investigations, indicates two distinct advances of Cordilleran glaciers and at least one advance of a continental glacier. Tills of different origin and age can be identified in the field on the basis of their contained erratics, geomorphic expression, and detailed stratigraphy.

P. Wagner (Ph. D. thesis, University of Michigan) has mapped the surficial deposits of the Cardston-Pincher Creek area (82 G and western part of 82 H) to decipher the character of the confluence of the Keewatin and Rocky Mountain ice sheets.

Detailed investigations of the surficial deposits of the City of Edmonton were started in 1965. A detailed drilling program will determine the preglacial topography as well as the extent and thickness of the overlying Saskatchewan Sands and Gravels, till, and sediments of glacial Lake Edmonton. A preliminary report will probably be published during 1966.

K. W. Geiger, Research Council of Alberta, completed and published a study of the bedrock topography of southwestern Alberta (82 H and southwest part of 82 I). The report shows the courses of preglacial streams and thickness of drift on maps to a scale of 1:250,000.

A final report by J. A. Westgate, who has been studying the surficial geology of the Cypress Hills, will be published in 1966.

The finding of Mammuthus primigenius and M. Jeffersoni in the Quaternary Saskatchewan Gravels and Sands is of major importance. This and other evidence indicate that the greater part of Alberta was not glaciated during Nebrasken and Kansan time; it is highly probable that the area escaped glaciation also during Illinoian time. Only during the Wisconsin did the Continental (Keewatin center) Ice Sheet cover Alberta. Results of this study were presented at the INQUA Conference by L. A. Bayrock in 1965.

Most of the laboratory analyses and all the field work has been completed on a study of till. It will be included in the program for a contemplated conference on the geological, hydrological, and engineering properties of till, being organized by the University of Alberta and to be held in Banff.

J. M. Hillerud completed his study of the Duffield Bison Site (M. Sc. thesis, University of Nebraska). His major conclusion is that Bison occidentalis is a northern variant of Bison antiquus and should be called Bison antiquus occidentalis.

S. Pawluk, University of Alberta, and L. A. Bayrock have been conducting analyses of till samples since 1958 from areas affected by continental glaciation in Alberta; they report that their project is nearing completion. Preliminary results are shown on maps which reveal systematic variations in the composition of surface tills in Alberta. Of particular interest to agriculture are maps of the distribution of trace elements such as cobalt, molybdenum, manganese, boron, nickel, etc., which show large areas with a deficiency of these constituents.

The Groundwater Division of the Research Council of Alberta has conducted a number of studies on surficial deposits of Alberta in relation to groundwater movement and content. These include mapping of the bedrock topography and a detailed study of composition of surface and sub-surface drift in the City of Lethbridge and vicinity. The latter investigations are being conducted by K. W. Geiger and J. A. Westgate, and are a comprehensive detailed study in a restricted area. The study of the geology involves the mapping of the surficial deposits, the bedrock geology, the preglacial and bedrock surfaces, and the stratigraphy. The study of the hydrology involves the mapping of groundwater occurrences, sampling of the chemical composition in the various geologic environments, instrumentation to determine the nature of shallow-groundwater behaviour, the flow characteristics in the area and the evaluation of potential aquifers.

Preliminary results of the mapping of bedrock topography of the Edmonton district by V. A. Carlson and G. N. Gabert, Research Council of Alberta, indicate a dendritic array of youthful channels buried by variable thicknesses of drift. O. Tokarsky mapped the groundwater and surficial deposits of the Peace River area in 1965.

The Department of Geography, University of Alberta, is compiling an atlas of the province in which maps of surficial deposits, preglacial channels and physiography will be included.

Saskatchewan

R. J. Mott, Geological Survey of Canada, made a reconnaissance survey of palynological sampling sites in central and northern Saskatchewan as a preliminary to the study of late-glacial and postglacial vegetational and climatic changes and geochronology. He reports: "Of special interest is the relationship of the boreal forest to the grassland and the migration of the boundary between the two in postglacial time. Organic deposits are rare in the grassland region and in the forest-grassland transition zone. Lakes are usually shallow and contain little accumulated organic sediment, although some deeper lakes do exist and it is hoped that these will provide suitable materials for study in these areas. Within the boreal forest, organic deposits and lakes are more abundant, but they are less accessible than in the inhabited areas to the south. Samples are collected from the grassland, transition zone, and boreal forest to determine what sediments can be used for palynological purposes and the type of pollen record that can be expected. Radiocarbon dates on basal organic materials from selected sites in various areas will outline the range of minimum ages to be expected. They will also date the pollen assemblages occurring at these levels in the pollen record and serve as guides for future sampling. Surface samples collected along transects across the forest-grassland boundary will be used to compare the

pollen and spore record with present-day vegetation. These comparisons will aid in the interpretation of pollen diagrams from the study area."

In southeastern Saskatchewan surface resistivity measurements using Schlumberger, Wenner, and Three-Electrode configurations were completed by J.E. Wyder, Geological Survey of Canada. Gravel deposits, discovered previously, were traced several miles to the east and form the basis for predicting, in cooperation with K.B.S. Burke, University of Saskatchewan, the location of the buried preglacial Missouri River channel. A horizontal-gradient gravity survey was conducted over the gravel deposit, but the initial interpretation of the results is inconclusive. Sixteen holes were drilled to provide reference sections for checking the geophysical studies.

P. Meyboom, Geological Survey, continued study of the groundwater flow near a willow ring in hummocky moraine in south central Saskatchewan by weekly observations of piezometers. These revealed that in the course of one water year the following sequence of flow conditions can be recognized: (1) a winter condition of "normal" downward flow; (2) a spring condition characterized by a groundwater mound underneath the slough and an associated flow pattern of lateral and vertical dissipation and, finally, (3) a condition of inverted water-table relief owing to a cone of depression around the phreatophytic willows and phreatophytes in the dry slough bed. The latter condition, which exists during summer and fall, is characterized by radial flow into the willow ring, brought about by reversed-shallow and diverted-deep groundwater flow.

R.A. Freeze, Geological Survey, completed studies of the application of computer methods to analysis of groundwater-flow systems under prairie conditions. His summer's fieldwork included a visit to the Good Spirit Lake drainage basin in Saskatchewan to maintain and improve the instrumentation installed in 1964.

R.O. van Everdingen, Geological Survey, is studying the influence of the South Saskatchewan River reservoir on piezometric pressures in confined bedrock aquifers as flooding proceeds. Pressure transducers were installed on a number of piezometers under the waters of the reservoir by a skindiver making it possible to study pressure changes beneath the reservoir even though the instruments are submerged.

J.S. Scott, Geological Survey, continued landslide investigations in the South Saskatchewan River reservoir area (72J-15). Pressure transducers on sealed piezometers were installed near the South Saskatchewan River south of Lucky Lake in an attempt to develop a method of obtaining instantaneous response to changes in groundwater pressure.

The following report by E.A. Christiansen outlines the work done by the Saskatchewan Research Council in Quaternary geology in 1965:

"Systematic investigations of geology and groundwater occurrences were completed for the Battleford area (73-C), Saskatoon area (73-B), and the Humboldt area (73-A). These investigations include about 50,000 feet of test drilling over an area of about 16,000 square miles. A total of about 400 miles of buried preglacial valleys was defined in these areas. Systematic investigations of the geology and groundwater resources of the Yorkton area (62-M, 62-N West quarter) and the Cypress Hill area (72-F) were continued and initiated respectively in 1965 and are scheduled for completion in 1966. A map showing the major ice-frontal positions and significant radiocarbon dates was published in 1965. Plans for an investigation of the urban geology of Saskatoon were initiated by the Saskatoon Geotechnical Group, and a grant of $5,000 has been obtained from the National Research Council to initiate this investigation. This grant will be spent entirely on test drilling, the data from which will provide a geological framework for future, more detailed studies. The systematic program of installing permanent observation wells in hydrogeological environments defined by test drilling continued in 1965. One shallow (50 feet) observation well and four deep (300-400 feet) ones were installed. All observation wells are six inches in diameter, cemented, screened, and equipped with automatic water-level recorders. Six additional observation wells of similar construction were installed for special purposes in connection with contract research programs. The Saskatchewan Research Council, Geology Division, contracted to undertake groundwater quality and water-level investigations for the Vanscoy and Blucher areas. These investigations have provided a real insight into groundwater chemistry and its relation to geology in the flow system. The groundwater investigation of the Estevan Valley, near Estevan, was completed by running a 450-gallons-per-minute pump test. These and other data were analysed on an electrical analog computer constructed to represent the geology of the area. The yield of the well field in this aquifer was estimated to be 5-10 million gallons per day."

The studies by D. L. Delorme and R. W. Klassen previously reported have been completed (see appendix to this report).

Manitoba

Studies by L. S. Collett, Geological Survey of Canada, are of particular interest to prospecting for groundwater resources on the prairies. The prospecting method used by Collett on an experimental basis is that known as the Barringer INPUT system which measures the resistivity of surficial deposits by airborne pulsed electromagnetic equipment. In April and June 1965 the Oak River Basin and Winkler areas in Manitoba, and the Steelman-Frobisher and Nokomis areas in Saskatchewan were flown using the

INPUT system. Flight lines were spaced at one-mile intervals and flown at 380 feet in the Steelman-Frobisher area and at 500 feet in the others. The method can definitely detect near-surface anomalies with a two-to-one resistivity contrast. In the Winkler area, the airborne survey took three hours working out of Winnipeg airport; the ground survey required three months to complete. The method may be of importance in detecting groundwater resources in surficial deposits of the prairie provinces in places where the deposits are largely of clays and glacial till interbedded with lenses of sand and gravel which are the potential aquifers.

More conventional groundwater studies in Manitoba were undertaken by A. Lissey, M. L. Parsons, and J. E. Charron, Geological Survey of Canada. Lissey's study of the Oak River Basin involved further instrumentation to determine regional flow systems. Pump and other tests were conducted to provide quantitative data on the materials in the basin so that an electrical analog model can be constructed for future studies. J. E. Charron compiled a well inventory for some 980 square miles in the Stonewall area, Manitoba. Other projects involved tracing groundwater movement by using fluorescein dye in holes drilled by a power auger. M. L. Parsons cooperated with the Manitoba Government in installing observation wells and piezometers in the Wilson Creek experimental watershed to assist in the studies of water balance and erosion.

L. Gray reports that the Water Control and Conservation Branch of the Manitoba Department of Agriculture and Conservation was active in two regional studies to evaluate the availability of groundwater, in a study to evaluate the development of groundwater in flowing artesian areas and a study to evaluate the development of groundwater in the urban area of metropolitan Winnipeg. Other activities included exploration for groundwater for municipal use at various locations, the installation of observation wells, and the collection and compilation of basic groundwater data. Basic data from drillers' reports are published annually.

B. B. Bannatyne reports the Mines Branch, Manitoba Department of Mines and Natural Resources, is preparing a report on the clays and shales of Manitoba. Clays of glacial and postglacial origin are used for making common brick, as an ingredient in Portland cement, and for light-weight aggregate. Firing tests on several clay samples indicate differences in composition among the clays and silty clays from Lake Souris, the Assiniboine Delta, the Valley River Delta and various parts of Lake Agassiz. Samples were collected from three locations along the Greater Winnipeg Floodway. As part of the report a series of isopach and structure-contour maps of all the bedrock-shale formations is being prepared. It is hoped that maps showing the topography of the bedrock surface and the thickness of the glacial drift can be drawn up, although lack of data will restrict the amount of detail over large parts of southern Manitoba.

In engineering geology, G.A. Russell, University of Manitoba, reports that early in 1965 freezing tests were carried out on Shelby Tube samples of Lake Agassiz clays. The preliminary tests were of a qualitative nature and demonstrated clearly that freezing produced a significant disturbance in the structure of the clay with a corresponding loss in strength. The tests were carried out in a specially designed freezing chamber financed by the National Research Council. Clay collected 40 feet below the surface, which was firm and solid before freezing, changed to a material with approximately the strength of hard butter after being frozen and thawed. This phenomenon suggests the possibility that Lake Agassiz clays can be divided into two types on the basis of whether they occur above or below the maximum depth of penetration of winter frost, that is, whether they had or had not been remoulded by natural freezing. In some construction jobs difficulties were encountered when the clay being used from deep excavations was frozen for the first time at the onset of winter. Also, the question can be raised as to whether Lake Agassiz clay to be used for sub-grade material should be allowed to freeze for one winter at least before placement.

Whereas the engineering studies of Lake Agassiz are of interest to the Quaternary geologists and to a better understanding of the stratigraphy, some archaelogical investigations in that area shed new light on some old prehistoric problems. W.J. Mayer-Oakes, University of Manitoba, reports that in 1965 a three-man archaeological survey party investigated the western shoreline of Glacial Lake Agassiz to find out more about the nature and extent of prehistoric human occupation of Campbell Beach. General results are encouraging, although somewhat negative in terms of evidence for association of very early cultures with the active period of beach formation; there is a lack of sites associated with the period of beach formation. Parts of the beach were much used as a travel route during Archaic times (4,000 to 500 B.C.). J.A. Elson, McGill University, working in close cooperation with the archaeological party, studied the strand lines and related end moraines of Lake Agassiz in 1965.

B.G. Craig, Geological Survey of Canada, carried out a reconnaissance survey of the surficial geology of the The Pas area in 1965. Most time was devoted to study of the The Pas moraine and related surficial geology. A strikingly asymmetric profile, coupled with the distribution of bedrock outcrops, suggests that the The Pas moraine comprises an accumulation of till along the front of a bedrock escarpment. The whole area was submerged by Lake Agassiz and has been modified by lacustrine action.

R.W. Klassen, Geological Survey, studied the surficial geology of the Interlake Region in central and southern Manitoba. Most of the land surface is a gently irregular till plain marked by broad ridges of bedrock up to 60 feet high. The drift is generally less than five feet thick, except where the bedrock surface drops abruptly. Much of the surface is poorly drained and swampy, and has been modified by Lake Agassiz. Ridges and terraces which

are the most distinctive minor landforms are best developed along the front of the The Pas moraine and around bedrock ridges. Intersecting minor lineations form striking patterns visible on airphotos, particularly in belts adjacent to large lakes. The absence of these lineations on bedrock highs supports the view that they are surficial features rather than the traces of bedrock structures.

Miss B. Kennedy, University of British Columbia, studied early postglacial frost effects in southwestern Manitoba.

Ontario

W.A. Gorman, Queen's University, is engaged in glacial studies of the Kingston area. This includes study of eskers to obtain data on distance of transport of various grain sizes, degree of rounding related to distance of transport, and, eventually, properties of an esker stream. Gorman is also attempting to work out rates of isostatic recovery in the St. Lawrence Lowlands, and from this the shape and size of the Champlain Sea at various times during its existence in the St. Lawrence Valley.

S.A. Harris, Waterloo Lutheran University, is studying the structure and origin of the Waterloo Sand Hills and surrounding area and the Galt and Paris Moraines and associated structures.

In eastern Ontario E.P. Henderson, Geological Survey of Canada, studied the surficial deposits of the Westport area. In this area striae, fluting and a few drumlins record fairly consistent movement of ice of the last glacial stage in a direction south of southwest, toward the Lake Ontario basin. During deglaciation, with retreat and thinning of the ice, topographic control of ice flow became increasingly effective, and a distinct late lobe formed and moved more to the westward across the area between Rideau and Newboro lakes, parallel to the long axis of their deep basins. Morainal elements partly outline the western limit of this lobe. Glacial deposits are particularly scarce in areas of hard Precambrian rocks that resisted the abrasive action of the ice. A more continuous till cover lies over much of the softer, flat-lying or gently dipping Paleozoic rocks. Small patches of unusually thick till occur on the flanks of hills and in the lee of escarpments. Glacio-fluvial sediments are present as kames, kame-moraines, eskers, and outwash. In Precambrian areas they are generally too small to map separately. In areas underlain by Paleozoic rocks they are fewer but larger and economically much more valuable. With retreat of the ice to the north and east, waters of a glacial lake spread over the entire area. Areal distribution of the lacustrine deposits suggests that they were laid down by cold, dense bottom currents closely controlled by relief on the lake floor.

G.D. Hobson and P.G. Killeen, Geological Survey, carried out seismic investigations over the Moose River magnetic anomaly near Otter Rapids

and Fraserdale, Northern Ontario. Determination of thickness of overburden permitted contouring of the bedrock surface; overburden thickness ranges from 15 to over 200 feet. Very persistent seismic velocities were recorded which can be correlated with the three distinct surficial materials, muskeg, sand, and clay.

E. H. W. Hornbrook, Geological Survey, supervised the drilling of ten boreholes to bedrock near the Texas Gulf Sulphur orebody near Timmins to sample the Pleistocene section and surface of the underlying bedrock. The object was to obtain information on the extent of the geochemical anomaly in the lower till in a down-ice direction from the mineral deposit.

C. F. M. Lewis, Geological Survey, commenced a study of the post-glacial shoreline features in northern Lake Huron basin in August and September, 1965, with the object of making an estimate of recent crustal uplift, and clarifying several details of Great Lakes history in this area. The study revealed numerous beach, deltaic, and fluvial features exposed above the present Lake Huron level between North Bay and Sault St. Marie, Ontario. Many beaches higher than the classic Nipissing-Great Lakes shoreline were noted. Other observations will probably document the pre-Nipissing fall of the Great Lakes and the rise of the water-level to the Nipissing stage.

P. F. Karrow, University of Waterloo, began mapping the Conestogo and Stratford areas in the Waterloo interlobate region (40 P-7, 40 P-10) for the Geological Survey; a complex distribution of Quaternary deposits was found. Some of the deposits can be attributed to specific ice lobes while others are of indeterminate origin. The youngest till sheet is probably the sandy Wentworth till which was carried into the eastern part of the Conestogo area by the westward-moving Ontario lobe. Entering the northern part of the Conestogo area, at least one and probably two or three tills were deposited by the Georgian Bay lobe. Multiple tills in the central part of the area may have been laid down by either the Georgian Bay or the Huron ice lobe. The Catfish Creek till apparently underlies most of the area; it was derived from the north and is of Tazewell age. Still older tills occur in places. Karrow reports that a number of shallow holes were drilled in connection with the "Woodbridge Cooperative Mapping Project". The field work for this mapping project is now completed and data are presently being compiled. At the Woodbridge section a mammoth tooth was found during the last one and half days of the INQUA post-congress trip G. C. S. Churcher, University of Toronto, is preparing a brief paper on this find.

The following information was also provided by P. F. Karrow:

A report on the Pleistocene geology of the Guelph area has been submitted to the Ontario Department of mines for publication. A report on the Scarborough area submitted in 1964 was expected to be published early in 1966.

H.R.N. Eydt, Biology Department of the University of Waterloo, is studying pollen sequences of several bogs in Waterloo County, Ontario. B.H. Feenstra, Carleton University, is making a detailed study of the sequences of four till sheets exposed at the Conestogo dam, Ontario.
O.L. White, University of Waterloo, is supervising an investigation of buried valleys in the southern part of the Bolton Map area which is being mapped by J.N. Fulop. The investigation utilizes an integrated geophysical program of seismic and resistivity surveys.
O.L. White is correlating engineering properties in geologic units for parts of southern Ontario.
W.M. Tovell and the late R.E. Deane reported on "Raised Beaches, east shore of Lake Superior" at the 1965 Annual Meeting of the Geological Association of Canada in Winnipeg. This paper also records some of the results of Deane's work on sedimentation in the Great Lakes.

We report with great sorrow the tragedy in October, 1965, when, on an expedition to the Bruce Peninsula, Professor Deane and three companions drowned during a storm while trying to photograph sediments under water around a sunken ship.

A.K. Watt reports on activities of the Ontario Water Resources Commission, Division of Water Resources, as follows:

"The Division of Water Resources continued its activities during 1965 in a number of programs relating to ground and surface waters and Quaternary geology. Investigations were made of approximately 70 complaints concerning interference with water supplies due to the operation of large-capacity wells. Municipal hydrogeologic surveys or test-drilling and well-construction projects were carried out to aid 17 municipalities in their search for improved water supplies. Approximately 40 special investigations were made regarding water supply, groundwater contamination, and waste-disposal sites. A detailed water-resources study to assess the water budget and make recommendations concerning present and future needs was undertaken in the Big Otter Creek drainage basin. A report on a similar survey carried out in the Big Creek drainage basin in 1964 is in preparation. Both surveys included the mapping of the Quaternary deposits and had ARDA's support.

"Work continued on the collection of synoptic hydrometric measurements in eight drainage basins, with adjoining satellite basins, in southern Ontario. A report on the nine areas studied synoptically in 1964 is being prepared with ARDA support. Groundwater levels and surface water flows were measured and attempts were made to correlate them with other hydrologic factors and the geology.

"As part of the program of the International Hydrologic Decade, four drainage basins representing different Quaternary and other features

were selected for extensive hydrometric instrumentation. The basins were: (1) Venison Creek, representing sand plains, (2) east and middle branches of Oakville Creek, representing till and clay plains, (3) Blue Springs Creek, representing ground, kame, and recessional moraines and outwash deposits, and (4) Bowmanville, Soper and Wilmot Creeks, representing interlobate and ground moraines, and lake plains. A fifth basin, Wilton Creek, was selected to represent limestone plains with thin surficial deposits. Several observation wells were installed in the Venison Creek Basin and fifteen staff gauges and nine stream-flow-gauging stations equipped with recorders were installed on Blue Springs, Bowmanville, Soper, Wilmot, Venison, and Wilton Creeks. Four of the recording stations were installed in cooperation with the Canada Department of Northern Affairs and National Resources.

"The assembly of hydrogeologic data was continued through the required submission of waterwell records by boring and drilling contractors, and the operation of observation wells throughout the province. The information is published in Groundwater Bulletins.

"The number and scope of surveys and investigations are increasing steadily. It is essential that young geologists and engineers be well trained in chemistry, sedimentary and Quaternary geology, hydrology, and mathematics if our needs for adequate water supplies are to be met effectively."

E. B. Owen, Geological Survey of Canada, provided consultation and advice on the surficial and bedrock-engineering-geology aspects of the twinning project on the Welland Canal for the Seaway Authority. A. F. Gregory, Geological Survey, initiated the first investigation of the applicability of various remote-airborne-sensing techniques to the study of groundwater. Several areas in Ontario were flown by an infrared sensing device. This device is still under security regulations and no comment can be made on the results, except to mention that imagery was obtained and is currently being analyzed.

A. Dreimanis, University of Western Ontario, reports as follows on various projects on Quaternary geology in progress at the University of Western Ontario:

Geology Department.

(1) Detailed investigations of the Port Talbot Interstadial deposits along the north shore of Lake Erie continue. The Port Talbot Interstadial, including the Plum Point Interval, was found to be at least 25,000 radiocarbon years old and represents a major stratigraphic unit of the mid-Wisconsin time. Test drilling during the summer and fall, supported by the Geological Survey of Canada, provided new material

for further studies and experts from various branches of biology have participated in the investigation of the plant and animal remains (J. Terasmae, I. J. Bassett, A. H. Clarke, H. B. Herrington, and others). New radiocarbon dates have been obtained or are pending from the Geological Survey of Canada and the Groningen radiocarbon laboratories. Two papers were presented at international congresses. The type section was reexacavated for demonstration at the INQUA Field Conference G in September, 1965. A. A. Berti, under supervision of A. Dreimanis and J. Terasmae, is studying the palynology of several sections. Three papers were published dealing with the Port Talbot Interstadial (Dreimanis and Vogel, 1965; Dreimanis and Karrow, 1965; Dreimanis, Terasmae, and McKenzie, 1965).

(2) A. Dreimanis and U. J. Vagners, supported by the Ontario Research Foundation, are continuing investigations of till lithology and various factors which influence it. A progress report was presented at the 7th International INQUA Congress (1965).

(3) J. A. Westgate studied Pleistocene sections in the Canada Cement Plant Quarry near Zorra, Ontario. He distinguished, by field and laboratory methods, nine separate tills all of which, except the lowermost, may belong to the last ice age.

(4) U. J. Vagners mapped the surrounding area of the Fort St. Marie I near Midland, Ontario, and hoped to complete the map and report in the spring of 1966.

(5) C. B. Gunn, supported by the Geological Survey of Canada, did field and laboratory work in areas in the Great Lakes Region, where diamonds in till have been reported. His preliminary findings, including several microscopic diamonds, suggest several possible bedrock sources. His investigations are continuing.

(6) G. E. Pinder investigated gravels of the Komoka Delta and found that the Maumee gravels are lithologically different from the Whittlesley gravels.

Geography Department.

(1) R. W. Packer continued his research, supported by the Geological Survey of Canada, into land-slope characteristics in southwestern Ontario. The statistical study of characteristic slope angles was extended by field observation to the valley of the Grand River during the summer of 1965.

(2) During the summer of 1965 V. W. Sim initiated a study of changing channel characteristics of small streams in the vicinity of London. Field installation of apparatus for measuring scour and fill and lateral channel displacement in Dingman's Creek was carried out in October and November with funds provided by the Middlesex College Research Fund.

(3) Observations on the magnitude and duration of frost heave were resumed during December, using the frost-heave apparatus established on the campus of the University of Western Ontario in early 1965. Thermocouples at eight depths to 125 centimetres have been installed and a record of winter soil temperatures is being developed. The work is under the direction of V. M. Sim.

Soil Mechanics Division of the Faculty of Engineering Science.

(1) The engineering properties and clay mineralogy of a hard glacial clay from Toronto, Ontario, are being studied by H. Hawson under supervision of R. M. Quigley. An attempt is being made to determine the influence of a small amount of peculiar swelling clay on the engineering properties of the hard glacial clay. The samples were taken from two large slope failures along the Don Valley Parkway, Toronto, Ontario. C. de Wit is studying the influence of swelling clay on the engineering properties of Leda Clay from Ottawa, under supervision of R. M. Quigley.

(2) J. McBain is investigating the shear strength of Lake Agassiz clays as a function of their pore-fluid-salt content under the supervision of R. M. Quigley. Drained direct-shear tests on remoulded clay from Winnipeg at natural and reduced pore-fluid-salt contents are currently underway.

(3) In association with J. J. Hamilton, National Research Council, R. M. Quigley is studying the clay mineralogy of 12 clay samples from engineering-research projects on swelling soils in western Canada.

Quebec

N. R. Gadd, Geological Survey of Canada, reports that completion of mapping of the St. Sylvestre area (21 L-6) concludes a four-year survey of the glaciation of a segment of the Appalachian Highland bordering the Chaudière River Valley, including an area of the St. Lawrence Lowland extending north to the St. Lawrence River at Quebec City and Portneuf. The work has resulted in the discovery of new glacial-moraine systems in

southern Quebec; the 1965 field season revealed further complexity and some new facets of their significance. The St. Silvestre map area includes several outcrops of asbestos-bearing serpentine, and many blocks, boulders and pebbles of serpentine occur in the glacial drift. The direction of ice movement shows that all boulders have come from sources northwest, north, and northeast of the places they are found in the drift. Because of this and because all serpentine fragments lie in northerly directions from known outcrops, Gadd concludes that areas in the vicinity of Leeds Village, an area within the valley north of Tara Mountain, and the broad area south of St. Elzear extending from the eastern flank of Tara Mountain to Vallée Jonction might be fruitful areas to prospect for new occurrences of serpentine and asbestos.

D.G. MacDonald, Geological Survey of Canada, studied the Pleistocene geology in the Richmond-Sherbrooke area. He finds retreat of the margin of the last ice sheet across the region was interrupted by two minor re-advances culminating in moraines. Both moraines are composed largely of ice-contact-stratified drift and are being exploited for sand and gravel. Two glacial-lake phases were associated with these ice-margin positions. The Champlain Sea inundated the northwest corner of the area, and marine fossils have been found up to 530 feet above present sea level. During regression, the sea constructed various strand features below this elevation. Minor amounts of gold have been discovered in till bordering the southeastern part of the region, the gold being very angular and of sand size.

J.A. Elson, in reporting on activities at McGill University, mentions that H.R. Grice has joined the staff to teach groundwater and engineering geology. Mrs. G. Douglas is continuing study of the permeability of clays. Current research involves the study of electrokinetic potentials and the threshold gradients necessary for low-velocity flows in clay. G. Mondoloni is studying the engineering-geology problems of the Lac Dusterlo division of the Kaniapiskau reservoir area in Quebec. J. Raudsepp is completing his work on the erosion surfaces of the Gaspé area. K. Mallick is carrying out geochemical studies on Mont St. Hilaire and has begun a study of the rate of creep in certain soils there. A comprehensive study of geomorphic processes on Mont St. Hilaire is planned by R. Thomas. The surficial deposits exposed in the Montreal subway and related excavations are being examined by R. Thomas and his students as opportunity affords.

R. Roy, Quebec Department of Natural Resources summarizes the activities of the hydrological division. The division has a staff of four geological engineers, two geologists, and four technicians. It is engaged in experimental and theoretical research in hydrogeology with the main function of helping municipal or private water services, as well as semi-public bodies, find sufficiently large groundwater resources and improve existing services. To this end studies were undertaken dealing with the geochemistry of water in the Eaton River Basin and in other municipalities which requested

aid. Seismic methods are being employed to determine thickness of overburden. During the year 1965, a total of 66 hydrogeological surveys were undertaken in 35 municipal counties. In the Eaton River Basin, which comprises an area of 250 square miles, a team under the direction of J. J. Tremblay and J. N. Grant made four seismic surveys and mapped surficial deposits in four sub-basins. With few exceptions, the surficial materials in this area are thin. The study will be completed in 1966 by drilling some observation wells. C. Grenier is currently engaged in a hydrogeological study of the Aylmer-St. Francois Lakes area; it is suspected that part of Lake St. Francois drains into Lake Aylmer through underground channels. P. Lasalle continued to map the Pleistocene and Recent deposits in the Arvida area. It is hoped that sufficient data will be collected to unravel the Pleistocene history of that area.

J. C. Dubé, Quebec Department of Natural Resources, studied the unconsolidated Pleistocene and Recent deposits and Quaternary geomorphology of parts of the St. Lawrence Lowlands and Appalachian Uplands in the Inverness area, Eastern Townships.

The staff of McGill University's Subarctic Research Station was engaged in permafrost and periglacial studies in the Knob Lake-Schefferville area.

Joyce C. Macpherson, McGill University, is preparing a Ph. D. thesis entitled "The post-Champlain evolution of the drainage pattern of the Montreal Lowland."

New Brunswick

H. A. Lee, Geological Survey of Canada, studied the Grand Falls morainic system in New Brunswick. During three weeks of field work he traced the system from the town of Grand Falls eastwards towards Chaleur Bay; apparently the system can be followed over a distance of about 150 miles. The length together with other independent evidence of former ice re-advances leads to the conclusion that the Grand Falls morainic system represents a major regional episode in the glacial chronology of eastern North America and is not the frontal debris of a localized ice lobe. M. L. Parsons, Geological Survey, is compiling water-probability maps of southern New Brunswick. R. H. MacNeill reports that an investigation of the possibility of using minerals in tills as a guide to the location of ore deposits is being considered. The New Brunswick Research and Productivity Council will probably undertake general mapping and study of Pleistocene stratigraphy in New Brunswick. The Council also proposed to initiate groundwater studies of some Quaternary deposits in the near future.

Nova Scotia

In 1965 G.D. Kelley, Geological Survey, reported identifying glacial features that indicate the Cobequid Mountains were involved only in regional glaciation and were not the site of a local active ice cap as had been previously suggested (see Flint, R.F., 1951, "Highland centers of former glacial outflow in northeastern North America", Bull. Geol. Soc. Amer., v. 62, p. 21-38).

R.H. MacNeill, Acadia University, reports that during 1965 three parties operated in Cumberland-Colchester, Pictou, and Antigonish counties. To date no evidence has been found of local ice-cap activity in the Antigonish highlands. This work will contribute to the study being carried on by ARDA in the northern part of Nova Scotia. Field checks were continued in the southwestern part of the province and a start made on preparation of preliminary maps and reports on the areas completed. The work was carried out by the Nova Scotia Research Foundation under the direction of R.H. MacNeill. This program is expected to continue until the whole province has been mapped. The Nova Scotia Department of Mines is carrying out three major groundwater studies under the direction of J.F. Jones. They include detailed investigations of some Pleistocene aquifers, groundwater-data processing and the establishment of an observation-well network which will add much to the knowledge of Pleistocene stratigraphy in Nova Scotia; effective liaison has been established between the Nova Scotia Department of Mines and the Nova Scotia Research Foundation. J.F. Jones and T.W. Hennigar are studying the groundwater chemistry of key aquifers in northern Nova Scotia, and P.C. Trescott is investigating the groundwater conditions in parts of Annapolis and Kings counties.

K. Greenidge, St. Francis Xavier University, did work on the Pleistocene deposits of northern Cape Breton in conjunction with a study of the botany of that area; this work will continue in 1966.

D. Swift, Dalhousie University, carried out field studies of raised Pleistocene marine terraces on the north shore of Minas Basin which will continue in 1966. M. Silverman, M.Sc. student at Dalhousie includes a discussion of the Pleistocene stratigraphy of the submarine deposits with a study of the continental shelf and slope off Nova Scotia.

W.F. Take, Nova Scotia Museum, is active in Pleistocene research with respect to ice-front positions.

Prince Edward Island

P.A. Carr, Geological Survey of Canada, is installing a series of piezometers near Charlottetown to study groundwater-flow systems and

determine the relationship between fresh and saline groundwater. The water levels fluctuate with the tides and the piezometers show some seawater intrusion. The seawater encountered in these piezometers originates from the estuary by direct infiltration through the fractures in the bedrock; most is encountered in the first hundred feet of drilling. The base of the freshwater-flow system is estimated to be between 600 and 700 feet; thus the freshwater-flow system varies between 100 and 600 feet below the ground surface. D. L. Delmome, who aided Carr, travelled along the shore to locate groundwater-discharge areas above high tide as well as between low and high tide. He finds that two mussels may be used in the differentiation of fresh water from marine water. The mussels are everywhere localized along bedrock fractures or bedding planes.

Newfoundland

I. M. Stevenson, Geological Survey of Canada, conducted a reconnaissance-geological investigation of the Northwest River map area which comprises about 14,000 square miles of eastern Labrador between North latitude 52° 00' and 54° 00' and West longitude 60° 00' and 62° 00'. He reports that the entire region has been glaciated and extensive deposits of sand, gravel, and clay cover many of the low-lying areas. Raised beaches with elevations in excess of 300 feet occur along the sides of many river valleys and on the slopes of hills throughout the area. The lowlands are characterized by extensive sand plains and muskeg areas that effectively obscure the bedrock. Chatter marks, striae, drumlins, eskers and a variety of other glacial features are prevalent throughout the area.

W. D. Brueckner, Memorial University of Newfoundland, reports completion of three Master's theses each containing a chapter on the physiography, glacial geology and related aspects of certain parts of Newfoundland which are a by-product of bedrock investigations in those areas. F. C. Pollett, Department of Mines, Agriculture and Resources, is making a survey of peat occurrences. J. Lundqvist has published a summary account of the glacial geology of northeastern Newfoundland. Further progress is reported on mapping the geology of the city of St. John's and its surroundings.

General Research

A. MacS. Stalker reports that the Quaternary Palynology, the Radiocarbon, and the Sedimentology Laboratories of the Geological Survey of Canada continue to operate at near-capacity. Several radiocarbon dates greater than 50,000 years have been obtained and the laboratory is now reaching the limit of range of the C14 method. About 10 per cent of the datings were for archaeological purposes.

Three members of the Pleistocene section of the Geological Survey (Hughes, Rutter, and Klassen) are stationed at the Calgary office, and in 1966 they and other personnel were expected to occupy the new Geological Survey of Canada building on the campus of the University of Calgary. D. St. Onge, N. Rutter, R. W. Klassen, and C. M. Lewis joined the Pleistocene Section of the Geological Survey in 1965. J. Le Menestrel of the Scientific and Technical Unit of the French Military Service was associated with the G. S. C. for six months in 1965 to exchange ideas on geomorphological mapping. V. Prest continues preparation of the new Centennial Quaternary Map of Canada and an accompanying text.

Interest in the vertebrate paleontology of the Quaternary is increasing, stimulated in part by the discovery of fossil-rich deposits in the Yukon, the Northwest Territories (Mackenzie District), and the Prairie Provinces. The National Museum, Ottawa, has appointed R. Harrington as zoologist in charge of Quaternary vertebrates.

I. C. Brown reports that the International Hydrologic Decade is off to a good start with about 175 approved projects, of which approximately 100 were under way in 1965.

The Department of Energy, Mines and Resources has concentrated all its water-research units in a new Water Research Branch, under the direction of A. T. Prince, which was formed October 1, 1965. The new branch includes groundwater but not engineering geology. J. A. Gilliland of the new branch is laying the groundwork for computer storing and processing of drilling and observation-well data. In cooperation with M. L. Parsons he also commenced installation of experimental observation wells at Iroquois Falls (Ontario), Carberry and Melita (Manitoba), and Cypress Hills and Moose Mountain (Saskatchewan).

RECOMMENDATIONS

The following recommendations are submitted:

1. That the National Advisory Committee support in writing to the National Research Council the request of the Canadian delegation to the 1965 INQUA Congress that an Associate Committee on Quaternary Research be established under the National Research Council.

2. That the report in preparation by the Ad Hoc Committee on Storage and Retrieval of Geological Data be distributed to all members of the Subcommittee on Quaternary Geology and that J. A. Elson of the subcommittee act as liaison officer between the subcommittee and the ad hoc committee.

3. That the National Advisory Committee support the dissemination of information on the economic and other aspects of Quaternary Geology to be defined and elaborated on by a three-man task force nominated by the subcommittee and consisting of L.A. Bayrock, P.F. Karrow, and A.M. Stalker.

4. That the urban geology of Toronto and Montreal be studied on a continuing basis, preferably by resident personnel.

5. That the mapping of the geology under the Great Lakes be undertaken as well as that of the surrounding land areas.

APPENDIX

List of publications of Quaternary geology and related fields provided by members of the subcommittee

Barton, R.G., Christiansen, E.A., Kupsch, W.O., Mathews, W.H., Gravenor, C.P., and Bayrock, L.A.,	(1965)	Quaternary in Geological history of western Canada: Calgary, Alta. Soc. Petroleum Geologists, Atlas, Ch. 14, pp. 195-200.
Bayrock, L.A.,	(1964a)	Fossil Scaphiopus and Bufo in Alberta: Jour. Paleontology, vol. 38, pp. 1111-1112.
———————	(1964b)	Postglacial uplift of the Edmonton District, Alberta, Canada: XXII Internatl. Geol. Congress, New Delhi, vol. abstracts, p. 229.
———————	(1965)	Incomplete continental glacial record in Alberta: VII Internatl. Congress INQUA, Boulder Colo., General Session, Abstracts, p. 18.
Bayrock, L.A., and Hillerud, J.,	(1965)	New data on Bison bison athabascae Rhoads: Jour. Mammology, vol. 45, No. 4, pp. 630-632.

Broscoe, A.J.,	(1965)	The geomorphology of the Cypress Hills - Milk River Canyon area, Alberta: Alta. Soc. Petroleum Geologists, 15th Ann. Field Conf. Guidebook, pt. 1, Cypress Hills Plateau, pp. 74-84.
Brown, R.J.E.,	(1965a)	Permafrost investigations in Saskatchewan and Manitoba: Natl. Research Council Publ. 8375, p. 36.
————————	(1965b)	Some observations on the influence of climatic and terrain features on permafrost at Normal Wells, N.W.T., Canada: Canadian Jour. Earth Sciences, vol. 2, pp. 15-31.
Brown, W.G.,	(1964)	Difficulties associated with predicting depth of freeze or thaw: Canadian Geotech. Jour., vol. 1, pp. 215-226.
Brueckner, W.D.	(1965)	Note on post-glacial features in Newfoundland, Eastern Canada: VII Internatl. Congress INQUA, Boulder Colo., General Session, Abstracts, p. 49.
Christiansen, E.A.,	(1965a)	Geology and groundwater resources of the Kindersley area (72-N), Saskatchewan: Sask. Research Council, Geol. Div., Rept. 7.
	(1965b)	Ice frontal positions in Saskatchewan: Sask. Research Council, Geol. Div., Map 2.
————————	(1965c)	Preglacial valleys in southern Saskatchewan: Sask. Research Council, Geol. Div., Map 3.

Clayton, L., Laird, W.M., Klassen, R.W., and Kupsch, W.O.,	(1965)	Intersecting minor lineations on Lake Agassiz Plain: Jour. Geol., vol. 73, pp. 652-656.
Craig, B.G.,	(1965a)	Glacial Lake McConnel and the surficial geology of parts of Slave River and Redstone River map-areas, District of Mackenzie: Geol. Surv. Can., Bull. 122, p. 33.
_____	(1965b)	Notes on moraines and radiocarbon dates in northwest Baffin Island, Melville Peninsula, and northeast District of Keewatin: Geol. Surv. Can., Paper 65-20, p. 7.
Craig, B.G., and Fyles, J.G.,	(1965)	Quaternary of Arctic Canada in Markov, G.F. et al. (eds.) Anthropogen period in the Arctic and Subarctic: Trans. U.S.S.R. Research Inst. Geol. Arctic, vol. 143, pp. 5-33 (in Russian).
Crawford, C.B.,	(1964)	Interpretation of the consolidation test: Proc. Soc. Civil Engineers, Jour. Soil Mechanics and Foundations Division, vol. 90, No. SM 5, pp. 87-102.
_____	(1965)	Resistance of soil structure to consolidation: Canadian Geotech. Jour., vol. 2, pp. 90-115.
Crawford, C.B., and Eden, W.J.,	(1965)	A comparison of laboratory results with in-situ properties of Leda Clay: Sixth Internatl. Soil Mechanics Conf. vol. 1.

Crickmay, C.H., (1965) An interpretation of erosional discrepancy, Cypress Hills: Alta. Soc. Petroleum Geologists, 15th Ann. Field Conf. Guidebook, pt. 1, Cypress Hills Plateau, pp. 66-73.

Delorme, D.L., (1965) Pleistocene and post-Pleistocene Ostracoda of Saskatchewan: Saskatoon, Univ. Sask., Ph.D. thesis.

Dreimanis, A., and Karrow, P.F., (1965) Great Lakes - Ohio River Valley: VII Internatl. Congress INQUA, Boulder Colo., Guidebook for Field Conf. G., pp. 90-110.

Dreimanis, A., Terasmae, J., and McKenzie, G.D., (1965) The Port Talbot Interstadial of the Wisconsin glaciation: VII Internatl. Congress INQUA, Boulder Colo., General Session, Abstracts, pp. 108-109.

Dreimanis, A., and Vagners, U.J., (1965) Till-bedrock lithologic relationship: VII Internatl. Congress INQUA, Boulder Colo., General Session, Abstracts, pp. 110-111.

Dreimanis, A., and Vogel, J.C., (1965) Re-evaluation of the length of the Port Talbot Interstadial in the Lake Erie region, Canada: Radiocarbon and Tritium dating Proceed. Sixth Internatl. Carbon-14 and Tritium Dating Conf., Paper 71, pp. 782-791.

Dyck, W., Fyles, J.G., and Blake, W., Jr., (1965) Geological Survey of Canada radiocarbon dates IV: Radiocarbon, vol. 7, pp. 24-46; also, Geol. Surv. Can., Paper 65-4, p. 23.

Fortescue, J.A.C., and Hughes, O.L., (1965) Copper, zinc, nickel, and lead in Lower Till material collected near a massive sulphide orebody in the clay belt of northern Ontario: in Rept. Activities, pt. II, Geol. Surv. Can., Paper 65-2, pp. 23-27.

Fuller, W.A., and Bayrock, L.A., (1965) Lake Pleistocene mammals from Central Alberta, Canada: Edmonton, Univ. Alta., Rept. Conf. held Aug. 29 - Sept. 3, 1963, pp. 53-64.

Fulton, R.J., (1965) Silt deposition in late glacial lakes of southern British Columbia: Am. Jour. Sci., vol. 263, pp. 553-570.

Fyles, J.G., and Blake W., Jr., (1965) Glaciation of the northwestern Canadian Arctic Islands: VII Internatl. Congress INQUA, Boulder Colo., General Session, Abstracts, p. 156.

Geiger, K.W., (1965) Bedrock topography of southwestern Alberta: Research Council Alta., Prelim. Rept. 65-1.

Goldthwait, R.P., Dreimanis A., Forsyth, J.L., Karrow, P.F., and White, G.W., (1965) Pleistocene deposits of the Erie Lobe: in Quaternary of the United States, VII Internatl. Congress INQUA, Boulder Colo., pp. 85-79.

Gorman, W.A., (1965) Paleogeography of the Champlain Sea: VII Internatl. Congress INQUA, Boulder Colo., General Session, Abstracts, p. 173.

Hughes, O.L., (1965) Surficial geology of part of the Cochrane district, Ontario, Canada: Geol. Soc. America, Special Paper 84, pp. 535-565.

Johnston, G.H., (1965) Permafrost studies at the Kelsey Hydro-Electric Generating station - Research and instrumentation: Natl. Research Council Publ. 79-43. Tech. Paper 178.

Johnston, G.H., and Brown, R.J.E., (1965) Stratigraphy of the Mackenzie River Delta, Northwest Territories, Canada: Bull. Geol. Soc. America, vol. 76, pp. 103-112.

Karrow, P.F., (1965) Bedrock topography, series II - Grand Bend, St. Mary's, Parkhill, Lucan, Lucknow-Wingham, Goderich-Seaforth, Durham, Dundalk: Ont. Dept. Mines Prel. Maps pp. 265, 266, 290, 291, 296, 297, 305, 306.

Klassen, R.W., (1965) The surficial geology of the Riding Mountain area (Manitoba - Saskatchewan): Saskatoon, Univ., Sask. Ph.D. thesis.

Kupsch, W.O., (1965) Jointing of boulders caused by flowing ice: Alta. Soc. Petroleum Geologists, 15th Ann. Field Conf. Guidebook, pt. 1, Cypress Hills Plateau, pp. 112-115.

Lee, H.A., (1965a) Investigation of eskers for mineral exploration: Geol. Surv. Can., Paper 65-14, pt. 1, pp. 1-17.

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Lundqvist, J.,	(1965)	Glacial geology in northeastern Newfoundland: Geologiska Föreningens Stockholm, Förhandlingar, vol. 87, pp. 285-306.
MacFarlane, J.C.,	(1965)	The consolidation of peat - a literature review: Natl. Research Council Publ. 8393, Tech. Paper 195.
Mackay, J. Ross,	(1965a)	Gas-domed mounds in permafrost, Kendall Island, N.W.T.: Geographical Bull. vol. 7, pp. 105-115.
_____	(1965b)	Glacier flow and analogue simulation: Geographical Bull. vol. 7, pp. 1-6.
Mackay, D.K., and Mackay, J. Ross,	(1965)	Historical records of freeze-up and break-up on the Churchill and Hayes Rivers: Geographical Bull., vol. 7, pp. 7-16.
Meneley, W.A.,	(1965)	The requirements of groundwater geology: Groundwater, vol. 3, pp. 2-3.
Packer, R.W.,	(1965)	Lag mound features on a dolostone pavement: Canadian Geographer, vol. 9, pp. 138-143.
Penner, E.	(1964)	Studies of sensitivity and electro-kinetic potential in Leda clay: Nature, vol. 204, No. 4960, Nov. 21, pp. 808-809.
_____	(1965)	A study of sensitivity in Leda Clay: Canadian Jour. Earth Sciences, vol. 2, p. 425.
Paterson, R.L.,	(1965)	A well-preserved grizzly bear skull recovered from a late glacial deposit near Lake Simcoe, Ontario: Nature, vol. 208, No. 5016, pp. 1233-1234.

Pinder G. E.,	(1965)	The study of a composite Pleistocene delta at Komoka, Ontario: Geol. Soc. America, 34th Ann. Meeting New York (abstract).
Rutter, N. W.,	(1965a)	Glacial geology of the Bow River valley, eastern Canadian Rocky Mountains: Edmonton, Univ. Alta., Ph. D. thesis.
Rutter, N. W.,	(1965b)	A late Pleistocene (?) glacial advance, Bow River valley, Canadian Rocky Mountains, Alberta, Canada: VII Internatl. Congress INQUA, Boulder Colo., General Session, Abstracts, p. 405.
Soderman, L. G., and Quigley, R. M.,	(1965)	Geotechnical properties of three Ontario clays: Canadian Geotechnical Jour., vol. 2, pp. 176-189.
Stalker, A. MacS.,	(1965a)	Pleistocene ice surface, Cypress Hills area: Alta. Soc. Petroleum Geologists, 15th Ann. Field Conf., Guidebook, pt. 1, pp. 116-130.
————————	(1965b)	Surficial geology, Bassano (Gleichen, East Half), Alberta: Geol. Surv. Can., Map 5-1965.
St. Onge, D.,	(1965)	Notes on the geomorphological maps of Ellef Ringnes Island, N. W. T.: Instituto Panamericano de Geografia e Historia, Reunion des Cartas Especiales, Ottawa, Ontario, pp. 97-112.
Terasmae, J.,	(1965a)	A review of palynological studies in eastern maritime Canada: Maritime Sediments, vol. 1, No. 2, pp. 19-21.

Terasmae, J., (1965b) Surficial geology of the Cornwall and St. Lawrence Seaway project areas, Ontario: Geol. Surv. Can., Bull. 121, p. 54.

Watt. A.K., (Ed.), (1965) Groundwater in Ontario, 1957: Ontario Water Resources Commission, Groundwater Bull. 3, p. 209.

Westgate, J.A., (1965a) Surficial geology of the Cypress Hills area, Alberta: Research Council Alta. Prelim. Rept. 65-2.

_____ (1965b) The Pleistocene stratigraphy of the Foremost - Cypress Hills area: Alta. Soc. Petroleum Geologists, 15th Ann. Field Conf. Guidebook, pt. 1, Cypress Hills Plateau, pp. 85-111.

REPORT OF THE SUBCOMMITTEE ON SCHOLARSHIP AND RESEARCH TRAINING

Presented by L.G. Berry

Members of the Subcommittee

L.G. Berry (Chairman)	Queen's University, Kingston, Ontario.
A.J. Frueh, Jr.	McGill University, Montreal, Quebec.
J.E. Gill	McGill University, Montreal, Quebec.
P.F. Karrow	University of Waterloo, Waterloo, Ontario.
W.H. Mathews	University of British Columbia, Vancouver, British Columbia.
A.L. McAllister	University of New Brunswick, Fredericton, New Brunswick.
V.S. Papezik	Memorial University of Newfoundland, St. John's, Newfoundland.
H.S. Perdue	Brandon College, Brandon, Manitoba.
Robert Sabourin	Université Laval, Quebec, Quebec.
P.E. Schenk	Dalhousie University, Halifax, Nova Scotia.
H.D.B. Wilson	University of Manitoba, Winnipeg, Manitoba.
J.T. Wilson	University of Toronto, Toronto, Ontario.

In a memorandum to all university departments of the earth sciences in Canada the proposal that the subcommittee prepare a Canadian version of the AGI booklet on careers or opportunities in geology was presented for discussion. A request was made for assistance in the planning and writing of the booklet. It was suggested that registration of students in geology might be on the upswing and we might soon again be in the position of having too many students for the jobs available. It was pointed out that the booklet should be planned to attract some of the brighter students into geology.

Replies received from subcommittee members, while only representing twelve institutions in Canada, were almost unanimous in wishing to have a Canadian booklet similar to the AGI booklet. Only one respondent thought that the AGI booklet was adequate and would be difficult to improve upon. This member also commented that the booklet should emphasize the "interesting and challenging aspects of the science" rather than just the availability of opportunities. Another correspondent suggested that the laboratory aspect of geological sciences should receive about as much attention as the field work. Several replies offered assistance in the preparation of parts of the booklet.

In the matter of student registration in geological sciences the replies ranged from "no increase" to "about 300 per cent." However, presenting the figures in terms of a percentage is misleading because they are usually small. On the average most schools represented here recorded small numerical increases.

One reply noted that the bulletin of the Alberta Association of Petroleum Geologists for December 1965 states that "there is a moderate shortage of geological graduates for employment" but "the number of geophysics graduates available is not more than 10% of the number of job opportunities". The demand for geologists is said to be increasing at the rate of 6% per year. To meet the shortage of geophysicists, industry is recruiting physicists and engineers at a rate which has quadrupled in the past five years. Professor J. T. Wilson concludes that "what industry wants today is neither straight physicists nor old-style geologists, but men trained in both geology and geophysics.... Does this not suggest a need to change the emphasis in our teaching?"

The opinion was expressed by Henry Schwarcz, McMaster University, that geology teaching should be more widespread in Ontario high schools. G. V. Middleton, McMaster University, suggests that some thought should be given to summer schools for high-school science teachers. He also suggests that this subcommittee should include some high-school teachers. Some data on the current situation in Ontario will be sought from the authorities. The Extension Department at Queen's University has had no requests for courses in earth science similar to those being organized in mathematics, physics and chemistry.

The problem of funds for support of promising students of second-class standing was raised again in the memorandum. Only one university reported that it lacked sufficient funds for the support of all promising graduate students. One recommended that entrance scholarships or bursaries in geology would be of value.

Professor Brueckner feels there should be more funds to support graduate students, especially in their first year of graduate work, since many have not reached the stage where they can effectively work as teaching or research assistants or are too occupied with first-year graduate courses to give proper attention to these jobs. He seeks the opinion of others on this problem. Perhaps the poor quality of assistance by first-year postgraduates is balanced by their improved work of later years.

The problem of postdoctorate fellowships was again raised. Several agreed that we require more such fellowships. Others noted that we would know soon how the new NRC scheme would affect us and the subject should be discussed at the annual meeting.

REPORT OF THE SUBCOMMITTEE ON STRATIGRAPHY, PALAEONTOLOGY AND FOSSIL FUELS

Presented by C.R. Stelck

Members of the Subcommittee

C.R. Stelck (Chairman)	University of Alberta, Edmonton, Alberta.
H.R. Belyea	Geological Survey of Canada, Calgary, Alberta.
W.G.E. Caldwell	University of Saskatchewan, Saskatoon, Saskatchewan.
S.S. Cosburn	Department of Mines and Petroleum Resources, Victoria, British Columbia.
L. Ferguson	Mount Allison University, Sackville, New Brunswick.
H. Greiner	University of New Brunswick, Fredericton, New Brunswick.
R.D. Hughes	Memorial University of Newfoundland, St. John's, Newfoundland.
E. Leith	University of Manitoba, Winnipeg, Manitoba.
E. Mountjoy	McGill University, Montreal, Quebec.
J.W. Murray	University of British Columbia, Vancouver, British Columbia.
S.J. Nelson	University of Calgary, Calgary, Alberta.
F.K. North	Carleton University, Ottawa, Ontario.

L.S. Russell — Royal Ontario Museum, Toronto, Ontario.

J.C. Sproule — J.C. Sproule and Associates Ltd., Calgary, Alberta.

M.W. Steeves — University of Saskatchewan, Saskatoon, Saskatchewan.

CURRENT RESEARCH

About 250 projects within the fields of stratigraphy, palaeontology and fossil fuels are listed in the Survey of Current Geological Research in Canada for 1964-65. This is not much different from the number of projects reported over the past two years and suggests that a plateau is being approached as the size of geological departments, research councils and geological surveys becomes stabilized. The unreported research of oil companies and mining companies may be assumed to include a proportionate number of projects; in the last few years the size of oil-company geological staffs has not varied greatly. The only real increase in stratigraphic-sedimentation studies has been due to the interest by mining companies in ore deposits such as the Pine Point (N.W.T.) lead and zinc deposits, Snake River (Yukon) iron-ore deposits and the potash developments in Saskatchewan; and the Gaspé mineral deposits are restimulating interest in the stratigraphy of that part of the Appalachian area.

The Geological Survey of Canada is once again moving into first place among the groups conducting comprehensive research in stratigraphy and palaeontology. In the 1940's the fingers of one hand would include all the palaeontologists of the Geological Survey. Today, in contrast, the staff includes one or more palaeontologists for each geological period, and a Precambrian geologist is being sought. The moving of the stratigraphic staff to the Calgary branch of the Survey is to be commended; it will provide excellent liaison with the oil-company geologists in studies of the western sedimentary basin.

Oil-company projects on the Atlantic Shelf and off-coast exploration of the Pacific margin and Mackenzie Delta basin are the three most important developments of the past year when integrated with the present work and potential of the Bedford Institute of Oceanography. Preliminary papers (mainly oral presentations) by Bedford Institute personnel and oil company personnel involved in these programs outline a threshold of discovery in the fields of micropalaeontology (mainly foraminiferal), basinal and continental shelf concepts and continental margin studies. The ability to drill in deep water with modern drilling barges and platforms allows the stratigrapher to

calibrate the geophysical pictures already obtained within a proper historical and geological framework. The continental shelves of the world are too important to have been left in the hands of theorists so long. Drilling on the Grand Banks area should provide data that will allow comparisons of the stratigraphic sections there with those in producing oil basins of the continent.

The discovery of the Rainbow Lake oil field and other patch-reef extensions in the northwest corner of Alberta is renewing interest in the relationships of reefs to evaporitic sequences and has restimulated investigations of the Middle Devonian reefal margins of the Elk Point salt-basin from Alberta to Manitoba.

DATA PROCESSING

It has been demonstrated that data-processing machines can handle many stratigraphic problems of correlation. They have been used successfully in print-out operations involving isopach and contouring studies. But, as with all labour-saving devices, the demand for raw material increases, and after the first fine demonstration working with a twenty-year backlog of data, the problem becomes no longer how to program, but how to gather enough data fast enough to keep the machine fed and to find a sufficient number of experts that can think up the questions to ask it. It takes no more personnel to interpret or use the data that comes from the machine. The chief benefit of data machines in stratigraphy, is that it permits solutions to problems involving tedious methods.

However, the primary observations must still be made by geologists. And because the primary observations have to be made by geologists, the demand for broadly trained men will continue to rise. Otherwise, the time of the experts in narrower fields will not be used to full capacity. The present big demand for well-site men reflects the need for gatherers of basic information.

NEW DEVELOPMENTS AND SUGGESTED PROJECTS

Western Canada

Cordilleran Region

The meeting of the Geology Division of Royal Society in Vancouver June, 1965 moved that the Division prepare a special volume with coloured maps on Cordilleran Tectonics. From a stratigrapher's viewpoint this should be an excellent preliminary to the analysis of the complex palaeogeography of the Cordilleran region. The plotting of the various islands of

the so-called Cordilleran geosyncline has been casually handled to date but would make an excellent project for several Ph. D. theses.

An excellent start has been made on this at University of British Columbia. J. W. Murray reports: "The .... project is concerned with the stratigraphy and carbonate petrology of middle and upper Palaeozoic limestones and dolomites. Dr. Danner and his students are unravelling the Devonian to Permian stratigraphy and depositional environments of the Cache Creek area, the Chilliwack area and the San Juan Islands. A picture of volcanic island archipelagos with adjacent carbonate shelves has been emerging. The faunas are largely of Asiatic affinities."

S. S. Cosburn points out that much of the geology of the west coast should be worked out with special attention to possible petroleum accumulations. Shell Oil is committed to this and is accumulating data that will influence development, if economic, and will stimulate research in the non-economic portions, with the customary delay in publication while the data and their economic aspects are evaluated. But, as the Atlas of the Geological History of Western Canada has demonstrated, such valuable information accumulated by industry is not lost; eventually it will be published.

F. Moretti suggests that more work should be done on the environments of ancient clastic deposition with accompanying lithogenetic studies. This is an important subject for research in connection with Western Cordilleran studies, especially if the archipelago concept makes an intense diversity of ecologies possible within relatively short distances.

The recognition and evaluation of the magnitude of major stratigraphic hiati should be developed as a means of dating important regional orogenic disturbances. This involves the development of an integrated biostratigraphic time scale to calibrate and be calibrated by geochemical geochronology. The development of palynology to its present state makes this possible today, although the Research Council of Alberta which attempted similar studies fifteen years ago encountered difficulties as the facies changed from marine to continental - a familiar phenomenon at time of orogeny. S. Srivastava's thesis (M. Sc., University of Alberta) ties the Cretaceous mammals with the palynology, the dinosaur zone, and the age datings carried out within the Lance by R. E. Folinsbee, et al. Similar work by L. Hills (Ph. D. thesis, University of Alberta) within the Cordilleran terrane ties Tertiary mammals with palynology and geochemical age-dating.

H. R. Belyea suggests, as a prime need, the study of the late Precambrian sedimentary rocks of the Cordillera. This succession, which exceeds 20,000 feet in thickness, is virtually unknown north of the Athabasca River.

"One of the fundamental problems of southern Cordilleran stratigraphy is the facies change in the Middle and Upper Cambrian. Along the

continental divide eight formations are recognized between the top of the Lower Cambrian Gog group and the base of the Dresbuchian Lyell Formation, and carbonate rocks dominate the succession. A short distance to the west a crude threefold division has been made of the equivalent shale-dominated succession. There is a great need here for studies in the areas of biostratigraphy, lithostratigraphy, sedimentology and sedimentary tectonics."

In connection with this, R.V. Best and students at University of British Columbia are attempting to resolve Lower Cambrian transcontinental correlations on the basis of Olenellid studies.

J.W. Murray has brought to us a sharp reminder that the so-called Cordilleran region includes also the west coast. "One project at University of British Columbia is concerned with the Quaternary history of southwestern British Columbia. This work .... involves a study of the Recent marine and Pleistocene sediments of the area. More specifically we are studying the oceanography and bottom sediments in Howe Sound (an open marine inlet), using bottom samplers, piston cores, bottom photography and a sparker survey. Another project involves measuring the thicknesses of Quaternary sediments and pre-Quaternary structure in Georgia strait by means of the same sparker equipment. Lastly we have been conducting a limited amount of work on the tidal flats around the Fraser Delta. The most noteworthy feature is the presence of well developed blue-green algal mats on the supratidal flats which appear to be annual and preserve at depth in the sediment ...."

Murray suggests that "one very important need is to obtain a better understanding of the modern ecology of invertebrate faunas .... What is needed is palaeoecological research on modern invertebrate faunas such as corals, brachiopods, bryozoa, sponges, etc. All these live in abundance here on the west coast yet we know next to nothing about their ecology. How can one possibly interpret the palaeoecology of Palaeozoic brachiopods when we know next to nothing of the ecology of modern brachiopods?"

The Rocky Mountain Cordillera has always produced projects that are closely associated with the Plains (and oil) studies. Caldwell reports students D. Jordon and N. Fischbuch are studying the basal Devonian beds at Kakwa Lake while the equivalents (?) are studied under the Alberta Plains. Student A.K. Petryk is studying Mississippian Foraminifera of the Southern Rockies and student M. Brooke is contrasting the Jurassic microfossils of the Williston basin with those of the Little Rocky Mountains of Montana.

The Plains Region

S.S. Cosburn reports that D.L. Griffen is doing research in northeastern British Columbia on the prolific gas reservoirs of the Middle

Devonian and their stratigraphy. There is no shortage of problems clamoring for attention in this region, but the most important and urgent at time of reporting are: a study of the stratigraphy of the Permian rocks and Stoddart group; a study of the Bullhead (L. Cretaceous) gas trends; the bedrock topography needs detailing; and there is need to study dolomitization within the carbonate rocks.

Studies of the Middle Devonian and earlier beds are being stimulated by the International Devonian symposium to be held in 1967 in Western Canada and by the Lower Palaeozoic symposium being held in Edmonton in 1966. These, coupled with the Banff seminar in the spring of 1966 on super saline rocks (Evaporites and Related Rocks Symposium) will stimulate interchange of recent information and techniques and definition of unexplored fields.

In connection with supersaline studies, Holter, on leave from the Saskatchewan Department of Mineral Resources, is preparing while at the University of Saskatchewan a regional stratigraphic account of the potash zones of the Prairie Evaporite Formation. H. MacIntosh is dealing with small-scale primary and secondary structures in ten "salt horses" in the Esterhazy and Patience Lake potash deposits. M. Hogue is studying the stratigraphy and structure of the gypsum outlier at Gypsumville, Manitoba. W.G.E. Caldwell has submitted a list of 25 publications and thesis titles on the evaporites of Saskatchewan from the University of Saskatchewan alone in the past three years.

Belyea would like to see criteria set up whereby diagenetic dolomites could be distinguished from "hypogene" dolomites using the Cambrian of the southern Rockies as a laboratory.

Murray suggests more research on planktonic Palaeozoic microfossils such as calpionellids. Except for conodonts (which may be planktonic at some stage) the extensive planktonic forms in the mid-Palaeozoic are not sufficiently konwn for long-range correlations.

The new wells in Rainbow Lake area and the open pits to be developed in the Pine Point area offer an excellent opportunity to study the faunas, flora and ecology of the Watt Mountain Formation which is contiguous to both ores and oil. The open pits should allow a study of the marginal reef structures of the Presquile Formation.

Belyea stresses the need for zonal and palaeontological studies at the Ph.D. level on small areas or on details of petrography or palaeontology. Such detailed studies give the factual data on which to build the wide network of correlation and integration necessary for palaeogeographic studies. She offers the following short unified theses projects: study of carbonate banks in the Ordovician-Silurian subsurface of southeastern Saskatchewan and

Manitoba; study of Middle Devonian Keg River Reefs similar to that done by Klovan for the Upper Devonian Redwater Reef; studies of flora and fauna of the Ashern Formation; extension of the Grizzley, Assineau and Gilwood and Granite wash studies to extend the work done by M. Suska; faunal zonation of the Besa River shale to augment E. Pelzer's lithologic studies; microfloral and microfaunal studies of the Fort Simpson, Hay River, Duvernay, Ireton Formations; microfloral studies in the Beaverhill Lake equivalent to reach from the Mountains to Saskatchewan to determine the nature of the thinning; similar microfloral studies for Beaverhill equivalents from Alberta into the black-shale equivalents in the Northwest Territories; documentation of the Frasnian-Fammenian boundary along the western side of Alberta; a study of algal bioherms in the Palliser Formation; microfloral and microfaunal correlations of the Williston Basin to Alberta sections of the Mississippian.

Caldwell suggests the following studies of the Cretaceous in Saskatchewan: sampling of the Cretaceous sections above the Bearpaw in the Cypress Hills area; searching for the Cannonball equivalents in the Ravenscrag Formation; development of Steeve's Cypress Hills palynological studies of the Whitemud Formation in Saskatchewan which should complement S. Srivastava's studies on the Alberta side; integration of the micropalaeontology and mineralogical studies of the Upper Cretaceous strata.

Caldwell as spokesman for the members of the Department of Geology, University of Saskatchewan, urges that all shafts for potash mining in Saskatchewan be sampled to test the Cretaceous and Devonian zonations. In outcrop-short Saskatchewan these shafts form the most critical and freshest outcrops. This Subcommittee endorses Caldwell's plea that the Geological Survey of Canada continue its program of sampling of each shaft.

E. Leith, reporting from Manitoba, lists the following active projects in the field of stratigraphy: B. Bannatyne is studying the clays and shales of the Manitoba Cretaceous as a follow-up to his 1963 report on the Cretaceous bentonite deposits; Bannatyne and H. McCabe are compiling a stratigraphy-map series of all Manitoba formations; H. Young is studying the Virden member of the Mississippian in Manitoba (stratigraphy and petrology); Leith and P. Zakus are studying the Whitewater member of the Mississippian; W. Douglas is working on the sedimentary petrography of the Silurian and Ordovician of the Hudson Bay Lowland. A study of the Silurian should be initiated to match S. J. Nelson's study of the Ordovician of the Hudson Bay Lowland (G. S. A. Memoir and G. S. C. publications).

The recent appointment of R. Fox to the chair of vertebrate palaeontology at University of Alberta is a direct outcome of sustaining grants made by the National Research Council over the past three years. An additional vertebrate palaeontologist on the Western Plains fills an academic need that is not taken care of by industry.

As regards fossil fuels on the Plains, it is assumed that the oil companies will carry out research in hydrocarbons. The new railroad along the west side of Alberta up to the Smoky River is already stimulating industry to take a new look at the coal-bearing formations of that region.

The economic returns from the opening of the "tar sands" plant by Great Canadian Oils (and Sun) will determine to a large degree the amount of research on these strata over the next decade.

Ontario and Quebec

E. Mountjoy reports on the research under way and proposed in Eastern Canada; he suggests that the subcommittee for next year should include a member from the Quebec Department of Natural Resources. This department's publications have been a most important source of primary information for the stratigrapher over the past decade or more, and without doubt these contributions will increase in amount and value in the future.

Sedimentation - Stratigraphy

J. Lajoie, University of Montreal, is currently investigating the relationship between crossbedding and direction of transport of terrigenous sediments using a theoretical approach with flume experiments and applying this to a palaeogeographic study of the Silurian of a portion of the Quebec Appalachians.

Recent studies on the Cambro-Ordovician Quebec Group sequence contribute towards our understanding of this complex series of sediments. In the L'islet-Kamouraska area Hubert (Ph. D. thesis, McGill, 1965) has demonstrated that these sediments were derived from an area of sedimentary rocks to the northwest and a Precambrian landmass to the southeast (abstract in Maritime Sediments, vol. 1, no. 4, p. 13).

P. St. Julien, Quebec Department of Natural Resources, has been studying the region southeast of Quebec City (northeastern Eastern Townships). He has established the stratigraphic sequence of rocks of Normanskill age and demonstrated that they lie unconformably on rocks of pre-Taconic age and are overlain unconformably by Siluro-Devonian rocks.

In the St. Lawrence Lowlands detailed sedimentation studies have been made. Lewis (Ph. D. thesis McGill, 1965) has outlined the petrography of the Potsdam Group in considerable detail. A master's student is currently examining the petrography and sedimentary structures of the Lorraine-Richmond sequence. Geological Reports 100, 101, and 102 of the Quebec Department of Natural Resources by T. H. Clark have recently been published

and record some of the important field relationships and drilling information for a central portion of the Lowlands. Pitchard (1964) recently completed a study of Chazy reefs in Quebec and adjoining New York and Vermont.

In the Gaspé-Temiscouata region B. Skidmore, Quebec Department of Natural Resources, reports that the lower part of the Matapedia Group contains Lower Silurian strata. It is clear also that in this region most lithological units are strongly time-transgressive and that the tectonic history varies rapidly as one proceeds from place to place. P. Enos has recently (1964) completed a sedimentation study at Yale University entitled "Anatomy of flysch: Cloridonne Formation (Middle Ordovician) northern Gaspé Peninsula, Quebec".

Projects under way or to begin in the summer of 1966 include: (1) pilot project on the Cambro-Ordovician rocks by Beland and Lajoie, University of Montreal, to arrive at a clearer picture of the palaeogeography which will combine detailed structural analyses, sedimentation, geochemistry and possibly geophysics and also be concerned with solving the complex structure of the region; (2) the compilation by P. St. Julien, Quebec Department of Natural Resources, of a tectonic-stratigraphic map of the Eastern Townships; and (3) continued stratigraphic and sedimentological study of the Cambro-Ordovician Quebec Group east of Quebec City by C. Hubert.

Worthwhile projects that have been suggested include: study of palaeocurrents in the Normanskill rocks of the Beauceville-Magog area which together with knowledge of source areas will help to elucidate the role of the Taconic orogeny in the Quebec Appalachians; study of palaeogeography of the Devonian in Quebec Appalachians similar to the work of Williams and Dineley at Miguasha; sedimentational and sedimentary structural studies of the Cape Bon Ami and Fortin Formations; and tracing of the Silurian-Devonian boundary throughout the Gaspé region.

Stratigraphy and Structure

Complex structure, metamorphism and poor exposures combine to make the unravelling of the geological history of the Quebec Appalachians a difficult task. It is necessary to consider both the problems of structure and stratigraphy together for progress in either field. However, by detailed studies considerable progress has been made in parts of this region.

Two recent studies by Rickard (1965) and Osberg (1965, Geol. Soc. America, vol. 76, p. 223) have contributed substantially to our understanding of the tectonic history of Sutton Mountain. Near Thetford Mines, P. St. Julien has sorted out the southeastern flank of the Sutton anticlinorium and demonstrated that it is a refolded recumbent structure. Further northeast, south and east of Quebec City, considerable progress has been made in

unravelling the complex geology by St. Julien and Hubert, Quebec Department of Natural Resources, and J. Beland, University of Montreal. Parts of this work, which completely changes the former conception of the stratigraphy and structure of the region, has not yet been published. Hubert has shown reasonably satisfactorily that the Cambro-Ordovician sequence of the L'Islet-Kamouraska area has been repeated by two to three major thrust faults. It appears likely that thrust structures are extensive and will probably be found elsewhere in the Cambro-Ordovician sequence of central Quebec.

Much remains to be done, especially in connection with basic mapping and establishing the stratigraphic sequences and lateral variations. In order to make significant progress it is necessary to map on a more detailed scale than one mile to an inch and to follow the belts of similar rocks laterally rather than restricting mapping to set areas bounded by lines of longitude and latitude. Basic mapping and unravelling of the stratigraphy and structure is reaching the stage where reconstruction of the palaeogeography and tectonic history of parts of the Quebec Appalachians is possible. More detailed sedimentological studies of depositional environments, direction of sediment transport and source areas appear feasible.

Excellent work in Precambrian stratigraphy is being done by E. Dimroth, Quebec Department of Natural Resources, and W. F. Fahrig, Geological Survey of Canada, in unravelling the stratigraphy and structure of the Labrador Trough. Another basic contribution is the work of Donaldson and Jackson on Archaean sedimentary rocks of North Spirit Lake area, Northwestern Ontario, indicating that they are rich in quartz (Can. Jour. Earth Sciences, vol. 2, 1965, pp. 622-647).

F. K. North looks forward to the new infusion of young stratigraphers in the colleges of eastern Canada resulting in a revitalized attack on the Palaeozoics of the Ottawa-St. Lawrence Lowland and the Ontario peninsula. The new infusion in western Canada came a few years earlier through the discovery of oil and has been a little slower in reaching the "hard-rock" areas of eastern Canada. His group would like to see an up-to-date scrutiny of the Bonaventure and Queenston Formations of uncertain stratigraphic position. As a group on the margin of the "hard rocks" North would like to see modern stratigraphic and sedimentologic techniques applied to selected areas of the Precambrian terrane (e.g. Schenk's work on the Huronian; Moore's work on the Grenville).

Palaeontology

Y. Globensky, Quebec Department of Natural Resources, is studying the conodont and scolecodont faunas of the St. Lawrence Lowlands. Berry (M. Sc. student, McGill) is studying the variation in a Stromatocerium

biostrome in the Ordovician Leray Formation, northeast of Montreal. J. Riva is continuing his research on Ordovician graptolites and on material from an Anticosti Island core.

Petroleum Geology

The deep tests on Anticosti Island were recently abandoned. In Gaspé Skidmore suggests that testing of the reef carbonates near the base of the Silurian should be undertaken because they may well be petroliferous.

Maritimes Region

Activity in the Maritimes in the field of stratigraphy and palaeontology has increased. At Acadia University studies are in progress on the Windsor Group exposed on the Meander and Avon rivers. A student is studying Echinoderm remains from the Windsor Group, in the same formation where others are studying variations in corals in relation to environment. Moore is studying the various limestone units in the Windsor.

At Dalhousie further work is being carried out within the Windsor Group with respect to fauna-floral relationships and ecology of the late Mississippian carbonates, using geochemical and geophysical methods as well as the more classical approaches. Schenk is also carrying out the first detailed sedimentological study of the main rock mass of Nova Scotia and is recovering microfauna from the Meguma Group. Palaeocurrent studies indicate a northeast-flowing current.

Holocene studies in the Bay of Fundy indicate that future projects will have to be orientated toward water-based coring and acoustic profiling.

The Mines Branch of New Brunswick is carrying out stratigraphic studies on the Mascarene Group and the Central Carboniferous basin with a view to their petroleum possibilities.

The Nova Scotia Department of Mines is attempting to subdivide the Precambrian George River Group into finer stratigraphic entities; this endeavour may be of value in prospecting for mineral deposits.

The University of New Brunswick has just completed a mapping project in the Charlo area and would like to see radioactive dating carried out to determine the relationships between flows and source plutons. Varma, a postdoctoral fellow, is working out the Carboniferous palynology of Central New Brunswick which suggests that a parallel study of the macroflora should be initiated.

Greiner is interested in the transcontinental aspects of the late Devonian Cyrtospiriferids of the Cordillera and Appalachians. Greiner also suggests further investigations in the fields of the Maritimes' Cambrian faunas, and on the fossil fish of the area.

Hughes, reporting from Newfoundland, sees significant advances this past year in stratigraphic studies. The recognition of the importance to stratigraphy of hystrichospheres and acritarchs with their restricted ranges, should allow palaeontological zoning and intercontinental correlation with Europe. He suggests a definite search for acritarchs in the Cambrian to Pennsylvanian rocks of Western Newfoundland. The micropalaeontological links with the Bell Island section (under A. C. Nautiyal) would make a good starting point.

C. C. Fong is studying the Archeocyathids and feels that the "root" systems are environmentally controlled and therefore should not be used for taxonomic criteria. He proposed to spend the summer of 1966 checking the palaeoecology of the Lower Cambrian of Newfoundland to back up this thesis. R. K. Stevens has completed the first reasonable and acceptable composite stratigraphic section of the Cambro-Ordovician beds of the Humber arm series, a facies intermediate between the western shelf and eastern geosynclinal facies. J. Utting and E. Belt have discovered the first Mississippian amphibian track-ways discovered in Newfoundland in the Codroy Valley, west Newfoundland, where Utting was completing a study of the fossil spores. W. D. Brueckner is studying the Precambrian rocks of the Avalon Peninsula. H. D. Lilly is carrying on submarine studies of recent and bed-rock beds of the Grand Banks area. Future work will include sediments of the Port-au-Port Bay.

An excellent journal called Maritime Sediments is keeping scientists aware of studies of modern and ancient sediments in the Atlantic Provinces and adjacent areas. The purpose of the journal is to outline current research projects, publish abstracts, progress reports on research and papers of interest, encourage discussion, give notice of meetings and field trips and personal news concerning people, new laboratories and equipment, etc. It is filling a useful role.

Arctic Region

F. K. North feels that a monographic treatment should be accorded to such a potentially classic fauna as the Arctic Permian, lying midway between classic Russian and American localities.

L. Hills feels that a detailed study of the Mesozoic and Tertiary microfloral-microfaunal assemblages should be made to unravel the later diastrophic history of the Arctic Islands by indicating possible breaks in the section (e. g. Eureka Sound Formation).

Rouse suggests a concerted effort to increase palynological studies in the Yukon and the Arctic Islands. A deep well on the delta of the Mackenzie river has been examined palynologically by the companies concerned and the data recovered endorse the economic worth of such studies. There should be an increase in this type of work.

Murray suggests more emphasis on the reconstruction of ancient depositional environments. What is needed, he says, are detailed studies upon specific rock suites. Similar projects could be initiated on the Ordovician-Silurian graptolite facies in the Richardson Mountains, now that Lenz and Jackson have outlined some of the biostratigraphy. E. Davies, University of Alberta, is bridging the gap in graptolitic studies between the Territories and the Glenogle Shale area by his studies of Cloudmaker (N. E. B. C.) Mountain collections.

Caldwell reports continuing studies of the corals and brachiopods of the Middle Devonian of the Mackenzie Valley and reports that Braun is building up his ostracod collection from the Middle and Upper Devonian of the Northwest Territories. These two men are proposing to re-visit the Northwest Territories and will attempt to fill gaps in collections for biostratigraphic studies.

RECOMMENDATIONS

"Sedimentation" should be included in the name of the subcommittee.

Geological Survey of Canada reports should be edited faster than at present, especially reports such as Bulletin 125 which seems to have little in its make-up to have held up its publication.

The Geological Survey of Canada should continue its practice of sampling the salt shafts in Saskatchewan; no cheaper method of collecting valuable information can ever be found than stationing a man at a shaft while the outcrop is prepared for him.

Future volumes of the G. S. C. Economic Geology Series reports on petroleum in Canada should be broken into a series of reports outlining the petroleum pools and resources of a number of areas. The chapters of G. S. Hume's old edition of this report did this in effect. These reports could then be each brought up to date as need arose. In the report on Western Canada the petroleum pools could be broken down by age and district.

REPORT OF THE SUBCOMMITTEE ON STRUCTURAL GEOLOGY

Presented by James T. Fyles

Members of the Subcommittee

James T. Fyles (Chairman)	Department of Mines and Petroleum Resources, Victoria, British Columbia.
Alex Baer	Geological Survey of Canada, Ottawa, Ontario.
R.L. Brown	University of New Brunswick, Fredericton, New Brunswick.
H.A.K. Charlesworth	University of Alberta, Edmonton, Alberta.
V.A. Haw	Mines Branch, Department of Energy, Mines and Resources, Ottawa, Ontario.
Pierre St. Julien	Quebec Department of Natural Resources, Quebec, Quebec.
W.H. Poole	Geological Survey of Canada, Ottawa, Ontario.
R.A. Price	Geological Survey of Canada, Ottawa, Ontario.
J.V. Ross	University of British Columbia, Vancouver, British Columbia.
J.O. Wheeler	Geological Survey of Canada, Vancouver, British Columbia.
H.R. Wynne-Edwards	Queen's University, Kingston, Ontario.

INTRODUCTION

A review of studies in structural geology based on information accumulated by the subcommittee suggests the following generalizations:

(a) About the same number of structural studies are being made this year as last year.

(b) There is a greater emphasis on structure than there was a few years ago.

(c) Integrated studies aimed at determining the tectonic history of a region are continuing.

(d) Most universities with geological departments have professors of structural geology who are actively engaged in structural research.

These generalizations indicate progress and a continuation of the trends outlined in last year's report. It is a particularly hopeful sign that at the universities there are now many competent men whose specialty is structural geology.

SUMMARY OF STRUCTURAL STUDIES

Structural studies made in Canada may be considered in the following categories:

(a) Field studies, regional and detailed.

(b) Integrated studies involving other branches of the geological sciences, mainly geophysics.

(c) Theoretical and experimental studies.

Field Studies

Studies of regional geology in which the understanding of the structure is more or less incidental to geological mapping are being continued mainly by government agencies. The importance of these studies in understanding regional structure, in determining tectonic history, and in outlining areas for more intensive work was emphasized in last year's report (Fifteenth

Annual Report, 1964-65, Part 1, page 60). Attention is drawn to several recent reconnaissance projects of the Geological Survey of Canada. Of particular interest is work in the Cordillera. The Coast Mountains project and several projects in the Rocky Mountains are providing basic data on the structure of these ranges. Of somewhat less structural significance are the geological-reconnaissance projects of the Survey in the Arctic and Labrador. Many projects of the provincial departments of mines in Quebec, Ontario, Manitoba, Saskatchewan and British Columbia also are of regional structural significance.

Detailed field studies are continuing at an increased rate. They are of two general sorts: one aimed at determining the structure and structural history of an area, and the other aimed at determining some structural principle or developing a new technique. Between 25 and 35 detailed structural field studies were made in 1965 and more than half of these were studies of folding and related faulting. Many were integrated with stratigraphy, some with igneous and metamorphic petrology, a few with joint studies, and a few with studies of metallic mineral deposits. Subcommittee members offer two notes of caution regarding detailed structural analyses. One member stresses the importance of taking into account the regional stratigraphy when studying the structure of a small area. Another comments that in each study the field facts should be clearly distinguished from the assumed processes.

R.L. Brown, University of New Brunswick, draws attention to the need for renewed interest in the tectonics of the Northern Appalachian region, particularly in the Atlantic provinces. In Newfoundland regional studies at Memorial University and by the Geological Survey of Canada are being done on possible Taconic klippe, and in the Bay of Fundy area some detailed structural analyses have been made and are planned at the University of New Brunswick. However, there is a need for more structural workers in this region and Brown points out that "little structural research is being undertaken in the Maritimes at present by resident Maritime geologists. This situation will only be remedied when the Maritimes' geology departments make positions available for specialists in structure".

Relatively few detailed field studies aimed at determining some structural principle or developing new techniques have been made recently. These are generally made in conjunction with other field studies, and in 1965 about half a dozen such studies were reported. In the Rocky Mountains, studies of the principles of folding and of data-collecting techniques are being made by R.A. Price and D.K. Norris, Geological Survey, and at the University of Alberta under H.A.K. Charlesworth. At the University of Manitoba a study is being made of pebbles in the San Antonio conglomerate to determine the geometry and kinematics of deformation of pebbles of different rock types in the same structural environment. An analysis of folding and cleavage has been made by F.D. Anderson and D.K. Norris, Geological

Survey, in an area in Newfoundland. Studies of the structural significance of hornblende lineations in metamorphic tectonites continue under W. M. Schwerdtner, University of Toronto.

Regarding such detailed structural studies Charlesworth comments:

"At the universities, I feel we should be more concerned with developing new methods of measuring, and new ways of interpreting structure, and less with measurements and interpretations of actual structures, except where such measurements and interpretations are being made to test a hypothesis."

Regarding new techniques Baer submits the following:

"Quantification is slowly gaining ground in geology, and beginning to affect field geologists directly. Work of the Robinson committee on storage and retrieval of geological data shows that information contained in most field notes could be transferred to punch cards. Practical attempts have already been made. In 1965, a G.S.C. party (Roddick, Hutchison, Baer) used punch cards to record routine field data in the Coast Mountains of British Columbia. Two files were set up, a card-per-station file, and a card-per-specimen file. Station cards contained information on specimens collected, their number and lithology, on observations of the different rock types at the spot, on intensity of foliation and on glaciation features. These cards were punched on the station. Specimen cards carry the code number and lithology of the samples and are completed as needed, when thin sections, point counts or chemical analyses are made, specific gravity measured, etc. In that case, information collected has been essentially petrological, adapted to the nature of the work (large-scale reconnaissance) and to the type of rocks (essentially plutonic).

"Structural field geologists should give serious thoughts to similar approaches. This will be more difficult, mainly because of the large amount of different data to code from the same station. Once a workable system has been found, however, information could be machine-processed with advantage. The search for homogeneous domains in a given area and the plotting of stereograms could be considerably improved and accelerated.

"I am not advocating an attitude whereby you collect the data and let the machine do the rest, but a powerful tool is at our disposal and we can only benefit from its intelligent use."

Considerable work on this sort of data collecting has been done by R.A. Price, who makes the following comment:

"Quantitative methods in the analysis of basic field data have been assuming a progressively more important role in research in structural

geology. Among these new research tools, statistical analysis and automatic data processing seem to have received the most attention. Their potential for increased sophistication, speed, and precision in the analysis of structural data could extend the scope of research in structural geology substantially and should be a matter of interest to all structural geologists. If these and other new research tools are to be applied with greatest advantage it is important that structural geologists master their fundamental principles and gain a full appreciation of their scope and limitations. They must be applied prudently, lest precision, speed, or sophistication in analytical techniques become ends in themselves. An approximate answer to the right question, however vague it may be, will always be more meaningful than an exact answer to the wrong question, which can always be made precise."

This summary of field studies indicates some progress, but in the general realm of field structural research Canada should be a leader. Few countries are endowed with such large areas of fresh, well-exposed rocks with interesting structural histories as we have in the Canadian Shield and Cordillera. For several reasons Canada has not been in the forefront of structural research and only very recently have a significant number of good structural studies been made. Although we can report progress we cannot be complacent and must advocate not only more and better field studies but also more analyses of principles and techniques based on field work.

J.V. Ross says: "Part of the reason for our lack of progress is a function of the geographic distribution of the universities. This has resulted in too infrequent meetings of those interested in structural aspects of geology, so that many of us are working in vacuo. I would therefore like to make a further plea for regular meetings and/or workshops for those interested in advancing and teaching structural geology. Such meetings should probably be arranged external to the National Advisory Committee and also have associated field conferences that are run by people capable of coordinating local work."

Studies Involving Other Branches of Geology

Structural geology makes use of and contributes to other branches of the earth sciences. Its relationship to stratigraphy has already been noted. Important integrated studies involving geophysics have been initiated recently. More than a dozen structural studies in which geophysics plays a major part are listed in The Survey of Current Geological Research in Canada, 1965-66. "Project Pioneer," a joint study of the University of Manitoba Department of Mines and Natural Resources in the Rice Lake-Beresford Lake volcanic-sedimentary belt, was started in 1965. Seaborne crustal studies in the Arctic Islands, the Lake Superior Late Keweenawan sedimentary basin, Hudson Bay, Interior Plains, and the Cordillera are

being made by the Geological Survey, Observatories Branch, and several of the universities. More or less geological work is being done in connection with these projects and it is to be hoped that the best structural interpretations will be made. Seismic work by the Observatories Branch in the Cordillera which has been going on for many years is being stepped up and integrated with the Cordilleran Structure Project.

In connection with studies of metallic mineral deposits, there is a notable swing away from structural studies of the localization of orebodies. Currently popular ideas about volcanic and sedimentary sources for base-metal deposits have reduced the emphasis on structural control that was in vogue 10 to 15 years ago. The idea that some orebodies have undergone more or less deformation has prompted studies of the deformation of sulphides. Experimental studies have been made at McGill University and are continuing. Many deformed orebodies are being described and we may expect that many more will be recognized. Experimental and theoretical studies are intimately associated with geothermometry, geochemistry, and ore microscopy; much is to be learned from metallurgists and chemists. The structural control of orebodies, however, cannot be neglected because no matter what their origin, most orebodies in Canada are strongly influenced by deformational structures. Many have formed along structures during deformation and the understanding of these structures is essential not only in exploration and mining but also in determining the conditions under which mineralization took place. Few studies of the structure of mineral deposits and mineralized areas have been reported, but probably much local and detailed exploration by mining companies and much geological work in mining camps by provincial departments of mines are largely studies of structural control.

Experimental and Theoretical Work

Except in the field of rock mechanics, experimental and theoretical structural studies have played but a minor role in the structural research in Canada. However there is evidence of an increase in the number of experimental and theoretical studies in structural geology.

Experiments in deformation using natural or synthetic materials or models are in progress at the University of New Brunswick (Lajtai), McGill (Krishnamurthy), Toronto (Currie), Saskatchewan (Stauffer), and by the Geological Survey (Norris). Theoretical studies at the University of British Columbia are being done by Ross and Kellerhals.

In the field of rock mechanics, V.A. Haw, secretary of the Canadian Advisory Committee on Rock Mechanics, has provided the following report:

"Work and interest in the field of rock mechanics increased in 1965. The Canadian Advisory Committee on Rock Mechanics continued with its

main functions of both stimulating and coordinating research activities in the field of rock mechanics, and took action on several projects designed to improve the climate for rock-mechanics research in both industry and universities. The committee has now been enlarged to eighteen members from the former twelve, and has also added three ex-officio members from other committees in related fields of work. It is hoped by this action that better representation on a regional and discipline basis will be achieved. At present, the committee membership is about equally balanced between industry and the universities, with the secretariat located at the Mines Branch, Ottawa.

"One of the functions of the Canadian Advisory Committee on Rock Mechanics is to provide advice on the distribution of research funds to Canadian universities. In 1965-66 Canadian universities received a total of about $50,000 to undertake research on a variety of projects in rock mechanics, and in the coming year this amount is expected to be increased to about $80,000. The annual bibliography, sponsored by the committee, was again prepared and is available for distribution. Studies were continued by the committee on the classification of rocks for the purpose of defining rock types in a way that would be meaningful to specialists in the field of rock mechanics. The committee also undertook an examination of research programs in rock mechanics at the Mines Branch in Ottawa and make certain specific recommendations to the director of the Mines Branch, which in brief are:

1. That additional priority be given to instrument development.

2. That more emphasis be placed on in situ stress measurements.

3. That strength properties of rock specimens be determined by long-term triaxial-loading methods.

4. That increased attention be given to the matter of communication of rock-mechanics principles to all that could take advantage of such knowledge, particularly those in industry that are concerned with mining operations.

"The number of universities undertaking research in rock mechanics increased during the past year compared with 1964, as did the scope of the research undertaken. Brief descriptions of the fields of research being covered at Canadian universities follow:

"University of Alberta

Desorption rates of coal were investigated for different types of gases and sizes of coal, and comparisons were made at different magnitudes of pressure.

"McGill University

Stress-analysis studies were undertaken, using both mathematical models and photo-elastic techniques, and studies were also made of rock failure under various types of confined loads with the purpose of gaining additional information on stress conditions around mine openings.

"Laval University

Stress-strain studies of rock at the point of failure were made in order to examine volume changes under various stress environments. A technique was adopted of using annular specimens for determination of shear strains when subjected to both expansion and contraction forces.

"McMaster University

Work was carried out on the relationship between fabric, strength, and mode of failure in sedimentary rocks, using petrofabric studies and triaxial test equipment to determine strength properties of specimens.

"Queen's University

Studies were under way to determine methods for the measurement of shear waves in rocks with the ultimate purpose of obtaining increased knowledge of the phenomenon that occurs in rock blasting. A second project was undertaken to correlate the velocity of sound in solid materials with the moduli of elasticity in the hope of detecting more readily the rate and magnitude of rock deformations around underground mine openings.

"University of Toronto

Two areas of work were investigated: (1) the effects of planes of weakness in behaviour of rock; and (2) the model analyses of ground movement.

"University of British Columbia

The techniques of interferometry were used to examine microscopic mechanisms of rock failure.

"The Mines Branch in Ottawa has a substantial program in rock-mechanics research on the way. During the past year, a satellite

establishment was located at Elliot Lake, Ontario, to take advantage of underground facilities to conduct experimental work. The work at Elliot Lake is mainly concerned with studies of ground control, and, in particular, the behaviour of underground pillars as they are subjected to different stress environments during the course of mining operations. The research program of the mining-research laboratories of the Mines Branch covers a wide spectrum of activities: physical rock properties are being investigated with the purpose of providing a basis for rock classification for engineering purposes; underground investigations are being made in a number of Canadian mines to determine deformation characteristics in mine openings; a large project on slope stability is under way in which stress distributions are being determined around open pits, laboratory experiments are being conducted on deformable models, and other factors are being studied that influence slope stability, all of which are being used as the basis for studies to provide theoretical predictions and design criteria in open-pit operations; a project on the mechanics of transmitting energy in rock resulting from blasting is under way with the purpose of determining the stress distribution and its variation with time around the contained explosion. A good deal of emphasis is being placed on development of instrumentation to measure stress and strain in rock, which is being done in cooperation with a number of laboratories in other parts of the world in order to achieve an economy in effort and the earliest possible breakthrough in this very difficult field."

Regarding rock mechanics Baer comments as follows:

"Many geologists tend to think of rock mechanics as laboratory work performed on rock samples. This is not always the case, and for a number of years field studies on stresses and deformations have been done in mine galleries. Aside from their immediate application to mining practice and safety, these studies provide a wealth of scientific information. The Mines Branch of the Department of Energy, Mines and Resources is doing some excellent work in that particular field. I would recommend that wherever possible organizations promote integrated field studies of the geometry (structural geology) and of the kinematics (rock-mechanics) of deformations."

The foregoing emphasizes the need for communication and cooperation between workers in the geological and rock-mechanics fields, and to aid in this the Canadian Advisory Committee on Rock Mechanics in 1965 invited the chairman of the Subcommittee on Structural Geology to become an ex-officio member of the Committee on Rock Mechanics.

SOUTHERN CORDILLERAN STRUCTURE PROJECT

A second season of field work was completed in 1965 on the Southern Cordilleran Structure Project, a project initiated at the suggestion of the

Structural Subcommittee. The number of studies directly under the project was increased and many closely related studies under different auspices were continued. The table (p. 121) prepared by the project coordinator, J.O. Wheeler, summarizes the work being done.

With regard to the Rocky Mountains, Price makes the following comments:

"There is also a pressing need for comprehensive regional syntheses of the existing data on the structural evolution of the Rocky Mountains. Most of these data originate with individual projects of rather limited scope that are not necessarily directed primarily toward the elucidation of geologic structure. They include the data of stratigraphic studies in both the Plains and the Mountains, geophysical studies, petrologic studies, and local regional geologic investigation, in addition to individual detailed studies of specific aspects of the geologic structures. Our present approach is much like that of the proverbial blind men examining the elephant. The pertinent results of all these various projects should be integrated in terms of their bearing on the structural evolution of the Rocky Mountains, or for that matter of the Cordillera, as a whole.

"Moreover, it is becoming increasingly apparent that the most fruitful approach to a better understanding of the geologic structure of the Rocky Mountains lies not in multiplicity of uncoordinated individual specialized studies but rather in comprehensive projects in which various specialized and detailed studies can be properly integrated, in terms of common objectives, to the mutual benefit of all participants.

"The Cordilleran Structure Project is one such project; and accordingly I offer my firm endorsement of its objectives. If the full potential of this project is to be realized, increased participation, particularly by specialists whose interests lie outside the narrow confines of structural analysis, is essential. The mutual benefits that could be gained from concurrent geophysical, stratigraphic, and petrologic studies are obvious. Furthermore, much might be gained by encouraging workers in these other fields to reassess their available data in terms of their implications for the objectives of the Cordilleran Structure Project. Perhaps this might be accomplished by means of a Cordilleran Structure Project Workshop sponsored or endorsed jointly by the various subcommittees of the National Advisory Committee."

COMPILATIONS

W.H. Poole reports on the Tectonic Map of Canada as follows:

"Compilation of the Tectonic Map of Canada by a committee chaired by C.H. Stockwell is a project of major importance. In 1965, the Survey

SOUTHERN CORDILLERAN STRUCTURE PROJECT (C.S.P.)

AREA	WORKER	FINANCIAL SUPPORT	ORGANIZATION AND PROJECT
CASCADE MTS. Manning Park	J.A. Coates	G.S.C.	Ph.D. Thesis, U.B.C. - C.S.P. Structure of Lower Cretaceous Rocks
INTERIOR PLATEAU (a) Nicola Lake Area	M. Schau	N.A.C.	Ph.D. Thesis, U.B.C. - C.S.P. Structural studies in the Nicola Group
(b) Shuswap Lake	W.K. Fyson	N.A.C.	University of Ottawa - C.S.P. Structure of Mount Ida Group and relationship to Shuswap gneisses (Monashee Gp.)
MONASHEE MTS. (a) Ratchford Creek	W.J. McMillan	G.S.C.	Ph.D. Thesis, U.B.C. - C.S.P. Structure of core and enveloping metasedimentary gneisses on west side of Frenchman's Cap Dome
(b) Mount Copeland North of Revelstroke	J.T. Fyles	B.C. Department of Mines and Petroleum Resources	Lead-Zinc deposits in Shuswap rocks - on south side of Frenchman's Cap Dome
(c) South of Revelstoke	J.E. Reesor	G.S.C.	G.S.C. - Granites in Canada Program Thor-Odin gneiss dome

SELKIRK MTS. Mount Revelstoke Park	J.V. Ross	G.S.C.	U.B.C. - C.S.P. - Eastern margin of Shuswap Complex
DOGTOOTH MTS. Northern part	P.S. Simony	N.A.C.	University of Calgary - C.S.P. Structure of northern Dogtooth Mountains
ROCKY MTS. (a) Operation Bow-Athabaska	R.A. Price E.W. Mountjoy	G.S.C.	G.S.C. - Helicopter supported reconnaissance between Jasper and Banff
(b) Marble Mountain and Fallentimber (West)	N.C. Ollerenshaw	G.S.C.	G.S.C. - Foothills structures

Preliminary results for all the above projects except those of Schau, Fyles, and Simony are reported in Geol. Surv. Can., Paper 66-1.

Field projects reported in 1964-65 by W.J. McMillan on Vedder Mountain, B.C., by J.W.H. Monger in type-area of Chilliwack Group, by K.C. McTaggart and R.M. Thompson in Cascade Mountains, D.B. Craig in Revelstoke in interdomal area, and by P.B. Read on structure of Central Lardeau area are now being written up.

Alan Stanley withdrew from the project, but the results of his work will be incorporated with those of J.V. Ross.

Plans for seismic studies in 1966 by the Observatories Branch under W.R.H. White along the western part of the Southern Cordillera structure profile have been made in consultation with workers on the Structure project. A reverse profile is planned for 1967.

An informal field conference for participants in the project was held at Revelstoke early in the summer of 1966. Work to date was reviewed, recommendations made for future work, and a forum provided for exchange of ideas and for the participants to get to know one another.

published the Tectonic Map of the Canadian Shield, a preliminary map in several colours. Stockwell reports that the Appalachian and Arctic regions have been compiled and need only re-examination and editing. Compilation of the Cordilleran region is well advanced. The manuscript map for the whole of Canada is expected to be completed in 1966 and published in 1967."

The new folio Geological History of Western Canada sponsored by the Alberta Society of Petroleum Geologists and published early in 1965 is a remarkable compilation of very great value in understanding the tectonic history of the Interior Plains and Eastern Cordillera. It is a particularly fine piece of work by experts who have put together information much of which has never been published. The Alberta Society is to be congratulated for conceiving and carrying through the project and preparing a most attractive folio. It is unfortunate that material in the folio on the Western Cordillera is out of date, particularly in view of the fact that a symposium sponsored by the Canadian Institute of Mining and Metallurgy on the tectonics and mineral deposits of this area was presented before the folio was published. The C.I.M.M. symposium volume[1] will be available in September, 1966 and should nicely complement the folio of the Alberta Society of Petroleum Geologists.

CONCLUSIONS

The foregoing suggests the following conclusions:

1. The recent increase in the number and quality of structural studies is encouraging but should not lead to complacency. Continued interest and increased financial support, particularly to the universities, is needed to make sure that recent progress, which really has just begun, produces useful and outstanding results.

2. There is continued need for cooperative work in structural field studies. In major projects every effort should be made to bring all pertinent fields of the earth sciences to bear on tectonic problems. Local studies should be assessed and coordinated with the regional setting. To quote Baer: "Integrated studies are a must if we do not want to know more and more about less and less." The National Advisory Committee can foster this type of cooperation through meetings and workshops.

3. Investigation of the use of statistics and data-processing techniques in structural analysis should be encouraged. There are many

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[1] Tectonic History and Mineral Deposits of the Western Cordillera, Can. Inst. Mining and Metall., Special volume, 1966.

problems and uncertainties in this field, and relatively few structural geologists have the background to tackle this sort of research. However, we must not let our new research tools pass by untested. This puts an added requirement on the universities to produce graduates trained in the understanding of the new tools.

4. Communication between the fields of rock mechanics and structural geology should be encouraged. This requires structural geologists capable of understanding rock mechanics, cooperation in research projects, and a means of spreading the general results of rock-mechanics research to structural geologists in terms that they can readily grasp. Some of these aims could be achieved by a structural geology-rock mechanics workshop, and by review articles in geological journals.

APPENDIX

GEOLOGICAL SURVEY OF CANADA RESEARCH

GRANTS TO CANADIAN UNIVERSITIES

1966 - 67

Name University	Title of Project	Amount
Baird, D. M., Univ. of Ottawa	Hydration of anhydrite to gypsum in Canada with emphasis on relation of hydration to rate and time of uplift in Arctic diapirs.	$1,310
Berry, L.G., Queen's Univ.	Crystal structure studies on minerals.	2,000
Braun, W.K., Univ. of Sask.	Upper Devonian (M. Frasnian) biostratigraphy and microfaunas of Saskatchewan and Alberta.	2,000
Brisbin, W.C., Univ. of Man.	Computer analysis of structural orientation data from the Rice Lake-Beresford Lake greenstone belt.	2,000
Brown, R.L., Univ. of N.B.	Detailed structural studies in the Bay of Fundy region of southern New Brunswick.	1,500
Burwash, R.A., Univ. of Alta.	Average crustal composition of Western Churchill Province.	2,200
Chao, G.Y., Carleton Univ.	Studies of minerals from the Desoudry Quarry, Mt. St. Hilaire, Quebec.	1,500
Charlesworth, H.A.K., Univ. of Alta.	Analysis of folding in the Interior Plains of Western Canada.	1,650

Name University	Title of Project	Amount
Church, W.R., Univ. of West. Ont.	Geology of the Burlington Peninsula and adjacent areas, northeast Newfoundland.	1,500
Clifford, P.M., McMaster Univ.	Detailed structural and metamorphic studies along the Grenville Front.	1,500
Cormier, R.F., St. Francis Xavier Univ.	Radioactive dating of rocks and minerals.	1,800
Crocket, J.H., McMaster Univ.	Some aspects of the genesis of strata bound sulphide deposits.	1,000
David, P.P., Univ. of Montreal	Study of selected sand dune areas in Canada.	1,500
Deutsch, E.R., Memorial U. of Nfld.	Palaeomagnetism and application of rock magnetism to geological structure in the Springdale-Whalesback area of north-central Newfoundland.	1,500
Dineley, D., Univ. of Ottawa	Heterostraci from the Read Bay and Peel Sound Formations, Somerset and Prince of Wales Islands.	1,500
Doig, R., Philpotts, A.R., McGill Univ.	Geochronology and petrology of some very late Precambrian intrusive rocks of the Chatham-Grenville type. Isotopic and petrologic study of anorthosites and related rocks.	3,000
Dreimanis, A., Univ. of West. Ont.	Stratigraphic correlations of glacial deposits between Lake Huron and St. Lawrence Lowland.	2,500
Dreimanis, A., Univ. of West. Ont.	Provenance of diamonds found in glacial drift in the Great Lakes region.	2,000

Name University	Title of Project	Amount
Dreimanis, A., Univ. of West. Ont.	Buried soils in the Banff National Park.	500
Elson, J.A., McGill Univ.	Strandlines and end moraines of Glacial Lake Agassiz.	1,500
Farquhar, R.M. & D. York, Univ. of Toronto	Age determinations and isotope studies of ancient Precambrian terrains in the Canadian Shield.	2,500
Fritz, Madeleine A., Univ. of Toronto	Symposium on the "Relationship of Mineralization to Precambrian Stratigraphy".	2,000
Fyson, W.K., Univ. of Ottawa	Relation of minor to major structures in the Maritime Provinces; tectonic structures on the south side of the St. Lawrence River, Quebec.	1,500
Geldart, L.P., McGill Univ.	Gravity investigation of faults and dykes.	1,500
Gélinas, L., Ecole Polytechnique	Etude de la différenciation magmatique des roches intrusives du Mont Royal.	1,500
Greiner, H.R., Univ. of N.B.	A study of the Welsh type Cambrian formations and of the Cambrian of the Bohemian basin, and their faunas.	440
Gross, W.H., Univ. of Toronto	Causes for the distribution of nickel in serpentinites in eastern North America.	1,500
Hall, D.H., Univ. of Manitoba	Frequency analysis of crustal seismic records.	1,000
Hall, D.H., Univ. of Manitoba	Amplitude and frequency studies in the interpretation of seismic reflection records in petroleum exploration.	1,000

Name University	Title of Project	Amount
Hill, P.A., Carleton Univ.	Distribution of hexagonal and monoclinic pyrrhotite and troilite in sulphide assemblages of known economic importance.	2,000
Hooper, K., Carleton Univ.	Preliminary investigations of Precambrian microfossils.	1,000
Hughes, R.D., Memorial Univ. of Nfld.	Newfoundland Precambrian fossils.	2,000
Hutchinson, R.W., & Edgar, A.D. Univ. of West. Ont.	Comparative studies of lithium-bearing pegmatites.	1,500
Karrow, P.F., Carter, J.C.H., Dathie, H.C., Fernando, C.H., Univ. of Waterloo	Study of fossil remains in interstadial and interglacial deposits of the Toronto district, Ontario.	6,000
Keen, M.J., Dalhousie Univ.	Seismic studies of the Continental Margin, northeast of Newfoundland.	2,500
Knop, O., Dalhousie Univ.	Sulphide minerals.	1,500
Koulomzine, T., Ecole Polytechnique	Etude comparative des méthodes électriques et électromagnétiques pour la prospection des gisements de sulfures.	2,500
Kranck, E.H., McGill Univ.	Study of the McBeth Fiord area, Baffin Island.	2,000
Laming, D.J.C., Univ of N.B.	Marine bedrock and sediment studies in the Gulf of St. Lawrence and Bay of Fundy.	1,500
Laming, D.J.C., Univ. of N.B.	Partial support of publication costs of MARITIME SEDIMENTS.	800 (terminal)

Name University	Title of Project	Amount
Ledoux, R. L., Laval Univ.	Caractérisation minéralogique des argiles des régions de glissements de terrain de la province de Québec.	1,550
Leith, E. K., & Anderson, D. T. Univ. of Manitoba	Pleistocene stratigraphy and sedimentation of southeastern Manitoba.	1,500
Lenz, A. C., Univ. of West. Ont.	Upper Silurian and Lower Devonian brachiopods at Royal Creek area, Yukon.	1,300
Lerbekmo, J. F., Univ. of Alberta	Composition, distribution and source of the White River volcanic ash, Yukon Territory.	900
Lespérance, P. J., & Mamet, B., Univ. of Montréal	Recherches en Paléontologie sur les trilobites de l'ordovicien supérieur, silurien et dévonien et sur les foraminifères carbonifères.	2,000
Martignole, J., Univ. of Montréal	Evolution pétrographique et structurale des séries catazonales au NE de Montréal.	1,687
Mathews, W. H., Univ. of B. C.	Geothermal studies, Mt. Seymour, British Columbia, and Stewart, British Columbia.	550
McAllister, A. L., Univ. of N. B.	An investigation of the structural and stratigraphic environment of the Key Anacon Mines Ltd. orebodies, Bathurst district, New Brunswick.	1,000
McCartney, W. D., Queen's Univ.	Metallogenic studies in Grenville Province, Ontario.	1,513
McGugan, A., Univ. of Calgary	Permian stratigraphy and Palaeontology southeastern British Columbia.	1,600

Name University	Title of Project	Amount
McNutt, R.H., McMaster Univ.	The genesis of anorthosites, field and Rb-Sr isotopic studies.	1,700
Middleton, G.V., McMaster Univ.	Multivariate statistical techniques in geology.	1,600
Milligan, G.C., Dalhousie Univ.	Investigations in George River Series, Cape Breton, Nova Scotia.	2,000
Moorhouse, W.W., Univ. of Toronto	Studies of basic rocks.	1,500
Mountjoy, E.W., McGill Univ.	Petrography and stratigraphy of Upper Devonian reef complexes, Alberta Rocky Mountains.	1,500
Nelson, S.J., Univ. of Calgary	Permo-carboniferous faunal zones.	1,200
Pajari, G.E. Jr., Univ. of N.B.	Mineralogy and petrochemistry of the Rapakivi type granites in the St. George granite complex. The geochemical control of copper deposition on Grand Manan Island, Bay of Fundy.	1,500
Perrault, G., Ecole Polytechnique	Minéralogie et pétrographie des roches alcalines d'Oka, P.Q. Minéralogie du Mont St. Hilaire.	2,000
Philpotts, A.R., McGill Univ.	Investigation of Monteregian rocks.	2,000
Pouliot, G., Ecole Polytechnique	Etude des carbonates dans l'intrusion carbonatite d'Oka, P.Q.	2,000
Rankin, D., Univ. of Alberta	Magnetotelluric studies of deep crustal structure in southern Alberta.	1,700

Name University	Title of Project	Amount
Ross, J.V., Univ. of B.C.	Rb/Sr dating in southern British Columbia.	1,500
Rust, B.R., Univ. of Ottawa	The sedimentology and palaeogeography of the Devonian Peel Sound Formation of Somerset and Prince of Wales Islands, N.W.T.	1,500
Saull, V.A., & Telford, W.M., McGill Univ.	Geological and geophysical field studies in the St. Lawrence Valley region.	2,000
Sauvé, P., Laval Univ.	Étude d'un filon couche noritique et de la minéralisation de cuivre-nickel, qui l'accompagne dans la fosse du Labrador. Étude des gisements de cuivre et de zinc de Cupra et Solbec, Canton de l'Est, Québec.	2,500
Schwarcz, H.P., McMaster Univ.	Sulphur isotope geochemistry in some Canadian ore deposits.	1,500
Schwerdtner, W.M., Univ. of Toronto	Kinematic significance of hornblende lineations in metamorphic rocks.	3,500
Shaw, D.M., McMaster Univ.	Statistical geochemical studies.	1,600
Simony, P.S., Univ. of Calgary	Geology of the Dogtooth Mountains.	2,200
Smith, M.E., Univ. of Ottawa	Element distribution between coexisting feldspars of high-grade metamorphic rocks, and its use as a geothermometer.	1,000
Smitheringale, W.G., Memorial Univ. of Nfld.	Geothermometry of the St. Lawrence fluorspar mine and/or the deposits of the Newfoundland zinc mine.	

Name University	Title of Project	Amount
Smitheringale, W.G., (Cont'd)	The distribution of trace elements in the mineralized volcanic rocks of the Notre Dame Bay area of northeastern Newfoundland.	1,500
Stelck, C.R., Univ. of Alberta	Palynology of Cretaceous Microvertebrate beds.	3,000
Suffel, G.G., Univ. of West. Ont.	Comparison of structures and textures in sulphide ores with those of metamorphic rocks.	900
Trembath, L.T., Univ. of N.B.	Sulphide calibration standards.	1,500
Trost, W.R., Dalhousie, Univ.	The chemistry of an inland sea.	2,400
Tupper, W.M., Carleton Univ.	Geochronology and K/Ar geochemistry of "Fossil Craters".	
	Geochemistry and wall rock alteration of the copper deposits, Murdockville, Quebec.	1,600
Turnock, A.C., Univ. of Man.	Mineralogy of a dome-shaped granite pluton from east-central Manitoba Precambrian.	1,300
Usher, J.L., Queen's Univ.	Cores of Ordovician rocks in the Kingston-Sydenham area.	3,500
Warren, H.V., Univ. of B.C.	Trace elements in some volcanic rocks.	1,500
West, G.F., Univ. of Toronto	Lake Superior seismic surveys.	2,500
Westermann, G.E.C., McMaster Univ.	Evolution and taxonomy of late Triassic Aviculopectinidae (Pelecypoda).	1,500

Name University	Title of Project	Amount
Williams, G.D., Univ. of Alberta	Groundwater geology of Alberta and adjacent areas.	4,000
Winder, C.G., Univ. of West. Ont.	Structural geology of southern Ontario.	1,500
Wynne-Edwards, H.R., Queen's Univ.	Analyses of rocks and minerals.	2,500
Young, G.M., Univ. of West. Ont.	Stratigraphy, structure and sedimentology of the Precambrian rocks of Harrow and McKinnon townships, Ontario.	1,000