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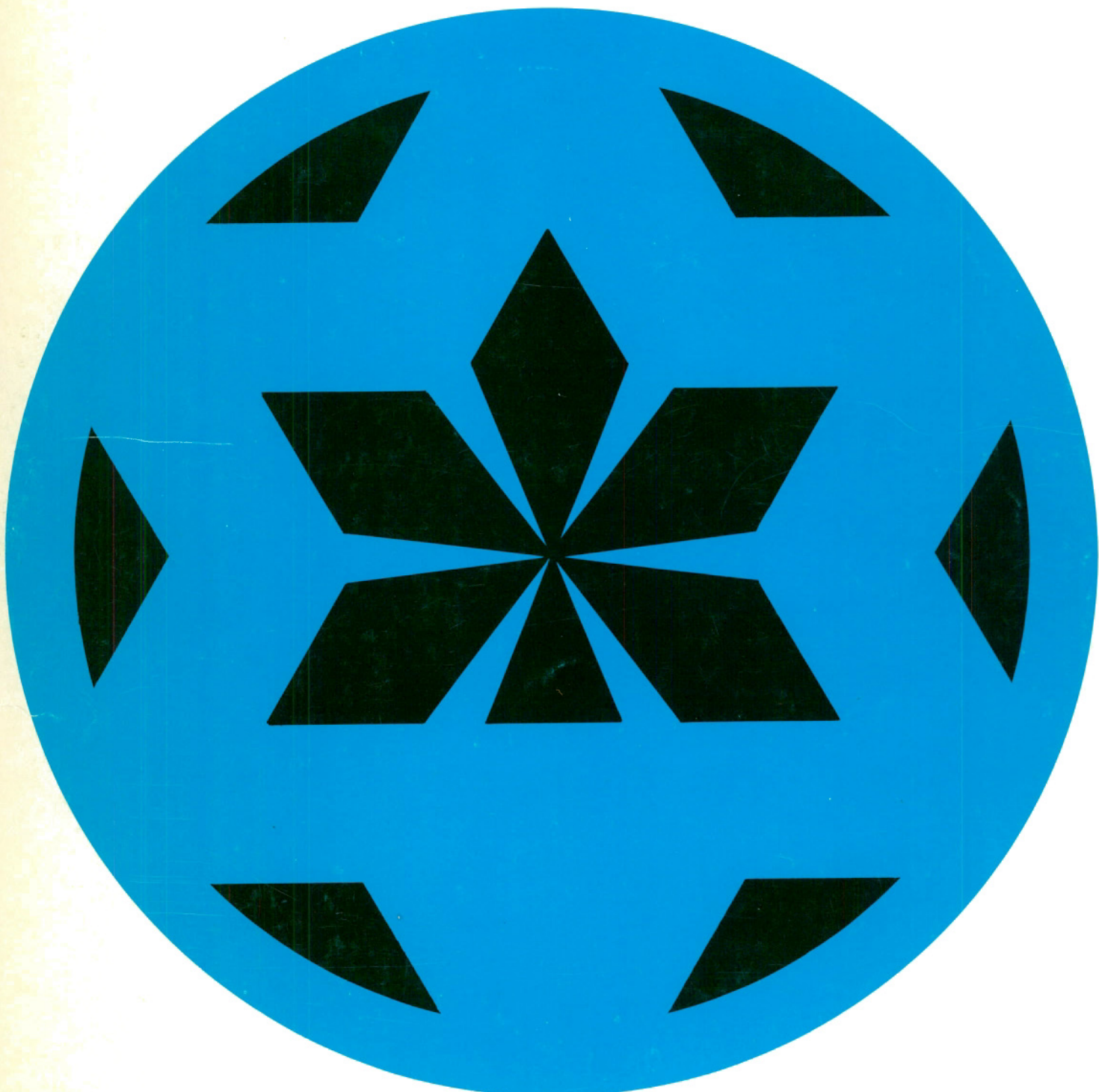
**Canadian
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Aspects of the Geosciences in Canada, 1975

Edited by
C.R. Barnes, T.E. Bolton, G.D. Garland and R.L. Slavin

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The blue sphere symbolizes the Earth; a single Pangean continent has fragmented from six triple-junctions to produce minor continents symbolizing the twelve member societies and also the twelve political units of Canada (C.R. Barnes).



Energy, Mines and
Resources Canada

Énergie, Mines et
Ressources Canada

**GEOLOGICAL SURVEY OF CANADA
PAPER 76-6**

**ASPECTS OF
THE GEOSCIENCES IN CANADA - 1975**

EDITED BY

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PART 1

INTRODUCTION AND OVERVIEW

The Canadian Geoscience Council in its role as the co-ordinating body of earth science societies in Canada has an obligation to inform the geoscientist as well as the general public on the importance of the geosciences to the cultural and economic welfare of Canada. The Council plans a series of annual publications to achieve this objective.

The first such report of Council, the Geosciences in Canada--1974 (Geological Survey of Canada Paper 75-6, 1975), was a comprehensive review of the state of our science. A similar comprehensive review is planned for 1976. The report on 1974 activities stressed the importance of the geosciences in the next quarter century because of the need for energy, minerals, fertilizers for food production and the need for the proper management of the natural environment. The major effort that Council made last year to carry this message to decision-makers in government and universities is discussed in the President's Report, elsewhere in this volume.

The present report, published between two comprehensive reviews, restricts itself to an examination of one sector of geoscience; to briefer commentaries on some other sectors or topics of wide interest, stressing 1975 developments; to data on some major research projects funded by various agencies; to data on Council's member societies and to a report of Council's own activities. Following the 1976 state of the science report, it is likely that the format of this present report will be followed in future years. Certainly we hope to include and analysis of some sector of the science in each report, prepared (as in the present case) by the member society concerned. This, and all future annual reports of the Canadian Geoscience Council, will be accompanied by a companion volume, "Current Research in the Geological Sciences". This list of current activities, formerly compiled by the Geological Survey of Canada, is now assembled under the aegis of the Canadian Geoscience Council. Thanks to the co-operation of our member societies and the Department of Energy, Mines and Resources, it now offers a more complete summary of our national activities in geological research than it has hitherto.

Another report complements our two annual publications: this is the Canadian Geophysical Bulletin, presently published by the National Research Council. Together, these three annual publications should keep geoscientists regularly informed and up-to-date on developments and progress.

Our Council is greatly indebted to the Canadian Society of Petroleum Geologists for permission to publish a part of the report of its Research Committee entitled "Research in the Earth Sciences Relating to Canadian Petroleum Exploration Geology". The CSPG report is the first systematic look at research and geological activity in an industry that is of great importance to the country. Total effort reported on by 88 respondents to the survey amounts to about 1000 man years per year; 25 per cent of the activity is basic or applied research and 75 per cent is regarded as development, interpretation, data collection and information. The subdisciplines treated are those of particular concern with petroleum geology; nevertheless the data should be of great interest to the whole geoscience community.

As the report is the first of its kind in Canadian geoscience and as it was prepared by petroleum scientists, members of a society with a special orientation in geology, a commentary on the report is included. The commentary quite naturally recognizes some weaknesses related to definitions, breadth of sample, imprecision of scale and possible uneven weighting. However, it must be understood that the CSPG Research Committee has made an important initial attempt to determine both the present levels and the directions of geological research related to petroleum exploration in Canada and also the kinds and future levels of research activity. The Committee acknowledges that these estimates of research (or activity) are made on an imprecise scale which "... precludes the use of the results in any quantitative way. However, relative trends and directions should be valid". Our Council publishes a part of this report in that same spirit.

The CSPG Research Committee report raises a number of questions related to petroleum geology that are of interest to the whole geoscience community: present and future research needs, distribution of basic research among industry, government and university, levels and sources of funding, and future manpower requirements. We look forward to reading in due course an analysis by the Canadian Society of Petroleum Geologists of the results of their survey along with appropriate comment and recommendations.

There have been numerous warnings, and our own Council has voiced some of them, concerning the paucity of research funds and the relative neglect of many important subdisciplines in our field. At this same time the Federal Government, in connection with Canada's new fiscal policy, has recently announced large reductions in research and development expenditures. To convince the public and the decision-makers of the needs for research, these will have to be justified, and as far as possible, quantified. We cannot over-emphasize the importance of the survey undertaken by the CSPG as an important first step in the necessary directions. Other member societies, particularly those in the applied fields, must follow their lead and examine the levels of support and current research emphases, identifying the gaps and making estimates of future needs. Our Council urges its member societies to seriously consider undertaking projects such as the CSPG survey.

Equipped with specific information on the whole spectrum of geoscience the Council and its member societies would be able to make informed representation to government, industry and the universities in support of our science and on science policy in general. Part of the solution appears to be greater support for research by industry. This in turn will require a favourable economic climate in the applied geoscience industries.

Very recently the Canadian Geoscience Council has been asked by government to assume certain duties in the international sphere: naming the National Committee for the International Geological Congress, naming a national geoscience representative to the International Council of Scientific Unions, and assuming management of the Canadian Committee of the International Geological Correlation Program. It is hoped that in the near future our Council of national geoscience societies will become the contact of all international geoscience agencies, adhering to some directly, and to others possibly through the Academy of Sciences of the Royal Society of Canada.

Several current international programs are reviewed in this report. The International Geodynamics Project is wholly non-governmental, and is a joint geological-geophysical attack on the fundamentals of plate tectonics. A number of Canadians have active roles in the various international working groups, and Canada will become even more directly involved with the transfer of the Secretariat from Paris to Vancouver and the appointment of a Canadian as the new Secretary General of the international committee. It is appropriate that the National Research Council and the Department of Energy, Mines and Resources are jointly supporting him in this position. The International Geological Correlation Program is a joint project of IUGS and UNESCO, and while principles of basic correlation will be included, there will undoubtedly be emphasis on practical applications, as related to mineral deposits. Thirdly, the report notes the participation of Canadian scientists in the Deep Sea Drilling Project, at least insofar as the receipt of sample material and the co-ordination of research effort is concerned. The study of these rocks is expected to provide information of great importance in the understanding of the ocean floors and global tectonics, and it is gratifying that the National Research Council has provided special support for these studies.

Much of Canada's geoscience activity and research is carried out by government agencies. This includes all the mapping and other investigations concerned with resource inventory. It is therefore most appropriate that we include some of the highlights of 1975 activities in government geoscience. The Geological Survey of Canada performs the greatest volume and widest variety of research of any single agency in the country. It is still carrying out pioneer studies on topics that range from frontier science to pragmatic studies of immediate economic interest. The Geological Survey's counter-part in solid earth geophysical research, the Earth Physics Branch, also reports a number of exciting projects completed during the year. Other Federal agencies, one old established (but with a new name, CANMET) and the other relatively new, the Canada Centre for Remote Sensing, also present summaries of recent progress.

The Provinces have been playing an ever greater role in geoscience research and we include reports from two in this volume. There would have been more except for an intervening mail strike. These agencies and other federal departments (e.g. Environment Canada) will be looked at in subsequent years.

This report contains progress summaries on four geoscience research projects at five universities sponsored by NRC Negotiated Development Grants. These comparatively large grants, spread over a number of years, enable the university to build up competence in an area considered desirable in regional or national interests. These grants help create centres of excellence as recommended in the Blais Report (Science Council of Canada, Special Study 13, 1971). The reports presented here all illustrate open niches in Canadian geoscience which are being capably filled. We are most disturbed to learn that due to budgetary restraints NRC has been forced to suspend further Negotiated Development Grants. This raises again the question of financing non-governmental research in geoscience, and as mentioned above, the necessity to justify the need and the possibility of additional future support from industry.

In Report No. 7 (April, 1970) the Science Council of Canada pointed out the "There is an obvious need for better data on Scientific and Technical Manpower and steps must be initiated to obtain them". This has not been done. In an attempt to come to grips with this problem our Council set up a Manpower Committee this past year to examine supply and demand in the earth sciences. The interim report of their investigations can be found elsewhere in this volume.

There are some useful data on supply in the Canadian Institute of Mining and Metallurgy annual report on the number of Canadian graduates in the mineral industry fields. However, collection of data on people employed in geoscience has a number of difficulties, not the least of which is a firm definition of the term geoscientist. At present various agencies include categories which are not recognized as geoscientists by other groups. Our Manpower Committee is working with the Council of Chairmen, Canadian University Departments of Earth Science to find a definition that will make future statistics more meaningful.

Our committee concludes that the number of graduates in earth science from Canadian universities has risen to approximate that forecast by the Blais report (Science Council of Canada, Special Study 13, 1971). However, while supply seems to have been forecast reasonably well, our Council laments the fact that there is no good quantitative analysis of what the future demand for geoscientists should be, based on the Canadian economy. The Technical Service Council, a non-profit placement service and personnel consulting firm run by industry, published in 1975 a report on Supply of and Demand for New Graduates in Engineering, Chemistry, Business and Commerce. Our Manpower Committee recommends a similar study for the geosciences; this recommendation is now under consideration by Council.

The final section of the Report provides useful current data on the Canadian Geoscience Council and its member societies and information on important activities.

Submitted on behalf of the Canadian Geoscience Council

by

R. L. Slavin, President

C. R. Barnes, Chairman, Editorial Committee

PART II

CANADIAN PETROLEUM EXPLORATION GEOLOGY RESEARCH

Editorial Note

The Council and the Committee considered it a worthwhile venture to examine current research in certain sectors of the Canadian geoscience community. This is only possible, however, when adequate data are available for study, and the geosciences are currently poorly organized for the gathering and analysis of such information. Fortunately, one sector, the petroleum industry, has just conducted a detailed survey of research related to Canadian petroleum exploration geology. The Canadian Society of Petroleum Geologists, through its Research Committee chaired by E. R. Parker, sent a computer processable questionnaire to over 200 organizations. The data have been compiled and, with a summary of the results, have been published in the December 1975 issue of the CSPG Bulletin.

The Society has kindly made the full data and report available to the Editorial Committee of which E. R. Parker is a member. This report was sent to two reviewers for comment: Dr. F. K. North of Carleton University, Ottawa, Ontario and Dr. L. W. Vigrass of University of Regina, Saskatchewan. The first part of the CSPG Report, including the Tables and Figures is reproduced below with minimal editing. The second section that considered subdiscipline reports will be incorporated within the 1976 CGC Status Report. N. C. Wardlaw prepared a third section reviewing Advances in Petroleum Geology for which the reader is referred to the December 1975 issue (v. 23, no. 4) of the Bulletin of the Canadian Society of Petroleum Geologists. The two reviews have been edited, together with observations by the Editorial Subcommittee, into a commentary that follows the CSPG Report.

Research in the Earth Sciences Relating to Canadian Petroleum Exploration Geology: An Overview

The Research Committee of the Canadian Society of Petroleum Geology

Abstract

A survey of existing research and planned activity was made of more than 200 organizations involved in petroleum exploration research. The results of this survey are analyzed and discussed. Reviews of the state-of-the-art of the more significant sub-disciplines of petroleum exploration geology are made, primarily by the members of the Divisions of the Society. These appraisals are the first of what is expected to be an annual review by the Research Committee.

Introduction

The Research Committee, author of this overview of research, was formed at the request of the President of the CSPG in the fall of 1974 for the purpose of providing a means of informing the membership of our Society of the state-of-the-art of petroleum related geological research underway or planned in Canada. In addition, this same committee was also charged with the responsibility of providing appraisals of the various sub-disciplines of geology which are required by the Canadian Geoscience Council (CGC) for its annual report (Geological Survey of Canada Paper 75-7, 1975) and to act as a liaison group with the Editorial Committee of that Council. It has generally been agreed that the results of the efforts of the Research Committee should first be provided to the membership of the CSPG before being passed on as the Society's contribution to the CGC.

Existing Research in Petroleum Exploration Geology and Future Trends

In order to come to grips with the widely diversified topics of earth science research, and in particular with those topics related to petroleum exploration, some form of bench-mark inventory is imperative. Two forms of inventory can be considered. One consists of a listing of individual research projects underway or planned in which the project, principal investigator, institution, funding, together with a description of the project, are tabulated in a form similar to that prepared by the Geological Survey of Canada (GSC Paper 74-5, 1974; 75-5, 1975), or one similar to that now prepared by the Smithsonian Institute in Washington, D.C. The other form of bench-mark inventory consists of a survey, in general terms, of what kind and amount of research is now underway and what research is needed in the future. This form of inventory, while not project specific does provide an overview and could reflect an industry consensus. While the committee chose, for practical reasons, the latter approach, the subject of a Canada-wide index of geological research projects is still being actively pursued both by the CSPG Research Committee and by the CGC Editorial Committee.

The form and content of the survey of existing and needed research was devised by the Research Committee in the spring of this year and the divisions of the CSPG were asked for their advice on the selection of topics to be surveyed. The response to what admittedly appeared

to be a complex and difficult questionnaire was surprising. Thirty-seven per cent of the 236 questionnaires sent out were returned — sufficient to provide a meaningful sample, since the respondents employ over 1400 geologists, 95 per cent of which are employed in petroleum geology. It is hoped that the results will provide an indication, particularly to the academic and government sector, of those areas of industry concern and interest.

In considering the results of the survey, two significant factors should be kept in mind. First, in a very detailed set of instructions, the definitions of the five categories of scientific activity, which for the purpose of the survey were called research, were clearly set out. The definitions followed those put forward by the Blais Commission. Respondents to the survey were asked to estimate their amount of effort in the following terms: nil, very slight (about 1 man month/yr), slight (2-6 man months/yr), moderate (7-12 man months/yr), extensive (13-24 man months/yr), and very extensive (over 24 man months/yr). This very arbitrary and imprecise scale precludes the use of the results in any quantitative way. However, relative trends and directions should be valid.

The research committee has consciously avoided drawing conclusions based on the results of the survey, believing that its function was to prepare a reference for the information of that portion of the earth science community interested in Petroleum Geology.

Results

Because of the complexity of the questionnaire, and the large number of returns, the total amount of data collected is extremely large. All of the replies were converted to digital records and stored on tape. A tabulation of the basic data is on file at the CSPG office should readers wish to examine the survey results in more detail. A summary of the replies to the general questions and to the subject questions, together with the Research Committee's comments is included as part of this report.

1. Replies to the General Questions

a) Distribution of Returns

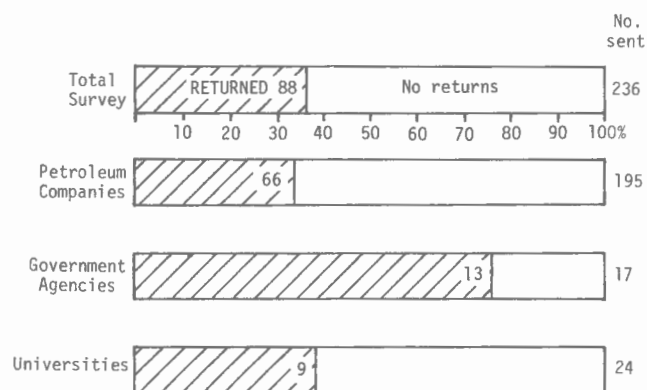


Figure 1. Returns by Respondent Class.

b) Distribution of Effort

Averaging all responses to the question "how is your effort distributed", 22% of the respondent's effort is directed to work in Frontier areas, 55% to the Producing areas, and 11% is directed outside of Canada.

c) Educational Level

Sixty per cent of those working on petroleum geology held Bachelor degrees, 21% held Masters, and 15% held Doctorate degrees. Sixty-four per cent of the academic staff were Doctors, whereas only 9% of the petroleum majors and 4% of the independent petroleum company employees held this degree.

Table I
Distribution of Education Level of Respondents
(per cent of total class response)

	Other	B. Sc.	M. Sc.	Ph. D.
Academic	0	20	16	64
Petroleum Major	2	65	24	9
Petroleum Independent	8	60	28	4
Petroleum Other	0	58	30	12
Consultant	0	100	0	0
Federal Gov't.	7	65	8	20
Provincial Gov't.	2	54	16	28
Other	0	100	0	0
Total	4	60	21	15

d) Hiring Levels

Over the past 5 years the 88 responding companies hired 177 geologists per year (49% B.Sc., 25% M.Sc., and 26% Ph.D.). The indicated hiring rate for 1975 at the time the survey was made indicates a reduction in hiring of 66 per cent to a total of 60 (62% B.Sc., 27% M.Sc., and 12% Ph.D.). It is of some interest to note the apparent shift of interest to the lower degrees.

e) Publication Policy

The replies to the question "what is your organization's policy on publication" are tabulated in Table II. In light of the 61 per cent response that publication is either imperative or encouraged, one wonders why our Journal is not swamped with manuscripts.

Table II
Publication Policy

	Imperative	Encouraged	Discouraged	Neutral	OK on Own Time	No Policy
Academic	33	66				
Petroleum Major	-	53		29		18
Petroleum Independent	9	45		12	12	21
Petroleum Other	11	44		11	11	22
Consultant		100				
Federal Gov't.	25	25		25		25
Provincial Gov't.	20	50		20	10	
Other	50					50
	61%		15%		7%	16%

f) Computer Use

Sixty-six per cent of the respondents utilize computers in exploration geology, 28% of the respondents using in-house facilities. An additional 16% plan to utilize computers in the future suggesting that 82% of all respondents will utilize the computer for geological purposes. One man for every 5.5 geologists employed is involved with geological computer work.

g) Distribution of Research

Analysis of the general question "how is your research effort apportioned to the six categories of research defined by the Blais commission" gave the results shown in Figure 2.

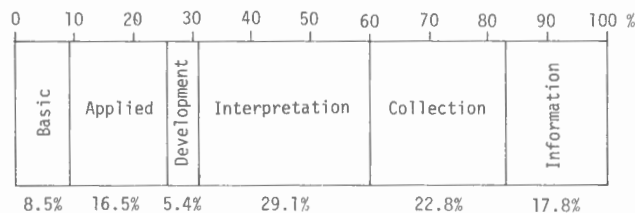


Figure 2. Distribution of Research by Type.

Considering the total research effort reported, albeit in relative units, the distribution by respondent class is summarized in Figure 3 and Table III. The low percentage of research by the academic institutions is surprising.

Table III
Distribution of Research Effort (%)
by Type and Respondent

	Basic	Appl.	Dev.	Int.	Coll.	Info.	Total (Est. Man Month/Year)	Per cent
Academic	34	9	4	2	7	7	114	8%
Petroleum (Incl. Cons.)	39	59	79	82	71	73	1009	70%
Government (and others)	27	32	17	16	22	20	314	22%
Total	8%	17%	5%	29%	22%	18%	1437	100%

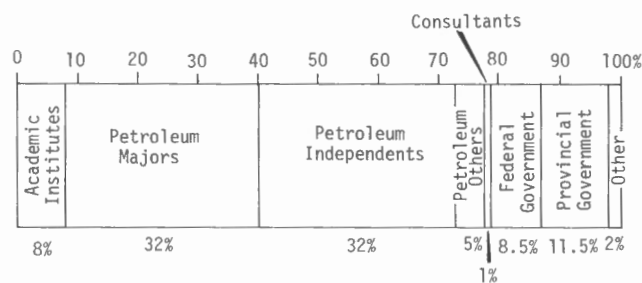


Figure 3. Distribution of Total Research Effort by Respondents.

h) Canadian Content of Research

In response to the general question on "distribution of research", the relative amount of research done in Canada is summarized in Table IV.

Table IV
Per cent Research Done in Canada

	Basic	Appl.	Dev.	Interp.	Coll.	Info.
Academic	83	100	100	100	91	88
Petroleum Major	52	61	45	67	71	65
Petroleum Independent	66	53	100	56	68	53
Petroleum Other	0	69	87	67	61	50
Industry	-	-	-	-		
Consultant	-	50	100	100		
Federal Gov't.	50	55	100	87	100	100
Provincial Gov't.	65	78	57	97	100	100
Other	-	100	-	100	100	100
All Respondents	64	66	61	67	74	73

(Editorial Note: Because of insufficient sampling, an imprecise scale, and lack of adequate weighting of responses, some of the data in this table are highly suspect.)

2. Replies to Specific Subject Questions

a) General Observations

A condensation of the replies to specific research activities in terms of major sub-discipline, both present and future, is summarized in Figure 4.

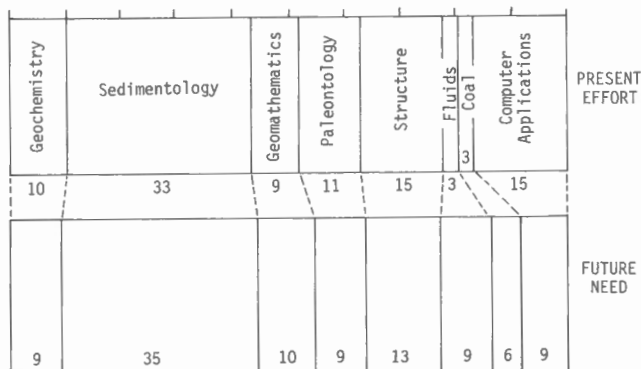


Figure 4. Relative Distribution of Research by Subject (per cent of total effort).

The relative amount of effort and the proportion of increase is represented in Figure 5. The indicated major increase in research needed in the area of subsurface fluids is particularly significant. It was reported that a total of 11 292 man months per year is now being applied to research on all subjects; future needs totalled 17 296 man months per year, a 53 per cent overall increase in effort.

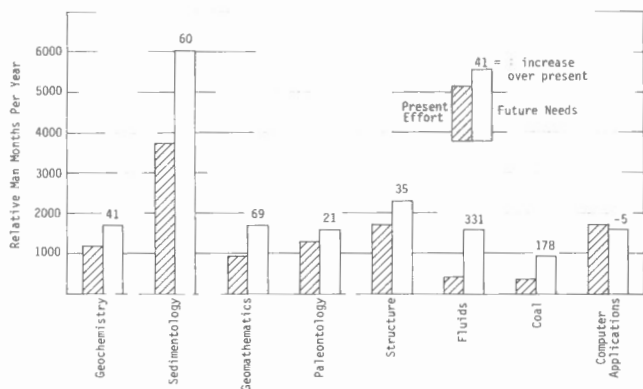


Figure 5. Reported Research Activity by Subject.

b) Interpretation of Returns by Subject Class

i) Petroleum Geochemistry

The significance with which explorationists regard petroleum geochemistry is reflected in the relatively high number of man months allocated by the various respondents to this new and relatively specialized field. As expected, the principal effort in this area is by the major companies. The independent companies are becoming increasingly aware of the potential of petroleum geochemistry as an exploration tool. Government agencies maintain a relatively small but continuing interest in this subject. The effort devoted to this subject by the academic community is very small.

Overall, the respondents foresee a 30 per cent increase in effort in this field. However, the various types of respondent view their future needs differently. Thus the major companies, in which petroleum geochemistry has been established for some time, foresee a 15 per cent increase in effort. In contrast, the independents, in which petroleum geochemistry is a more recent innovation, require a 350 per cent increase in effort. Surprisingly, both Provincial and Federal Government agencies forecast a decline in their need for petroleum geochemistry.

The division of effort between the major subject categories again reflects the type of organization. Thus, the major companies devote almost equal effort to Thermal Maturation, Source Rock, and Oil Typing while Formation Waters are less extensively studied. The independent companies and Federal Government agencies place most emphasis on Maturation Studies. In the case of the Federal Government agencies, this reflects a largely reconnaissance effort in Frontier areas. In contrast, the effort in Provincial Government agencies is mostly in Oil Typing and Correlation, and reflects the nature of the problems in the extensively explored areas under their jurisdiction.

Both the major and independent exploration companies foresee a substantial need for study of formation waters. This need is related to the interest in subsurface fluids recorded elsewhere in this survey.

ii) Sedimentology

The study of modern sediments provides a means of obtaining environmental criteria which may be applied to ancient rocks and for the petroleum industry the distinction between basic and applied research is notably unimportant. It is therefore not surprising that petroleum majors expect to initiate a fourfold increase of effort on modern sediments. They are presently continuing work on deltaic environments more or less in proportion with the economic importance of this type of sedimentary body. In addition, the majors are working on the problems of fluvial deposition, an area essentially neglected by others but of increasing economic importance in the subsurface. The Federal Government agencies expect to double their efforts in exploring modern nearshore environments and Provincial Government agencies evidently would like to become involved in modern sediment projects particularly in the shallow marine realm. The academic institutions indicated little future change in their areas of activity whereas by contrast the petroleum independents, hungry as always for information, would like to see very substantial programs on all fronts with the exception of the very expensive deep-ocean, and in that area the petroleum majors appear to have it all to themselves.

The Federal Government agencies report a reasonably well-balanced program of research on ancient rocks with about an equal emphasis on carbonates, clastics, and chemical sediments. In the future a large increase on nearly all fronts is anticipated, however, there is a very conspicuous decline in basic research on carbonates (none at all) and surprisingly enough only a slight increase in porosity studies even though the Federal Government may soon be a petroleum producer in its own

right. By contrast the Provincial Government agencies, though maintaining their activity in most categories of study, anticipate a very dramatic increase in studies of porosity development and the related fields of diagenesis and sedimentary geochemistry. Further, these agencies, recognizing the financial benefits that may be produced, place strong emphasis on applied research. A similar interpretation can be made upon analyzing the response of the academic institutions where the greatest proposed increase in research activity is in the field of porosity development and/or destruction and diagenesis. The universities are still much interested in carbonates and anticipate a somewhat heightened level of future activity in carbonate studies. The petroleum majors by contrast appear to consider clastics to be the best bet in the future, whereas, they now have a fairly even balance between carbonate and clastic work. The petroleum independents, though not presently very active in research, would like to see an increase in all aspects of basic and applied research on ancient rocks.

It is apparent that the petroleum industry, and to some extent the Provincial Government agencies, recognize the economic importance of sedimentology. The research activities of the petroleum industry tend to reflect what may be deficient in the research activities of others. There has simply not been enough work done on the diagenetic system, on fluvial sediments, on any number of important sedimentologic problems. The petroleum majors, often the first to recognize important developments, tend to work steadily at improving their situation. The Federal Government agencies appear to cover much the same research ground as do the petroleum majors, possibly an example of convergent evolution. The petroleum independents have a relatively low level of research activity yet they too recognize what needs to be done and this is reflected in their proposals for future work. Here, it would seem, is an unfulfilled need that could perhaps be satisfied by industry-supported research and publication of the results. Similarly, the universities could be informed of what petroleum explorationists need to know and by this means less variance in objectives might be attained.

iii) Paleontology

Although the forecast of future needs for research in paleontology indicates a rise of 20 per cent above the current research effort, this figure is less than the about 50 per cent projected for total future geological research needs. Some caution can be introduced into assessment of responses to the questions on indicated future activity in that these are requests for general opinions

and not for an organization's own plans, and some answers may reflect that increased activity is needed, but perhaps largely by other organizations. This factor may be particularly true with regard to future needs for increased activity in basic and applied research in paleontology, which at present almost entirely are met by academic institutions, major companies, and government agencies. Figure 6 summarizes present research activity and future needs according to fields of paleontology. Palynology and micropaleontology dominate present activity, together comprising about 85 per cent of the total.

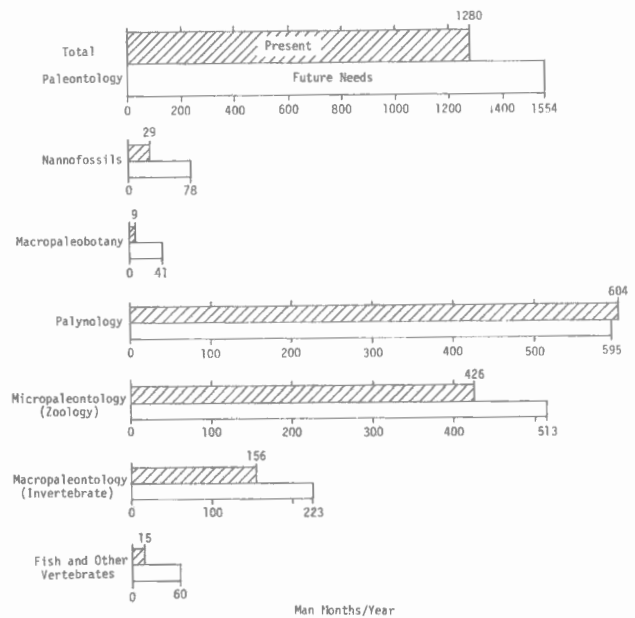


Figure 6. Distribution of Research Effort in Paleontology.

The consensus of the survey is that the current level of palynological activity is sufficient, that the present small amounts of research being conducted in nannofossils, fish and other vertebrates, and macropaleobotany are far too low, and that activities in invertebrate macropaleontology and micropaleontology (primarily foraminifers, conodonts and ostracodes) need to be increased moderately. The responses to the questions of future needs stressed priorities for more basic research in all fields of paleontology and for applied research in nannofossils, macropaleobotany, and fish and other vertebrate fossils. The prime objectives of paleontological research are the biostratigraphic and paleoecological applications to petroleum geology, both in

subsurface and in outcrop, with some application (primarily palynology and macropaleobotany) to degree of metamorphism.

iv) Geomathematics and Computer Applications

Petroleum-oriented geomathematics are for the most part computerized so that responses to questions related to geomathematics and computer applications are related, and may be expected to show parallel trends. However, the survey results forecast a 69 per cent increase in the need for geomathematical research against a 5 per cent decrease in the need for computer applications research. This change in emphasis, mainly by the major oil companies, indicates a swing towards log, reservoir, and remote sensing analysis and away from the large data files that have dominated applications research for many years. There is a continued interest in data banks and improved interactive systems, but most of the problems related to resources appear to have been solved although there remains a great deal to do in implementation. Major oil companies are still interested in improving data files, storage, retrievals, and methods of presentation but indicate that wireline log files need increased emphasis. Future geomathematical research will be primarily directed at log and reservoir analysis as well as remote sensing, hydrodynamics and geothermics.

Independents have similar interests to the majors but suggest an overall decrease in future effort.

Canadian universities are not strongly oriented towards geomathematics but do look at a variety of problems. Their response indicates a change from research in map analysis towards a greater involvement in remote sensing and reservoir studies. They forecast a marked decrease in computer application research. Federal Government agencies indicate a modest increase in future geomathematical and computer application research. However, their forecast is without trend indicating a little bit of effort towards almost everything. They appear to have relinquished their leadership in the drive to organize major computer accessible data files.

Provincial Government agencies propose a slight increase in both geomathematical and computer applications with a modest but continuing interest in multivariate analysis. There is a continuing interest in data files particularly those with a paleontological orientation.

v) Structural Geology

The tabulated results of the CSPG Research Questionnaire indicate that the bulk of the present effort for geologists employed in structural geology is in interpretative research. This research is heavily weighted toward

structural mapping, structural analysis, descriptive analysis, and plate tectonics. Photogeology, remote sensing, and geophysical techniques are the major interpretative tools of the structural geologist. Rock mechanics, model studies, and computer applications have a modest and limited role at the present time. The predicted future need in structural geology shows modest increase (1703 to 2307 man months per year) but the survey indicates a dramatic change in emphasis in a number of categories. The classical areas of structural geology (structural mapping, analysis, etc.) is expected to remain at about the same level and form the bulk of the effort in structural geology. Future developments will emphasize the development of the interpretative tools such as remote sensing, photogeology, rock mechanics, models, and computer applications. A two-fold increase in effort is predicted for photogeology and remote sensing largely by academic institutions and major petroleum companies. A major increase of effort by Federal Government agencies is largely responsible for a predicted two-fold increase in rock mechanics; however, the total effort is still relatively small. Increased effort by academics, major oil companies, and Federal Government agencies results in a predicted two-fold increase in model studies and computer applications.

vi) Subsurface Fluid Mechanics

In all subject categories of this class most of the work is being done by the petroleum majors. All other respondent classes are contributing little to the present effort. Present research in this area amounts to 3.2 per cent of the total research effort and future needs increase this proportion to 9.1 per cent.

Of the types of research, interpretative and applied are given the most emphasis and basic research the least emphasis.

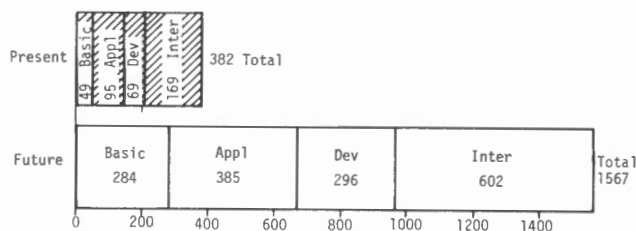


Figure 7. Distribution of Research Effort in Subsurface Fluid Mechanics by Type.

The subject categories in order of increasing importance as reflected by present effort are: osmotic effects, diffusion effects, cation adsorption – exchange, bacterial processes, capillary phenomena, fluid temperatures, sediment compaction, fluid potentials and petroleum recovery.

The questionnaire indicates that research effort should be increased substantially for all categories of research.

Diffusion effects and osmotic effects are seen as being most worthy of increased percentage of research effort in the future.

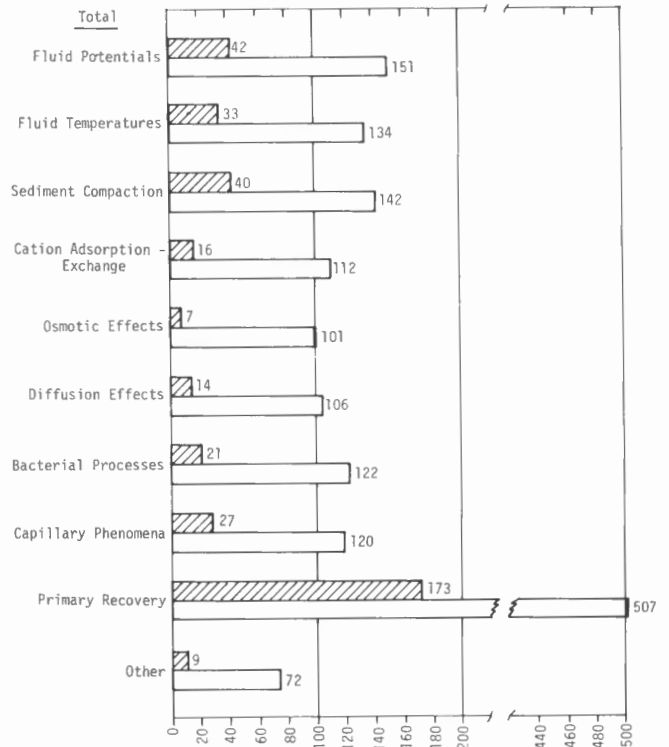
Of all the subjects covered by the questionnaire, studies of subsurface fluids are seen as being the most important for increased future research effort. A 331 per cent increase in effort is indicated as required.

vii) Coal Geology

A review of the survey data on coal geology will be deferred to next year's report when the survey results will appear together with a major appraisal of the state-of-the-art of this subdiscipline.

Figure 8 (opposite)

Distribution of Effort in Subsurface Fluid Mechanics by Sub-Category.



Commentary on Report of CSPG Research Committee

"Research in the Earth Sciences Relating to Canadian Petroleum Exploration Geology"

The Editorial Subcommittee (C. R. Barnes, T. E. Bolton, G. D. Garland) invited brief reviews of the CSPG Report from Dr. F. K. North, Carleton University, Ottawa and Dr. L. W. Vigrass, University of Regina, Regina. Observations by these two petroleum geology specialists have been combined with those of the Subcommittee to provide a commentary on certain aspects of the Report. The CSPG Research Committee, chaired by E. R. Parker, is to be congratulated on this bold first attempt to provide a detailed assessment of current and future research activity in Canadian petroleum exploration geology. The authors of the Report emphasize that the results cannot be used quantitatively, despite the bulk of collected data. This underlines the difficulty of preparing quantitative analyses of sectors of the geoscience community. With the CSPG and much of the petroleum industry based in one city (Calgary), the organizational problems in conducting the study should have been at a minimum. Future studies of other sectors will lack this advantage but will be able to adopt and build on the mode of analysis developed by the CSPG Research Committee. Our commentary on the Report considers aspects of the methodology and of the results obtained.

a) Accuracy of Questionnaire Results

In a study of this type, using a specially designed questionnaire, the results must be judged carefully.

The data are presented with little qualification. From the illustrations provided in the report, anomalies are evident. First, the term "respondent" is ambiguous for in Table I (Educational Level of Respondents) and elsewhere graduate students and technical and support staff appear to have been included. The low proportion of Ph. D. 's in the Academic and Government sectors is anomalous; further four Federal Government agencies report twenty of one hundred and six petroleum geologists have Ph. D. 's but elsewhere the same agencies report their average hiring rate for Ph. D. 's during the past five years has been twenty-two per year. Second, in Table IV, only 50 per cent and 55 per cent of basic and applied research respectively is reportedly done in Canada by the Federal Government. This is clearly suspect and other results may be biased by the weighting factors selected for the questionnaire. For example, the reply from a company with two geologists may be given the same weight as one from an agency employing fifty geologists. Third, it should be understood that the estimated future needs (Figs. 4 to 8) are estimates for the discipline areas rather than for the institutions performing the research. These "needs" may be related more to ideal situations than to planned expansion or redirection.

b) Definition of Research

The authors of the CSPG Report used the term for all six categories of scientific activity defined by the Blais Commission (Science Council of Canada, Special Study 13, 1971). This broad definition of research must be emphasized for some readers may view research, and thus the data, differently and future similar surveys in other sectors may adopt an alternative definition.

c) Present Activity and Future Research Needs

Two-thirds of the research reported was done in Canada with total effort estimated at about 1000 man/years per year. About 70 per cent of all research reported consists of collection, interpretation, and information; only 25 per cent can be called either basic or applied research, with a further 5 per cent as development. Hence, by far the most significant and interesting work is an outgrowth of drilling for this is the source of much data. Fields more familiar to non-petroleum geologists receive less attention, and the work reported for them is not at an impressive level. Understandably, very little of the research reported is performed in universities (in petroleum geochemistry hardly any of it), and there has been a perceptible shift of interest towards staff scientists with lower degrees.

The pattern of relative distribution of research subjects shows little major change for the future. With the exception of a desired increase in Fluids research (3 to 9 per cent) and Coal research (3 to 6 per cent) and a surprising drop in Computer Applications research (15 to 9 per cent), all other research areas vary by 2 per cent or less with Sedimentology remaining the dominant element.

The overall desired increase in research for the future ("future" being a term requiring greater definition) exceeds 50 per cent of the present level. The implications of this, in terms of manpower, can be derived from the data in Figure 5 and indicate that an increase of this order is equivalent to 6000 man months per year, i. e. 500 additional geoscientists. As indicated in section 'b' above, the accuracy of this expected need may be questioned. The future demand will also depend on a favourable economic climate for increased exploration activity.

In the chapter of the survey report on "Interpretation of Returns by Subject Class", the reports on the several sub-disciplines vary greatly in mode of presentation. Some reports are logical and lucid; others are not. The illustrations accompanying the paleontology report (Fig. 6) and the fluid mechanics report (Figs. 7, 8) are each worth one thousand words; it is regrettable that similar illustrations were not prepared to present the data on the other sub-disciplines.

In the field of sedimentology, the Canadian contribution is minor with only two of twelve references listed for research in this sub-discipline being Canadian. The emphasis has switched to deltaic and fluvial processes and strongly away from basic research on carbonates, except in the universities. The section devoted to structural geology is so general as to be quite uninformative. Research in paleontology is dominated by interest in palynology and micropaleontology; the few publications referred to are all Canadian, and all concerned with the Arctic. In geochemistry, only a little over one-third of the publications listed are at all directly Canadian. For geomathematics (which for the purposes of this report surprisingly includes remote sensing), a need is emphasized for the compilation of digital well logs into data base files. This has led to striking advances in data base management through sophisticated new devices, but no indication is given of how much of this applied research is Canadian, and a general movement away from computer applications is acknowledged.

The research done on data and material derived from drilling operations is considered under the broad heading of Petroleum Geology. Most striking are developments in logging, porosity and compaction studies, and an all-round increase in interest in subsurface fluids in general (causes of geopressuring, gas hydrates from Arctic wells, alteration of hydrocarbons within the reservoir and similar topics).

An apparently puzzling anomaly is evident. Although the report deals largely with research relating to petroleum exploration geology, there is no substantial reference to the most vital and contentious issue currently facing the petroleum industry in Canada: the understanding of still-undiscovered resources of oil and gas, and what exploration to date has taught the petroleum geologists about the probabilities of our Frontier regions yielding these in prolific quantities. Ten Canadian specialists were among the delegates invited to the American Association of Petroleum Geologists conference on this topic during 1974. The proceedings of this conference have already been published, but no reference is made to them — despite numerous references to other highly successful and praiseworthy conferences and symposia.

This is the first systematic and comprehensive survey of the Canadian petroleum industry to determine level and distribution of geological research. Despite a distrust of the quantitative assessment following from the survey, the authors have succeeded in their objectives: to provide an indication of who is doing what in petroleum geological research and to show what the industry considers is needed in the near future. Both specialist and non-specialist should find the report worthy of study.

BRIEF SUMMARY OF SOME KEY DEVELOPMENTS IN CANADIAN GEOSCIENCE

RECENT ADVANCES IN APPLIED RESEARCH
IN THE MINERAL INDUSTRY

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The depressed state of base metal markets during 1975 led many mining companies and service organizations of the private sector to concentrate their research efforts on the geological, geochemical and geophysical aspects of uranium and precious metal deposits.

Focal points of interest in uranium geology were the eastern margin of the Athabasca Sandstone in Saskatchewan, the Proterozoic clastic sedimentary rocks of the Baker Lake district, Northwest Territories, and certain granitic rocks of the Johann Beetz area, Québec. Extensive geological mapping and geochemical surveys were carried out in these areas.

Geological studies applied to the search for gold deposits were carried out in the traditional gold mining camps of Ontario and Québec, with attention being directed towards elucidating the genetic and spatial relationships between gold deposits and the ultramafic to felsic volcanic rocks.

Geological and geophysical work aimed at finding massive sulphide deposits in Archean volcanic rocks was concentrated in the northeastern half of the Abitibi greenstone belt, in the Slave Province, and elsewhere in the Northwest Territories, with the emphasis placed upon definition of felsic volcanic centres in areas where these important features had not been recognized previously.

In mining geophysics there were no radical new developments but rather a continued effort to improve existing systems, both ground and airborne. With increased emphasis on uranium exploration, much of the development work was devoted to radiometric equipment, resulting in a considerable increase in the range of available instruments. Electro-magnetics, however, was the only field in which new systems that reached either testing or production status, showed potential for significantly improving performance.

The McPhar Instrument Corporation flight-tested their Quadrem Five Frequency Quadrature phase system. The use of multiple frequencies is designed both to improve depth penetration under a wide range of overburden conditions and to enable the system to map flat-lying near-surface layers.

The Apex Parametrics Ltd. Maxmin II ground EM equipment reached production status. In this instance, the availability of four operating frequencies, excellent power line rejection and up to 800-foot coil separation permit exploration for deep targets under the most adverse conditions.

RECENT TRENDS AND
SIGNIFICANT RESULTS IN GEOPHYSICS

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The Canadian situation in all branches of geophysics is thoroughly described each year in the Canadian Geophysical Bulletin, published by the National Research Council. Unfortunately, the most recent issue, Volume 27, December 1974, became available so late in 1975 that its usefulness was seriously diminished. This account will comment upon the trends and results suggested by a reading of Volume 27 from those areas of geophysics relevant to CGC: solid earth and exploration.

All earth science activity requires a knowledge of position on earth, and it is encouraging to note that the Geodetic Survey has developed a National Positioning Control Survey Data File, by which any person requiring position control can readily obtain it. Research in theoretical geodesy has now developed in two universities: New Brunswick and Laval, reversing the trend which saw its virtual disappearance in Canada a few years ago. A knowledge of variations in sea level is of great importance in solid earth science as well as in oceanography, and use is being made of oil drilling rigs on the continental shelves to provide platforms for tide gauges in the open seas. Regional coverage by gravity surveys continued, and among the structural studies carried out by gravity, the effect of loading of the lithosphere received attention. Thus, anomalies over the Sverdrup Basin suggested that most of the depression was produced by loading of a viscoelastic plate, while very prominent positive anomalies along continental shelves are now attributed to uncompensated sedimentary loads. Density logs from four hundred and thirty-five wells have been correlated, to provide new and more representative information on the density of sedimentary formations.

In earthquake seismology, the use of the array of seismometers continued to increase. Canadian scientists used the Yellowknife array for studies of both the upper 800 km of the mantle, in which important lateral inhomogeneity was detected, and of the core-mantle boundary, where scattering of waves by irregularities was observed. More portable arrays were in use at Mica Creek, British Columbia, in Alberta, near London, Ontario, and in Eastern Canada. The seismicity near Mica Creek was impressive, with 1233 events being recorded on a single fault near the damsite; the activity is apparently not related to reservoir loading. Studies of individual earthquakes are important, particularly within the North American plate, where they are infrequent and statistics are poor. Thus, the investigation

of a single earthquake on the Quebec-Maine border is significant, because it occurred outside of the recognized areas of seismicity, and also because a focal mechanism was obtained: strike-slip on a plane striking either N40°E or N37°W. In seismic crustal studies, large explosions from mining operations continued to be used, but a significant discovery was that "Vibroseis", an earth thumper, could be used as a source, even to depths of the lower crust and upper mantle.

A moderate amount of activity in theoretical seismology and in high pressure studies was reported. Only one laboratory is recorded as working at truly mantle pressures, but significant results were obtained by it, particularly on the effect of water on the electrical conductivity of olivine. In heat flow, there was more emphasis on permafrost studies and on interpretation, than on new measurements outside of the permafrost area.

New developments in the mapping of the geomagnetic field included coverage over the continental shelves, and the discovery of a major anomaly crossing the Grand Banks. The relationship of this anomaly to fracturing caused by a continental collision has been suggested. Geomagnetic induction studies to detect areas of anomalous electrical conductivity continued to play an important role. A most interesting project was the measurement of the coast line effect over the shelf north of Banks Island, by the placing of recording magnetometers on the ice, on a line extending 272 km to sea. In other studies, the recognition of conductivity anomalies in the crust, in addition to those of probable mantle origin, was a common factor. Paleomagnetic measurements placed emphasis on the extension of polar paths into the Precambrian, through Grenville time to the interval 2200-1800 m. y. A coherent polar wander path, for the latter time for both the Slave and Superior Provinces is evidence that these provinces were connected, by the rocks of the Churchill Province, and did not act as separate plates. Ocean floor samples from Legs 34 and 37 of the Deep Sea Drilling Project were received by Canadian laboratories, and paleomagnetic work continued on lunar samples. Some theoretical work on the origin of the earth's magnetic field was reported, as well as some of the first Canadian experimental results in hydrodynamics applied to the core. The latter were directed toward the motions produced in a decelerating rotating fluid, and to oscillations of a stratified rotating fluid; both experiments will be extremely relevant to the geomagnetic dynamo, if it becomes established that the core is gravitationally stable.

Activity in glaciology included field studies in about 2 dozen distinct glacial areas, as well as theoretical studies of flow and response to climatic change. Temperature measurements on one surging glacier, the Steele, indicated remarkably "warm" ice, but whether or not this is the result of the surge is not yet known.

Isotope and geochronology laboratories have devoted some of their efforts to isotopic measurements as applied to environmental studies. No dramatically new techniques appear to have evolved, but the refinement of the relatively new ⁴⁰A/³⁹A method, and especially its

application to very young rocks, continued. As in the case of paleomagnetism, the first JOIDES samples were received by Canadian age laboratories.

The Bulletin contains a rather long chapter on Volcanology. Much of this, however, relates to the petrological study of ancient volcanic rocks, and is fully as geological as it is geophysical.

Finally, an interesting chapter deals with aspects of research and operational activity in applied geophysics, both mining and petroleum. In mining applications, research was conducted by universities, government and industry, with emphasis on borehole exploration, and multiple (including audio) frequency electromagnetic methods. The total dollar activity of the Canadian mining geophysics industry was estimated to be \$21.3 million in 1974, up from \$18.0 million in 1973. Of this amount, \$13 million was for aerial surveys, offered by thirteen companies, and approximately half of the total represented sales outside Canada. Fifteen companies were producing geophysical instruments for sale.

In connection with petroleum exploration geophysics, virtually nothing is said of industry-based research in Canada. The operations side in 1974 was depressing, with activity down to four hundred and forty-two crew-months, from a peak of nine hundred and forty-one crew-months in 1967. The article states: "one of the most distressing features of the declining exploration activity is the migration from Calgary of many highly-skilled and technically competent professionals, representing expertise which has been built up over a period of twenty-five years of steady exploration effort". The contrast between the mining and petroleum geophysics situations is thus apparent, with the Canadian-based mining geophysics industry able to maintain and increase its activities through the sale of its expertise and instruments abroad.

The overall impression of the entire solid-earth geophysics scene in Canada during the year under review is that activity was at a high level, with an encouraging number of significant results, in spite of the continuing decline in the real value of research support. Probably the latter was responsible for a shift in emphasis from major expedition-type data gathering projects or the establishment of major new laboratories, to the thoughtful interpretation of data already acquired.

CANADIAN PARTICIPATION IN INTERNATIONAL PROJECTS

International Geological Correlation Program

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Carleton University, Ottawa, Ontario

The International Union of Geological Sciences together with UNESCO recently established the International Geological Correlation Program (IGCP). The program is a co-operative venture designed to facilitate

and encourage international co-operation in research projects, yet is not itself a source of research funds.

In 1973 the International Board divided the scope of IGCP into four divisions and established a Scientific Committee for each. These divisions were as follows:

1. Time and stratigraphy: the practical implications.
2. Major geological events in time and space, and their implications in environmental processes.
3. Distribution of mineral deposits in space and time and relation of the processes of ore formation to other events in earth history.
4. Quantitative methods and data processing in geological correlation.

At the 1975 Board meeting in London, particular emphasis was placed on four "priority areas", which have now been defined in the following terms:

1. Methods of time determination.
2. Evolution of the Earth's crust, with special emphasis on the Precambrian.
3. The Quaternary (the geological environment).
4. Sources of energy and minerals.

The projects so far sponsored by the program are set out in two Newsletters issued by the Canadian National Committee in 1974 and 1975. Canadian earth scientists are involved in fourteen of them, and may become involved in several of a dozen new ones recently approved.

The project farthest advanced, into the active publication stage, is that on Circum-Pacific Plutonism. Others with large and very active Canadian participation include the Caledonian Orogeny, the Correlation of Caledonian Strata-bound Sulphides, Correlation of the Precambrian in Mobile Zones, Archean Geochemistry, Ophiolites, and Quaternary Glaciations in the Northern Hemisphere. At somewhat less advanced stages of organization and development, but nonetheless with active Canadian involvement, are the projects on the Precambrian-Cambrian Boundary, Ecostratigraphy, Pre-Pleistocene Tilloids, Mid-Cretaceous Events, Holocene Sea Levels, and Ore Deposits Separated by Continental Drift.

International Geodynamics Project

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The Third Report by the Canadian Geodynamics Subcommittee was published in 1975. The twenty-three-page report provides a concise review of the background, current work and future objectives of Canadian participation in the International Geodynamics Project (IGP). In particular, it notes the new developments in instrumentation that are being used to advance sophisticated geophysical observations. The report of the Committee clearly indicates both active and leading Canadian

participation in most areas covered by the IGP. The following outline of the current involvement by Canadian geoscientists in the IGC is abstracted from the introduction to the Third Report.

The scope and broad objectives of a program for Canadian participation in the International Geodynamics Project were outlined in the Second Report by the Canadian Geodynamics Subcommittee, published by the Earth Physics Branch of the Department of Energy, Mines and Resources in 1972. The program is a comprehensive one that embraces most of the complete spectrum of research in the Solid Earth Sciences in Canada. It emphasizes interdisciplinary participation, and is focused on the identification and measurement of current and past motions of the Earth's crust, and the determination of the causes of these motions. The program consists of seven broad areas of research:

- (1) maintenance and development of expertise in the measurement and interpretation of short-term ground motions;
- (2) studies of the deep-seated causes of motion, including the rheology and other physical and chemical properties of the mantle, and theoretical studies of lithosphere plate motion;
- (3) determination of the nature and significance of recent movements associated with the St. Lawrence seismic zone;
- (4) analysis of the volcanic, sedimentary and metamorphic history, time-space relationships, and tectonic environment of the Appalachian, Cordilleran and Innuitian fold belts and their adjacent ocean basins;
- (5) determination of the nature and significance of the principal tectonic subdivisions of the Canadian Shield;
- (6) analysis of the tectonic and compositional evolution of the lithosphere based on comparative studies of Archean, Proterozoic and Phanerozoic rocks; and
- (7) the establishment of more accurate time scales.

There have been important changes in the nature and scope of Canadian participation in the International Geodynamics Project since the Second Report of the Canadian Geodynamics Subcommittee was prepared. A significant part of the Canadian effort in the Geodynamics Project has become closely integrated with the activities of various ICG Working Groups, and several aspects of Canadian research in geodynamics which were considered only very briefly in the Second Report are now recognized as important components of the Canadian program, whereas other areas of research which were considered separately in the Second Report have become more closely integrated.

These changes, which are part of the normal evolution of any scientific research program, have made it necessary to reorganize the framework within which Canadian contributions to the Geodynamics Project can be reviewed and future Canadian activities can be planned. Current activities pertinent to the Geodynamics Project are broadly distributed among

various federal and provincial government agencies, most of the larger Canadian universities, and many mining and petroleum exploration companies. Five main areas of current research activity have been identified:

(1) Global dynamics, including studies of rotational dynamics, the gravity and magnetic fields, and core dynamics;

(2) Short-term motions and deep-seated causes of motion, including studies of earth tides, post-glacial uplift, precursory phenomena of earthquakes, recent seismicity, and rheology and dynamics of the lithosphere and upper mantle;

(3) Crustal evolution, analysis of tectonic and compositional evolution of the lithosphere based on comparative studies of the record of Archean, Proterozoic and Phanerozoic rocks, including the role of lithosphere plate motions, geochemical evolution, and the nature and significance of variations in physical and chemical properties of minerals and mineral assemblages from the crust and upper mantle;

(4) Phanerozoic fold belts and their adjacent oceans, determination of the volcanic, sedimentary and metamorphic history, time-space relationships and geotectonic implications of the Appalachian, Cordilleran and Inuitian fold belts and their adjacent ocean basins; and

(5) Canadian Shield, determination of the nature and global tectonic and evolutionary significance of the principal tectonic subdivisions of the Canadian Shield.

Deep Sea Drilling Project, Leg 37,
and Deep Drill 1974: A Progress Report

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Oceanic crustal material collected during the 37th voyage of the Deep Sea Drilling Project's drill ship *Glomar Challenger* was studied by eighty-seven principal investigators from universities and research institutions around the world. Canadian investigators comprised more than half this group. The Deep Drill 1974 team at Dalhousie supported the overall program by creating a computer compilation of all results providing invaluable aid in integrating data from the various labs into a comprehensible form for synthesis into the cruise report, the initial reports of the Deep Sea Drilling Project Volume XXXVII.

The background of DSDP Leg 37 and Deep Drill 1974 by now is familiar to most Canadian geoscientists. For the six years prior to Leg 37 the DSDP had sent the *Glomar Challenger* around the world's oceans on a program of reconnaissance sediment coring. During that period, for a number of factors, but mainly as a result of technological difficulties little serious attempt was made to penetrate and obtain a section through Oceanic Layer 2. With the advent of hole re-entry capability and at the urging of an interested sector of the world's scientific community (especially from the group in Atlantic Canada) the Deep Sea Drilling Project scheduled a multiple re-entry deep-penetration leg.

They planned for a single site to be drilled on the Mid-Atlantic Ridge at 37°N latitude some 30 km to the west of the site of the French-American mid-ocean undersea study (FAMOUS) dives. The National Research Council of Canada funded a series of individual proposals by investigators within Canada for analyses of material from this drilling and provided a large grant to Deep Drill 1974 to perform independent research to co-ordinate the activities of the entire Canadian group, and to interface with the Deep Sea Drilling Project.

Actual drilling was accomplished in June and July, 1974. The original goal of a single 1000-m penetration was not realized due to the failure of the casing at the primary site, 332B, causing the hole to be abandoned at a depth of 721.5 m subbottom (579 m into Layer 2). However, the remaining drilling time was utilized to drill three more deep crustal penetration holes on a 200 km transect across the American Plate on a line parallel to the spreading direction.

Starting with the receipt of core material in Halifax in August 1974 and continuing through the Fall and Winter 1974-1975, these were reviewed, classified, and data extracted for computerization. A second conference of shipboard scientists was held at Dalhousie University, 2-6 August 1975, when all papers submitted were reviewed and synthesis of results began. This synthesis will be completed by December 1975 with publication of the initial reports volume scheduled for Spring 1976.

The sheer bulk and variety of the individual studies involved in the overall program prohibits detailed discussion here of the efforts and intriguing findings of the Leg 37 researchers. However, the principal results can be summarized as follows:

1. Demonstration of the complexity, both horizontally and vertically, of Oceanic Layer 2.
2. Correlation of marine geophysical data with actual rock types and their occurrence.
3. Delineation of the thickness and complex magnetic properties of the oceanic layer producing the linear magnetic properties observed at sea.
4. Discovery of ultramafic rocks at shallow depth beneath disturbed pillow lava sequences, site 334.
5. Understanding of the make-up and origin of the subdivision of Layer 2 and into 2A and 2BM.
6. For the first time, a complete set of oceanic basalts with their complex geochemistry is in hand permitting us to determine the process of magma genesis beneath an active spreading centre.
7. The evaluation of the effects and extent of basalt sea water interaction beneath the deep ocean floor.
8. Verification of increasing basement ages with distance from the axis of a spreading ridge using fission track dating techniques, enables correlation with paleontologically and paleomagnetically inferred ages.

GOVERNMENT RESEARCH

Geological Survey of Canada, Department of Energy, Mines and Resources

J. O. Wheeler, Deputy Director General,
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Program Rationale

The Geological Survey of Canada is charged with providing a comprehensive inventory and understanding of the geology of Canada as a basis for national planning and policy making. Its main objectives follow seven major thrusts directed to: ascertaining Canada's energy and mineral resources; facilitating exploration and development; encouraging regional development; promoting effective use of the Canadian terrain; identifying and assessing natural hazards; identifying geological features affecting environmental equilibrium; and disseminating information on Canada's landmass and the resources it contains.

To meet these objectives the Geological Survey's program is directed towards four main areas of concern: the geological framework of Canada, including its off-shore regions; identification of resources available in Canada; quantitative appraisal of these resources; and on-going development of technology to improve the identification of the geological framework and its contained resources.

The geological framework is mapped and described by systematic aeromagnetic, multiparameter offshore, and bedrock and surficial geological surveys. These are commonly at a scale of 1:250 000, although when required more detailed scales are used. The surveys are enhanced and complemented by specialized regional studies employing petrological, structural, paleontological and stratigraphic research, isotopic age and paleomagnetic determinations, and the measurements of chemical, physical, and engineering properties of earth materials. All these provide a more perceptive understanding of the geological framework and of the processes involved in its evolution.

The information and concepts derived from the surveys and specialized regional studies form the base for the Resource Identification and Resource Appraisal studies that are essential if we are to know the mineral, energy and terrain resources available in Canada.

Resource Identification studies include the determination of the nature and classification of the deposit-types of mineral and fuel commodities and construction materials and the recognition of the geological settings favourable to their occurrence. They also include the regional geochemical and airborne gamma-ray spectrometry surveys used in the Uranium Reconnaissance Program by which regions with anomalously high background of trace elements may be identified.

Resource Appraisal uses all information available to provide quantitative determinations of the potential abundance and probable distribution of mineral and fuel resources. Similarly, Terrain Evaluation requires an inventory of the terrain in Canada and an assessment

of its susceptibility to natural hazards and of its capability for various types of use.

Technological Development begins with several years of research and development leading to the production of a prototype instrument or equipment. When the prototype has been sufficiently tested and considered suitable for systematic use the technology is transferred to industry and the systematic work undertaken by contract.

New Programs

Three new programs were introduced in 1975 by the Geological Survey of Canada. The Uranium Reconnaissance Program has been designed to provide high-quality systematic reconnaissance data relating to the distribution of uranium in Canada to serve as a guide and incentive in exploration for new deposits and to provide a basis for national uranium resource appraisal. The principal operations are federal-provincial shared cost, contracted airborne radiometric and lake- and stream-sediment geochemical surveys. The Geological Survey is undertaking preliminary orientation and feasibility studies as required, as well as on-going R&D activities related to methods of uranium exploration.

The Subsurface Radioactive Waste Containment Program, funded largely by Atomic Energy of Canada Limited, embraces an appraisal of (1) salt deposits and (2) barren, compact granites that may be suitable for the storage of radioactive wastes. The first phase of this program consists of an evaluation of regions of Canada for suitable sites for storage of waste and the selection of potential sites. The second phase will concern the detailed evaluation of selected sites.

The third new program consists of a shared cost Canada-Manitoba Non-Renewable Resource Evaluation Program. It is a four-year program concerned with the inventory and appraisal of mineral resources, largely base metals, in the Precambrian Shield of Manitoba.

Highlights of Results and Discoveries

Some results and discoveries that have enhanced our knowledge of the geological framework of Canada are outlined below.

Highlights from Regional and Economic Geology Division follow:

- 1) An important unconformity was noted for the first time in the western Bear Province between approximately 8000 feet of Aphebian (?) volcanics and sediments and a granitoid basement. The age of the basement is not known although material has been collected for age determinations. To the east, in the Slave Province at a locality on Point Lake, basement to Yellowknife Supergroup is about 3 billion years old based on U/Pb on Zircon. Current work is defining the existence and distribution of basement to the oldest known supracrustal rocks of the Slave Province. Although such a basement has long been postulated it

is now for the first time being defined and mapped in a number of areas.

2) Studies on central Baffin Island of the stratigraphy and metamorphism of the Piling Group and its relations to the basement show intense structural involvement of the basement along the northern and southern limits of the basin. Marble units of the Piling Group are largely confined to the northern limits of the exposures of Piling Group sediments. The central and southern part of the basin is characterized by grey-wackes with some volcanics and scattered iron formation. Metamorphism in the stratigraphically younger units in the central part of the belt reach lower amphibolite grade whereas uppermost amphibolite and, in the south, granulite facies assemblages are found along the edges of the basin. This study is establishing the sequence of deposition, deformation and metamorphism of a Precambrian belt extending from a point southwest of Melville Peninsula, northeast across Baffin Island and perhaps to Greenland, a distance of over 600 miles.

3) Studies in the Kirkland-Larder lakes - Timmins region of Ontario has shown correlation of Temiskaming Group, Highway 11 Basalts and Boston Iron Formation with stratigraphic equivalents in the Midlothian region to the west. It is probable that further work will show correlations throughout the region between Timmins and Kirkland Lake. These correlations over an extensive region of Archean stratigraphy in a mining camp characterized by stratabound mineral deposits has considerable importance for future exploration.

4) In central British Columbia, operation Takla brought together a number of geologists with varied expertise to study and sort out problems of structure and stratigraphy in rocks ranging in age from Precambrian to Tertiary. In particular the operation focussed on the late Triassic and early Jurassic in view of the numerous copper showings discovered in rocks of these ages. The Takla Group as a result of this work is confined to rocks of Triassic age, dominantly of marine depositional origin with local reddish coloured, subareal eruptive volcanics in the more northern exposures. These reddish coloured volcanics contain most of the copper prospects. The Hazelton Group, of Jurassic age, consists of a lower non-marine volcanic and volcanoclastic unit and an upper marine volcanic and sedimentary unit. Thus the work has served to work out some of the confusion that has heretofore obscured relations between Hazelton and Takla Group rocks.

5) Other work of the Division centred around geochronology using K/Ar, Rb/Sr, and Pb/U methods through sampling in well-defined problem areas in close integration with field studies. Results have broad implications not only in establishing stratigraphic and igneous successions in individual areas but also for broad regional correlations. For example U/Pb determinations on Zircon from acid volcanic rocks of Archean age from such widely dispersed areas as the Abitibi Belt, the Kaminak Lake region of central Keewatin, the Prince Albert Group of Melville Peninsula and the Yellowknife Supergroup of the Slave Province all show roughly contemporaneous acid volcanism at about 2700 m. y.

The Institute of Sedimentary and Petroleum Geology reports as follows:

6) Seven maps, at a scale of 1:250 000, of parts of Mackenzie Arc in Yukon and Northwest Territories not only delineate major structural elements but also document mineral occurrences in relation to their stratigraphic setting.

7) Significant biostratigraphic reports include a revision of zonation for Middle and Lowest Upper Devonian strata of central Mackenzie Mountains, a report on Middle Ordovician conodonts of Ottawa-Hull area and Carboniferous Ammonoids of the Arctic Archipelago.

8) Spectacular examples have been described of Upper Paleozoic rocks in the Sverdrup Basin which exhibit facies changes from red beds, through evaporites, shelf carbonates to basinal carbonates and shales and also of gravity slide megastructures in deep-water carbonates.

Terrain Sciences Division notes the following:

9) In order to provide background information relative to petroleum exploration and development and other land use activities in the Arctic Islands terrain inventory mapping was carried out on Banks Island, Bathurst-Cornwallis Islands and Somerset-Prince of Wales Islands covering an area of some 61 000 square miles.

10) Study of a refugium in the northern Yukon (Old Crow Basin) in an area where some of the oldest (between 20 000 and 30 000 years B.P.) radiocarbon dated traces of man have been found in North America, involving stratigraphic and paleontologic (fossil plants and insects) investigations and with archeologists and botanists of other agencies.

Progress in Resource Identification studies and Resource Appraisal was marked by the following:

11) As part of its objective to make a comprehensive inventory of non-renewable resources of western and Arctic Canada, the Institute of Sedimentary and Petroleum Geology has prepared a second major evaluation of Canada's hydrocarbon resources. In addition an assessment of the major coal deposits of Saskatchewan, a joint federal-provincial project, is in final stages of completion. In the field of mineral deposits, strata-bound lead-zinc deposits of Northeastern British Columbia, Yukon and Northwest Territories have been shown to occur in Devonian rocks close to a facies change from platform carbonates to basinal shale.

12) A major advance has been made by establishing that pore fluids expelled during the diagenesis of clay minerals have possibly given rise to the movement of hydrocarbons and mineral-bearing fluids in sedimentary rocks. Criteria have also been developed by which it is recognized that such diagenesis has taken place.

13) Economic studies by Regional and Economic Geology Division continued on all major commodities,

with new efforts directed toward evaluation of Uranium resources. A start has been made in accumulating and integrating all information available in the Selwyn Basin – Mackenzie Mountains to develop a metallogenic model in which mineral occurrences are related to specific stratigraphic units and to the regional patterns of deposition of the Lower Paleozoic succession.

Significant work on terrain performance and programs undertaken by Terrain Sciences Division includes:

14) A series of seventeen maps at 1:50 000 scale have been compiled for the Ottawa Valley area defining the areal extent of the landslide susceptible "Leda Clay" and the location of major landslides to provide environmental-engineering geology information for geotechnical consultants and regional planners.

15) Activities related to the Beaufort Sea Project included investigations related to shoreline studies of permafrost and coastal processes, sea bed scour by drift ice and of sediment dispersal in suspended matter and bottom sediments in order to assess the environmental status of the region and the impact of proposed exploratory drilling for oil and gas.

16) Studies of the seasonal sedimentation dynamics of the Fraser Delta tidal flats and delta slope in order to provide a better understanding of and for predicting stability and sensitivity of these areas as background required for urban and industrial development.

17) Bottom sampling and offshore surficial geologic mapping on the continental margin off southwestern Vancouver Island, jointly with DOE Resource Charting Cruise. Data collected revealed areas with concentrations of gravel and sand of particular interest in view of the need for aggregate by the British Columbia construction industry.

18) Results of major studies of beach dynamics by Atlantic Geoscience Centre (AGC) on Magdalen Islands completed in 1974 were published during 1975. The beach was studied during August and November periods and major changes in morphology have been interpreted in terms of wave action and other environmental factors.

Participation by Geological Survey scientists in externally funded deep sea investigations:

19) Three legs of the Deep Sea Drilling Projects (DSDP Legs 41-43 and 44) have been of great significance in elucidating the history of the East Coast Continental Margin. L. Jansa of AGC participated in Leg 41 which drilled offshore West Africa where the eastern half of the Nova Scotia Sedimentary Basin is located. F. Gradstein of AGC participated in Leg 44 which drilled off Cape Hatteras a complete sequence of Jurassic Foraminifera.

20) Sea floor photographs and samples of turbidite sediment were recovered by scientists of Terrain Sciences Division from the Arctic Ocean abyssal plain in water depths of 3700 to 3800 m working from the sea ice at the camp of the Arctic Ice Dynamics Joint Experiment (AIDJEX).

Progress in the development of technology and data systems include:

21) A joint industry-government project between Atlantic Geoscience Centre and HUNTEC has been initiated to develop an on-line survey system for the evaluation of geotechnical properties of the sea floor. The seismic reflection equipment comprises a deep-towed sound source of a boomer design. The boomer has special characteristics which greatly increase the resolution of surficial layers. The first use of this equipment was to provide bedrock control which has greatly increased the efficiency of subsurface bedrock sampling with the BIO drill.

The highlights of the Resource Geophysics and Geochemistry Division during the past twelve months may be summarized under three main headings:

- i) Increased productivity per man-year in the area of systematic data gathering;
- ii) Innovations in the realm of data gathering systems and data reporting formats;
- iii) New applications for geophysical techniques in the solution of geological problems.

The number of line kilometres of aeromagnetic survey flown under the Federal-Provincial program has increased appreciably over the 1973/74 period from 250 000 line km to 275 000 line km. All together 243 new aeromagnetic maps at a scale of one mile to one inch or larger were issued.

22) As part of the new Federal-Provincial Uranium Reconnaissance Program, 70 000 line km of production have been achieved during the summer of 1975. This consisted of 36 000 line km undertaken by contractors in the District of Keewatin, at a wide line spacing of 25 km, with the remaining production in the provinces of Saskatchewan, Manitoba and Ontario at 5-km line spacing. Release of this data in map form will take place during the early part of 1976.

23) As another contribution to the Uranium Reconnaissance Program, the 50 000 km² lake sediment geochemical survey undertaken in 1974 was completed in the summer of 1975 with the open filing of all results. This work was contracted out under specifications developed from earlier experimental surveys by the Geochemistry Section. Two similar contracted surveys amounting to another 50 000 km² were completed as far as sampling was concerned in the Northwest Territories during the summer of 1975. Several geochemical orientation surveys were carried out in various parts of the country in preparing for future programs.

24) A twin-boom gradiometer system was installed on the GSC experimental aeromagnetic survey aircraft. Test surveys with this unique equipment have shown substantially improved resolution by comparison with data obtained with a single sensor magnetometer, thus making easier a clear differentiation of near surface

magnetic features from deep seated ones. This development offers promising applications both for detailed geological mapping and mineral exploration.

25) Combined applications of the seismic and electrical methods in the study of permafrost on land, have greatly improved the reliability of interpretation. Detection of submarine permafrost has been greatly facilitated by recognizing the information contained in first seismic arrivals.

26) Significant new developments have been made in co-operation with the Communications Research Centre, with the construction of a radar soil-moisture measuring device. This promises to be relatively simple and lightweight equipment and there are indications that apart from direct applications in agriculture, forestry, and civil engineering problems, this information which can be obtained from an aircraft will be of use in applying corrections for absorption of gamma radiation by soil moisture.

27) A portable weather satellite receiver station has been developed in collaboration with the Polar Continental Shelf Program, as a means of monitoring the distribution of cloud cover, and checking weather forecasts, in remote areas of the far north. This has proved already that it can provide instant information to improve the safety of aerial and marine navigation in the north.

Earth Physics Branch, Department of
Energy, Mines and Resources

E. B. Manchee, Program Officer,
Earth Physics Branch, Ottawa, Ontario

Recent developments in the work of the Earth Physics Branch include the following:

a) The results of the microseismicity study conducted in the summer of 1974 in a 5000 km² area around La Malbaie, Québec, have been analyzed and interpreted. Very accurate hypocentral determinations have been made and for the first time fault plane solutions of events in the area have been obtained. It will thus be possible to define the boundaries of the active zone with good precision and elucidate the tectonics of the area.

b) The "Vibroseis" technique has been successfully adopted to deep crustal studies, to depths of the order of 40 km. Including data reduction expenses, the cost is roughly comparable to deep seismic sounding using dynamite, but "Vibroseis" results are superior.

c) Work has commenced on means of detecting and possibly predicting the presence of gas hydrates ("frozen hydrocarbons") in areas of northern Canada where drilling for hydrocarbons is carried out. Certain drilling difficulties might thus be overcome and a new energy resource developed.

d) A Western Canadian Telemetered Seismic Network has been established in British Columbia. Besides the central station located at Victoria, outstations are located at Port Alberni, Haney and Pender Island. The Network is similar to that installed in 1974 in eastern

Canada, employing digital transmission of seismic data and a DEC PDP11/40 minicomputer for control.

e) Offshore gravity surveys were conducted in the Arctic, off the west coast of Vancouver Island and in James Bay and Hudson Bay. Data reduction and management was improved by development of the ASSOBS system for adjusting and integrating offshore gravity survey results and of a single system for handling both land and offshore data.

f) Tests were conducted to evaluate a gravimeter inertia platform for shipborne surveys and systems for measuring gravity from fixed-wing aircraft.

g) Advances in the interpretation of gravity anomalies included analyses of the boundaries of Precambrian tectonic provinces as possible ancient plate boundaries, the modelling of several anorthositic intrusions in Eastern Canada and integration of models of Sverdrup Basin evolution into studies of the evolution of the Arctic Basin based on the geophysical atlas of the Arctic now being compiled.

h) In geodynamics the use of microgravimetry for studies of groundwater migration was successfully demonstrated by field studies in which secular changes in gravity were monitored over a precise network of stations.

i) Polar motion studies were advanced by the development of a central computerized data acquisition system in Ottawa to handle data from the Ottawa and Calgary Satellite Doppler tracking stations.

j) In paleomagnetism, recent studies in demagnetization have led to the recognition of polyphase magnetization as a general property of Precambrian rocks. A listing of data currently available from the Precambrian has been published; these data have allowed a beginning to be made on the development of a magnetostratigraphy for the Precambrian with important consequences for the origin and tectonic history of the Shield.

k) Significant changes in the amplitude and direction of magnetotelluric measurements made over a one year period in a seismically active region near La Malbaie, Québec, have indicated the possibility of detecting changes in electrical resistivity associated with shallow earthquakes.

Canada Centre for Remote Sensing,
Department of Energy, Mines and Resources

A. F. Gregory, Chairman, Working Group on Geoscience, Canadian Advisory Committee on Remote Sensing and President, Gregory Geoscience Limited, Ottawa, Ontario and L. W. Morley, Director General, Canada Centre for Remote Sensing, Ottawa, Ontario

An overview of Canadian progress in the use of LANDSAT data in geology

During the past three years, Canadian geologists have been assessing the geological use of LANDSAT (formerly ERTS) data in the context of a vast but relatively well known hinterland. Aerial photographs, topographic maps and geological maps at reconnaissance

scales are available for most of the country. Nevertheless, LANDSAT data in four wavebands and with a resolution of about 80 m comprise a significant new source of information. While such inexpensive data are not yet widely used, geologists and allied technologists are the principal users of LANDSAT data in Canada. In particular, a relatively few oil and mineral exploration companies and geological consultants use as many images as the remaining geological users, excluding reference collections.

About three-quarters of the Canadian geological users have been using LANDSAT data since they became available in 1973; the remainder started use more recently, primarily in 1974. Nearly a quarter of the Canadian users also have experience with LANDSAT data for other parts of the world.

Visual photogeologic interpretation of black-and-white prints comprises the principal Canadian method of analysis. Digital processing and machine assistance have not been developed for practical geological applications. However, relevant research suggests that a major advance in the digital classification of Arctic terrain is imminent.

Practical applications are sparsely documented in the literature. However, known applications are related primarily to reconnaissance for geological structure and disposition of geological materials. Over half the geological users of LANDSAT data claim a modest to large benefit from the use of such data but cannot identify specific dollar benefits.

The level of development of practical geologic applications in Canada is greater than predicted in a pre-ERTS forecast. Visual interpretation of LANDSAT images will soon become a prime tool, in conjunction with others, for geological reconnaissance. They will be especially valuable in poorly explored, arid areas where vegetational cover is sparse. Automated processing will remain in the research stage until specific, low-cost methodologies are developed.

Canada Centre for Mineral and Energy Technology,
Department of Energy, Mines and Resources

W. M. Gray, Canadian Rock Mechanics Group,
CANMET, Ottawa, Ontario

Rock Mechanics

In 1972 a five-year project relating to open-pit mining was undertaken by the Canada Centre for Mineral and Energy Technology (CANMET), with cost sharing and active participation by industry. This project includes studies on the effects of groundwater on slope stability and on methods of drainage. Case histories of slope stability problems caused by groundwater and permafrost are being documented. The effects of different blasting patterns on wall rocks in various formations are being studied. Techniques for investigating structural geology before mining, including geophysical and photogrammetric methods, are being developed. Surveys of open pit and natural failures in relation to structural geological parameters are being

made and case histories of pit redesign to solve problems are being compiled. Procedures for both laboratory and *in situ* testing to determine mechanical properties of rock formations and structural discontinuities are being evaluated, together with indirect geophysical techniques. Instrument systems for the continuous monitoring of the movement of wall rock during mining, with transmission and processing of data for warning of impending failure, are under study. Methods for evaluating the probability of slope failure for various pit geometries and different modes of failure are being developed. The feasibility of using cable bolts, other bolting systems and shot-crete to improve stability of pit slopes is being investigated.

In another CANMET project carried out with the co-operation of mining companies, problems of rock mechanics and of fill distribution systems related to the cut-and-fill methods of mining are being studied.

Co-operative research is being done at a mine using an open stoping method of underground mining and breaking through into the bottom of the pre-existing open pit. The application of this system depends on the stability of the hangingwall and the footwall as well as the pit walls.

In co-operation with a mining company a raise boring machine has been successfully operated under semi-automatic conditions using a motorized valve system. Field trials are being continued to prove the control system in a variety of rock conditions. Additional controls for both pilot-hole drilling and reaming operations will then be tested.

Mineral Resources Branch,
New Brunswick Department of Natural Resources

R. R. Potter, Director,
Mineral Resources Branch,
Fredericton, New Brunswick

The Mineral Resources Branch provides the mineral, petroleum and construction industries with basic geological, geophysical and geochemical data to encourage and assist in the discovery, development and optimum utilization of the Province's mineral resources. New Brunswick is experiencing one of its best years, both in the exploration for new, and development of known mineral deposits. In the Bathurst-Newcastle area, detailed drilling and metallurgical testing was carried out in four known massive zinc-lead-copper deposits. Also, a very high-grade discovery was made by a local prospector in the Nine Mile Brook area. Exploratory work for salt-potash, uranium and base metals continued in the southern part of the Province. New Brunswick's first offshore well was drilled in the Bay of Fundy, and a regional program to evaluate the oil shale potential of southeastern New Brunswick was under way. Significant new reserves of coal were delineated in the Central Carboniferous Basin.

Several large mapping programs were carried out by the Mineral Resources Branch in co-operation with the Canada Department of Regional Economic Expansion (DREE). These included detailed 1 inch equals $\frac{1}{4}$ mile

mapping of the Bathurst-Newcastle area, and the Silurian-Devonian strata to the west. Maps of the Precambrian Caledonian area were published and work was in progress within the Silurian-Devonian sedimentary and volcanic rocks, and Devonian intrusives to the west. Detailed studies of the industrial mineral and structural material potential of the Province continued. Potash, salt and glauberite discoveries, made by geologists of the Branch in the course of a DREE-sponsored investigation, were also announced. Geochemical and geophysical surveys were carried out, not only to support existing programs, but to provide basic information to encourage efficient exploration by mining companies and prospectors.

Core storage facilities were completed at the Bathurst and Sussex regional offices, and a new building is under construction at Fredericton to accommodate drill core, cuttings, and analytical laboratories.

New projects are being planned under the General Development Agreement, negotiated previously between the Province and DREE. Special emphasis will be placed on evaluating the coal and uranium potential of the Province. Further studies on industrial mineral and structural material resources are planned, and a large area of central New Brunswick will be mapped in detail. Investigations dealing with infrastructure requirements and processing facilities will be initiated.

Saskatchewan Geological Survey

J. E. Christopher, Acting Assistant Director,
Saskatchewan Geological Survey,
Regina, Saskatchewan

Studies of the Precambrian region:

Most of the southeastern portion of the Precambrian Shield of northern Saskatchewan is now covered by primary maps at various scales. The following were mapped and/or defined:

- (a) in the Wollaston belt – basement granite inliers, a supracrustal sequence and more of the northeasterly trending mylonitic zone defining the southeastern margin;
- (b) east of (a) – an older mafic and dioritic complex, deformed into easterly trending gneisses with mylonites;
- (c) to the south and southeast of (a) – the northern portion of the Rottenstone domain of northeasterly trending, tight, upright folds and pink to white granite or granodiorite neosomes;
- (d) in the La Ronge area – predominant shallow-dipping granitoids and migmatites, which become intermixed with narrow belts of supracrustals eastward;
- (e) in the Pelican Narrows and Amisk Lake areas – the major north-south Tabernor belt marking the western margin of the Kiseynew domain; and
- (f) at the Manitoba border (Mari Lake) – easterly dipping nappes of "Kiseynew gneisses" and basement cores.

To the northwest, a five-year program of mapping a 20-mile-wide annulus of the Athabasca sedimentary basin was initiated between Cree and Wollaston lakes. Primary goals include the stratigraphy, structure and geomorphology of this periphery.

Studies of the Phanerozoic region:

The surficial sediments of the La Loche-Clearwater valley region, in particular the ligniferous and heavy-oil impregnated Cretaceous Mannville Formation, are under study. Farther south, two studies on Devonian formations (Winnipegosis and Dawson Bay) of the potash-mining and the Winnipegosis of the oil-producing district are virtually complete.

UNIVERSITY RESEARCH

NRC Negotiated Development Grants

Negotiated development grants awarded by the National Research Council to universities can be extremely influential in determining the scale and direction of research in any field. To date, six of these have been granted in the earth sciences. Funds, to the average amount of \$498 000, are given over a period of four or five years, and these may be used for the salaries of professionals, post-doctoral fellows or technicians, or for major equipment. They may not be used for graduate students support, or for supplies and similar current expenses. In the case of the more recent grants, there has been a reluctance to use the funds for new academic appointments, because of the difficulty of obtaining university commitments for their continuation beyond the periods of the grants.

Grants Awarded:

Grantee/ University	Title	Term
Dr. J. A. Jacobs/ Alberta	Earth and Planetary Physics	1970-75
Dr. R. A. Blais/ Ecole Poly- technique/McGill	Mineral Exploration Research	1972-75
Dr. H. G. Thode/ McMaster	Isotopic and Nuclear Studies in the Earth Sciences	1972-76
Dr. H. D. B. Wilson/ Manitoba	Precambrian Studies	1972-77
Dr. D. F. Aumento/ Dalhousie	Study of Material from a Deep Hole in the Atlantic	1973-76
Dr. D. W. Strang- way/Toronto	The Continental Crust and its Mineral Deposits	1974-79

Brief progress reports on the more recent awards follow. Dr. Aumento's report is included in the section on Canadian participation in international projects.

Negotiated Development Grant to Ecole Polytechnique/McGill University to establish the Mineral Exploration Research Institute

A. Becker, Department of Mineral Engineering,
Ecole Polytechnique and Managing Director,
MERI, Montréal, Québec

The Mineral Exploration Research Institute (MERI) is dedicated to the task of stimulating the establishment of a body of knowledge which could serve as a guide to mineral exploration. It was founded in 1972 by the two universities in response to the recommendations of the Solid Earth Science Group of the Science Council of Canada. They indicated a need for an organization which would stimulate interaction between industrial, government and university spheres of influence and which would render accessible to industry and government the many specialized skills and facilities commonly found in universities.

The initial funding for the Institute was granted to the universities by the National Research Council of Canada through a \$200 000, three-year negotiated development grant. The first instalment of \$50 000 was awarded in 1972 while the two subsequent instalments were conditional on comparable industry support of the Institute's activities. This condition was successfully met and further NRC support of \$75 000/year was obtained during 1973 and 1974. The grant terminated on the 31st of May 1975. The Institute derives its present support from contract research work, and, to a much lesser extent from its corporate membership program. The latter source, however, is not intended to produce significant revenue but rather to enlarge the Institute's sphere of contact. To this extent the recent response from Canada's Mineral Exploration fraternity has been most encouraging.

The combined financial support of industry, government and the National Research Council enabled the Institute to carry out to completion nearly thirty industrial research programs. These varied in duration and complexity but on the average each represented some \$8000 of research work. This work was nearly evenly divided between the disciplines of Geology, Geochemistry, Geophysics and Geostatistics.

As might be expected the individual research projects showed a wide degree of diversity. They ranged from studies on the performance of an airborne geophysical system, to the *in situ* determination of copper content in a mine face. They covered such dissimilar but possibly related subjects as clay mineralogy and IP phase shift measurements, or, magnetotellurics and the distribution of gold mineralization. In spite of the diversity of the work undertaken, the Institute is now emerging as a centre of excellence in its field of endeavour. In particular, Professor Pham's group doing research on magnetotellurics merits a special mention as they have done much to develop the method

to the point where this new technology is now transferable to industry. Again, in the field of geophysics, many advances were made in downhole geophysical prospecting and the interpretation of airborne electromagnetic survey data. At the opposite end of the mineral exploration sequence we are pleased to report the formation of a research group directed by Professor Michael David whose efforts are directed towards the elaboration of new geostatistical methods. This group has gained international recognition through its participation in research programs which originate in the United States and South America.

It is also worthwhile to mention the impact of the Institute on the Earth Science Departments of the participating universities. During the past year the Institute employed three full-time research associates and one programmer. It has hosted two foreign post-doctoral fellows, and, it has enabled a large proportion of faculty members and graduate students to participate in applied research programs directly related to Canada's scientific and economic welfare.

Negotiated Development Grant to McMaster University for Isotopic and Nuclear Studies in the Earth Sciences

H. G. Thode, Department of Chemistry,
McMaster University, Hamilton, Ontario

The National Research Council of Canada awarded a Negotiated Development Grant to McMaster University in July, 1972 for the expansion of facilities and effort in the general area of isotopic and nuclear studies in the earth sciences. The research group involved is an interdisciplinary one lead by Dr. H. G. Thode, Department of Chemistry, and including Dr. W. B. Clarke, Department of Physics and Drs. J. H. Crocket, R. H. McNutt and H. P. Schwarcz, all of the Department of Geology. The Negotiated Development Grant will terminate in July 1976.

The primary objectives of the grant were to allow researchers using similar mass spectrometer facilities to update and improve their equipment in an area of rapidly changing technology. A major step taken was the acquisition of a computer with time-sharing facility and the design of electronic interfacing circuitry to permit machine data processing of output from up to five mass spectrometers. Two mass spectrometers are currently capable of on-line automatic data processing. For some applications automatic data processing will provide an improvement in precision by a factor of approximately ten. Other important instrumental developments include the design and construction of a mass spectrometer for hydrogen-deuterium isotopic measurements. This instrument is now ready for initial testing trials.

A diverse range of projects was included in the research activities of the group during 1974-75. In the stable isotope area studies of sulphur, carbon, and oxygen isotopic variation were particularly active. Projects involving sulphur isotope analysis of the lunar regolith, sulphur and carbon isotope studies of Archean banded iron formations from the Michipicoten and Woman

River areas, Ontario, and sulphur and carbon isotope studies of both recent and ancient sediments and their implications on petroleum genesis include some of the projects on which considerable progress was achieved. The latter study demonstrated that sulphur and carbon isotopic compositions are useful tracers of evolutionary and migratory pathways of petroleum. In conjunction with the lunar studies which have demonstrated that sulphur isotope fractionation favouring enrichment of ^{34}S occurs on the lunar surface, experimental studies of sulphur isotope effects attendant on the thermal decomposition of troilite under vacuum conditions are in progress. Oxygen isotope studies of Archean crustal rocks have continued in an attempt to understand more quantitatively the extent to which continental crust is cyclically rejuvenated during orogenic cycles. These studies will be integrated with strontium isotopic studies to provide a more comprehensive and integrated model of the evolution of Precambrian crust. Other areas in which oxygen isotope studies (in conjunction with $^{234}\text{U}/^{230}\text{Th}$ age determinations) have been applied is in paleoclimatology studies of caves in which continental climate reconstruction over the past 200 000 years is being attempted.

In the field of radiometric isotopic studies a number of projects using the strontium technique have been completed. Geochronology of the Sudbury area with particular reference to understanding the very complex tectono-metamorphic history of the region has resulted in a much more precisely defined metamorphic chronology for the area than previously available. The demonstration, from studies of rocks from the Central Andes of Chile and Argentina, that strontium isotopic composition varies systematically with the geometric elements produced by progressive subduction of a lithospheric plate provides useful constraints on the process of magma generation association with plate subduction processes. Research is continuing on a new rock geochronology technique involving the production of fission-produced xenon from uranium decay. The method has been applied to the dating of zircons with good agreement with conventional U/Pb methods and attempts are presently underway to test its applicability to the dating of sedimentary rocks and certain uranium-bearing minerals.

Trace element studies using the McMaster Reactor as a neutron source for radioactivation analysis have also been an active research area within the group. Studies on rare earth element abundances in rocks from the Sudbury Irruptive and noble metal abundances in rocks and ores from the Sudbury, Kirkland Lake and Kenora districts of Ontario as well as the Merensky Reef horizon of the Bushveld Complex, South Africa, have been completed.

Negotiated Development Grant to University of Manitoba for Earth Sciences Research on Precambrian Problems

H. D. B. Wilson, Department of Earth Sciences,
University of Manitoba, Winnipeg, Manitoba

The objective of the program is to obtain an understanding of the various environments that occur within

the Canadian Shield, and to relate the distribution of metals to these environments so that the mineral resources can be extracted continuously, and in increasing amounts, in a systematic manner to keep pace with increasing population and advancing technology.

We believe that we shall have accomplished the major portion of the objective for the five-year program (1972-77) set out in our original application for the grant. Most of the major activities should be completed, although, in some, we have altered the program to fit our new knowledge and changing conditions. Most of the changing conditions were due to the current inflation problems which forced us to move into less costly programs, and to forego some of our plans. Particularly, activities in northern Manitoba and other areas involving air transportation have had to be cancelled because costs have gone beyond our reach.

An overall appreciation of the six activities in our original program is summarized:

Activity I. Crustal map of Manitoba and adjacent areas.

We shall have completed approximately the southern two-thirds of the area we had hoped to cover. The northern areas became beyond our reach cost-wise, so our resources were concentrated on what appears to be the more productive reflection work which is helping to solve particular problems. We still regard the crustal map of the north as important information necessary to unravel the history of the Churchill structural province.

Activity II. Metal distribution in major rock types of the Shield.

We shall have reached an understanding of metal distribution in Archean greenstone belts and in Archean granites. This should give us an understanding of the first great unit of continental cores — the granite-greenstone terrain of all Archean shields. We shall have made progress on the metal distribution in the granite and paragneisses of mobile belts of the Archean as represented by the English River gneiss belt. However, basic data on this belt will be far from complete. We shall have a basic understanding of metal distribution in the post-orogenic alkaline intrusions and the Proterozoic lavas. We are acquiring considerable information on metal distribution in volcanic rocks of the Churchill Province as represented by the Flin Flon belt, but shall lack data concerning sedimentary rocks and intrusions in the Churchill Province.

Activity III. Metal composition and geological environment of mineral showings in the Canadian Shield.

We have completed a file of mineral showings in Manitoba and Saskatchewan. Cards list data and references and all are plotted on overlays for geological maps. This file is open for use.

Activity IV. Precambrian sedimentary basins.

This is the least advanced of our activities partly because of the resignation of our sedimentation expert,

and partly because of the higher cost of working in pertinent areas. However, the research has reached important milestones. It is possible to divide the English River block into two portions, a paragneiss-granite style in the north half, and a batholithic-banded gneiss style in the southern half. We have recognized the existence of a supracrustal "shelf" series in the north half which is mineralized with copper, and copper-nickel. This confirms the existence of supracrustal formations in the Canadian gneiss belt similar to those in the Limpopo and Namaqualand Mobile Belts of South Africa and Botswana where discoveries of more than 300 million tons of base metal ore have been made in new districts discovered during the last decade. We now know the directions for an important future research effort in Canadian gneiss belts.

Activity V. Source and origin of Archean granite.

This activity will be completed to our satisfaction. We can document the intrusion and crystallization in an Archean granitic batholith. The seismic group has determined the position of the base of the granite by refraction methods. We can suggest a hypothesis for the origin of the granite which does not pre-suppose existing sialic material.

Activity VI. Archean volcanic belt.

We believe that we have accomplished our objective in understanding the nature and development of an Archean volcanic belt, and furthermore, that Archean volcanic belts are unique. They were formed on all continents in the same manner, but at different times within a particular time range of less than a billion years. This leads to the important conclusion that each shield went through similar development stages during the Archean and Proterozoic, so that development stages can be correlated, but they are not time correlations. Thus purely time concepts, such as Apehbian, are based on physical development stages and are not correlative on other continents. They cannot, therefore, be used in the same way as Phanerozoic time periods which are based upon almost simultaneous organic development stages.

Now that our research has reached the present stage, we see clearly many important projects and experiments that are suggested by the stage we have reached, and which would bring us a step nearer to our goal. The sedimentary basins of gneissic belts, and the greenstone belts may be used as examples.

We can recognize the existence of the economically important "shelf" series in the Canadian mobile belts because we know how to recognize this series, and know the criteria to distinguish it from basement gneiss, remobilized basement, and the monotonous turbidite sequences. We could undertake to locate these favourable ore related sequences in the gneiss belts of the Archean such as the English River and Quetico belts, or in the Grenville in the Sudbury-Ottawa-Orillia triangle.

The Canadian Archean in western Ontario and Manitoba offers an unique opportunity to determine the

nature of a "shelf" series which is so highly metamorphosed in mobile belts. The English River mobile belt gneisses apparently extend westward with decreasing metamorphism into the Bird River belt sediments in Manitoba, and southward to low grade metamorphosed sediments along the south margin of the English River belt.

The recognition of the stratigraphy and the knowledge of the complex distribution of stratigraphic units in the Kenora block provide the opportunity to unravel the structural history that brought the greenstone belt into its final configuration.

The apparent division of the northern half of the Kenora block into predominantly upper stratigraphic units, and the southern half into lower stratigraphic units suggests a seismic experiment to determine whether the granitic crust is thinner in the southern half of the block as may be predicted from the peculiar stratigraphic distribution of volcanic groups.

The recognition of stratigraphic distribution provides a map of favourable and unfavourable areas for ore deposit exploration. We have demonstrated this in a well exposed belt such as the Kenora-Dryden belt. A further experiment should be carried out to determine whether stratigraphic distribution can be determined in a poorly exposed greenstone belt such as that in the Rainy River area. We should determine the possibility of recognizing the favourable Upper Diverse Volcanic Group in covered areas by applying the geological, geophysical, and geochemical criteria which can be used to identify the stratigraphic position. This could lead to airborne geophysical exploration at reasonable cost in the many poorly exposed areas of the Archean shield.

Negotiated Development Grant to University of Toronto to Study the Continental Crust and its mineral Resources

D. W. Strangway, Department of Geology,
University of Toronto, Toronto, Ontario

The University of Toronto groups in Geology and Geophysics were awarded a five year grant by the National Research Council. The initial funding became available on April 1, 1974 and amounts to a total of \$900 000. In its early stages the funding is being used to develop a number of analytical facilities.

We have established a neutron activation laboratory to do both instrumental and radiochemical analyses. The work under the direction of Dr. Chou will concentrate on problems of crustal significance using rare earth elements and problems of ore deposit significance using trace metal studies. Also under active development is a major computer-controlled chemical analytical laboratory. This laboratory is built around minicomputers and a modular concept utilizing CAMAC hardware. Initial experiments to be operated in this way are X-ray fluorescence and a new electron microprobe. Already the microprobe capability has been converted to an energy dispersive system. These facilities when in full operation, will be able to provide standard analyses

but are designed to have the flexibility to accommodate new developments. In future other experiments will be set up for computer control.

A major capability for doing deep electromagnetic sounding has also been completed. This system basically uses controlled sources to develop signals for detection by magnetotelluric techniques. The system is built around a general purpose digital data acquisition system and has been used to provide electrical cross-sections in the Appalachian province.

Coupled with the major grant, we were fortunate to get a major laboratory from NASA which provides us the comprehensive capability to make studies of

electrical, magnetic and seismic measurements over a wide range of temperatures, pressures and environments. Specific projects underway include a study of microcracks and magnetic over-printing in relation to ancient impacts; a study of Cretaceous microfossils from Europe, North America and the Atlantic to throw light on inter and intra continent paleoenvironments; electrical and seismic properties at crustal temperatures and pressures; magnetic over-printing in Precambrian rocks; deep electromagnetic crustal sounding, shallow electromagnetic crustal sounding; trace element partitioning in sulphide deposits; and models of crustal evolution.

CANADIAN GEOSCIENCE COUNCIL 1975 ANNUAL REPORT

Report of the President

This year was a benchmark in the short history of our unique co-ordinating council for it brought us full recognition as the strong and influential voice of geoscience in Canada. It was also a year when we continued to make important progress towards our major goals: fostering close relationships among the various geoscience societies; promoting development of our science in the best interests of the nation; improving geoscience education; and providing advice to government on science policy.

Recognition as an influential voice for geoscience came mainly through our report "The Geosciences in Canada -- 1974" prepared last year and published early this year. The report received wide distribution within the earth science community and was sent to appropriate members of the Federal and Provincial cabinets, to the Presidents of all Canadian universities and to such national groups as SCITEC, the National Research Council and the Science Council of Canada. The recommendations and conclusions of the report formed the basis for fruitful discussions with the Honourable C. M. Drury, Minister of State for Science and Technology, the Honourable D. S. Macdonald, Minister of Energy, Mines and Resources, and Dr. W. G. Schneider, President of the National Research Council, and their senior advisors.

In these meetings, Council stressed the importance of the geosciences to Canada's welfare in view of the country's needs in energy, minerals, food production, and the care of the natural environment. Specific recommendations were made for additional support to research in the geosciences and increased funding at the universities; and for representation by earth scientists on various boards, councils and granting agencies that seek solutions to national problems where geoscience plays an important part. In the meetings with the two Federal cabinet ministers, we expressed concern about the possible loss of Canadian experts in the resource industries and a subsequent decrease in enrolment in geoscience at the universities because of differences in attitude among the Federal and Provincial governments and Industry on resource policy. Council offered no solution to this political matter, but urged a speedy solution in the best interests of Canada.

As a result of these meetings with senior government officials, Council was invited to and did submit the names of a number of distinguished geoscientists who will be considered for appointment to the Science Council of Canada, the National Research Council and the Grants Allocation Committee of NRC. Council also has been invited by the Science and Technology Division of the Department of Energy, Mines and Resources to nominate a number of earth scientists to a special Advisory Committee for the Geological Survey of Canada.

An important objective of Council is to encourage among Canadians an appreciation of the cultural and economic importance of the geosciences to Canada. This objective was strongly advanced during the past year under the enthusiastic leadership of Dr. Gordon Winder. Assisted by a grant from the Canadian Geological Foundation, the CGC sponsored two weekend workshops in geoscience for high school teachers, one in Calgary organized by Dr. C. Yorath and the Education Committee of the Canadian Society of Petroleum Geologists, and one in Wolfville, Nova Scotia, organized by Dr. R. MacNeill of the Atlantic Geoscience Council. Both workshops were very successful; consideration is being given to sponsoring similar workshops elsewhere in Canada in 1976. The Education Committee also updated and republished Council's Resource Document for Teachers which lists material and people available to assist in earth science education at the high school level.

With the co-operation of a number of member societies, the CGC has sponsored several workshops on geoscience subjects that spanned the interests of several member societies. We sponsored a Computer Workshop in Geology in association with the 1975 Geological Association of Canada/Mineralogical Association of Canada Annual Meeting at Waterloo. The previous year Council sponsored a workshop for geoscientists interested in international development, again in conjunction with the GAC/MAC Annual Meeting. The co-operation of these two member societies in making their secretariats available for the organization of such meetings is greatly appreciated. Council's first major scientific meeting, "Exploration '77, a symposium to present the role of geophysical and geochemical methods in the search for base metals and uranium", will be held in Ottawa in 1977. Planning and organization are well advanced under Chairman Dr. A. G. Darnley. Exploration '77 will be a follow-up to the successful Symposium on Geophysics and Groundwater held at Niagara Falls in 1967 which was sponsored by the former Associate Committee for Geodesy and Geophysics. Council undertook to sponsor the 1977 meeting because the multidisciplinary nature of the symposium extends beyond the prime interests of any single member society. As in the cases of the earlier workshops we have sponsored, this event will stand alone, with no plans for continuity or repetition. Council is well aware that it must not sponsor technical meetings that may interfere with the plans of its member societies.

An important concern of the Canadian Geoscience Council is that there be in the future a sufficient number of earth scientists to satisfy Canada's needs. A committee under the Chairmanship of Peter Savage has been formed to investigate 1) levels of enrolment in the geosciences in Canada, 2) the disposition of recent

graduates to careers, and 3) estimates of future job availability. Data on some of these subjects are available in a number of member societies and in other agencies. The committee hopes to co-ordinate these data and interpret them in the broad context of Canada's future needs for geoscientists.

Council broadened its organizational base during the past year by providing for representation on Council by earth science groups which would have non-voting Associate status. The Committee of Chairmen of Canadian University Departments of Earth Science has accepted such status, as has a senior officer representing the earth sciences within the Department of Energy, Mines and Resources. Council is still seeking some way to bring a voice from the provincial Departments of Mines and Petroleum to its deliberations without making Council unwieldy, and while preserving its status as an association of societies.

As a follow-up to Council's successful report of 1974, the decision has been taken to prepare a new report on the State of the Geosciences in Canada--1976. The new report will remove some of the unevenness of the first report, strive for more objectivity and provide for a greater participation by member societies than was possible under the tight schedule of 1974. Dr. C. R. Barnes has accepted Chairmanship of this Editorial Committee and is well along in planning and organization. For 1975, the CGC report will be a review of current research in the geosciences with commentary on both geological and geophysical research, and an overview of geological research in one particular segment of earth science, the petroleum industry. This last subject will be based upon an in-depth review presently being completed by the Canadian Society of Petroleum Geologists. With respect to the already existing Geological Survey of Canada (GSC) report "Current Research in the Geological Sciences", the CGC committee is working with the GSC to attempt to improve the input and to computerize the data so that it is more readily accessible. This is a major project for the CGC in 1975.

International non-governmental relations in the geosciences are at the present time co-ordinated through NRC and EMR. There are indications, however, that government agencies wish to vest this responsibility with the scientific societies. Council has accepted in principle a proposal by the Academy of Science of the Royal Society that the Royal Society act as an umbrella organization to meet this need: the Royal Society would be the adhering body to the International Council of Scientific Unions and would be the initial contact for and co-ordinate the activities of such discipline groups as the International Union for Geological Sciences and the International Union for Geodesy and Geophysics. In accepting the Royal Society's proposal in principle, Council itself expects to represent the special interests of the geosciences in consultation with the member societies most directly concerned. However, one of our member societies, the Canadian Geophysical Union, feels very strongly that it should be the direct contact with the Royal Society umbrella organization for the IUGG rather than working through CGC. The matter of this representation remains to be resolved.

The Canadian Geoscience Council has now achieved national stature as a voice for geoscience. It is known and respected by government, the scientific community at large and such national bodies as SCITEC, the National Research Council and the Science Council of Canada. We ourselves as geoscientists are well aware of the impact of our science on our own lives and the country's welfare and of the importance our science will have for the future supply of energy, minerals, water, food, and for the rational preservation of our natural environment. Council will best serve its member societies and indeed, our country, by making everyone more aware of the cultural and economic values of the geosciences; by improving education and increasing research; by assuring that the necessary number of geoscientists will be available when needed; and by presenting a voice for our science in shaping the future.

Definite progress has been made toward these objectives through the co-operation of the member societies and the dedicated work of their representatives on Council. Much of our success results from the mix of councillors from the different sub-disciplines and from industry, university and public sectors which brings a necessary and valuable perspective to Council's deliberations. The Canadian Geoscience Council, however, only reflects the views and aspirations of its members. The societies must therefore continue to send knowledgeable and astute representatives to Council to continue the advancement of geoscience in Canada.

R. L. Slavin; President
December 7, 1975

Report of the Secretary-Treasurer

There were twelve Member Societies in the Council in 1975 with no changes from the previous year. Table V lists the Member Societies along with their objectives and activities. In addition to the Member Societies, observers from the Earth Science Division of the Royal Society of Canada, the NRC Associate Committee on Geotechnical Research, and the Committee of Canadian University Departments of Earth Science are invited to meetings of Council.

Funding of the Council activities are obtained from three main sources; sustaining grants and contracts with Energy, Mines and Resources Canada, fees paid by Member Societies and a grant from the Canadian Geological Foundation to assist with the activities of the Education Committee. The main expenditures of the Council are in support of Education and Editorial Committees' activities.

Council itself held its 16th, 17th, 18th and 19th Meetings in 1975, as well as a Special Meeting with senior officials from Energy, Mines and Resources, at the time of the 19th Meeting. This was the second year that such a meeting has been held and with indications that it will become an annual event. The accomplishments of the Council are listed in the President's Report.

The active membership of the Council during 1975 included:

President	R. L. Slavin
Past-President	H. R. Wynne-Edwards
Vice-President	E. R. W. Neale
Secretary-Treasurer	W. J. Eden
Recording Secretary	E. C. Appleyard
Executive Member	D. I. Gough
Editorial Committee Chairman	C. R. Barnes
Education Committee Chairman	C. G. Winder
Manpower Committee Chairman	P. J. Savage

Member Society Representatives:

Association of Exploration Geochemists, Canadian Section – G. J. S. Govett, R. W. Boyle
Canadian Exploration Geophysical Society – K. A. Morgan, J. S. Dowsett
Canadian Geophysical Union – R. D. Russell, J. L. Roy
Canadian Geotechnical Society – W. J. Eden, A. W. Clifton
Canadian Institute of Mining and Metallurgy – P. H. Grimley, G. W. Mannard
Canadian Rock Mechanics Group – M. S. King, R. A. Price
Canadian Society of Exploration Geophysicists – P. J. Savage, J. H. Harding
Canadian Society of Petroleum Geologists – G. D. Grant, D. W. Organ
Canadian Society of Soil Science – S. Pawluck, G. C. Topp
Canadian Well Logging Society – J. Pickel, G. N. Wright
Geological Association of Canada – M. J. Keen, P. M. Kavanagh
Mineralogical Association of Canada – G. Perrault, J. A. Mandarino

The Editorial Committee, which has been responsible for assembling and editing this volume, consists of C. R. Barnes (Chairman), G. D. Garland (Vice-chairman), T. E. Bolton, N. Morgenstern, R. A. Parker and G. Perrault.

W. J. Eden; Secretary-Treasurer
December, 1975

Report of the Manpower Committee

In its Report No. 7 (April, 1970) the Science Council of Canada pointed out that "There is an obvious need for better data on scientific and technical manpower, and steps must be initiated to obtain them". That these steps have not been taken with respect to the Earth Sciences has become painfully apparent.

The need for a manpower inventory and an analysis of demand is critical for the future of the Earth Sciences in Canada. To quote again from the Science Council Report No. 7 "This situation is common to all fields of science in Canada and is a weakness in the formulation of a national science policy, in the development of manpower training policies by universities and other

educational institutions, in immigration policy, and in recruiting, salary negotiations, and career planning".

The CGC Manpower Committee was assigned three specific tasks:

1. To prepare a statement on the level of enrolment in the Geosciences in Canadian universities;
2. to determine the disposition of recent graduates to careers; and
3. to comment on the future job availability in the light of the projected need for geoscientists in Canada.

The Canadian Institute of Mining and Metallurgy publishes annually a report on the "Number of Canadian University Graduates in the Mineral Industry Fields". This admirable compilation is the principal source of statistical information in this field.

One does not have to get too far into this subject before one realizes that who, as a geoscientist, is being counted depends entirely on one's definition of a geoscientist. The danger being that, as we survey employers concerning the disposition of graduates, we may not be counting the same people we counted in the university. To help us in this regard the Council of Chairmen, Canadian Department of Earth Science is examining the definition of geoscientist. The Council of Chairmen is also considering the possibility of circulating a questionnaire to recent graduates to determine, if possible, what their actual experience has been in finding employment in their chosen field.

With the exception of various levels of government and the petroleum industry many employers of geoscientists have not yet been convinced of the need for these investigations. Some fervent evangelism on the part of the Geoscience Council's member societies is called for.

Once the political diatribes have been removed from the answers to a request for a forecast of demand the task then remains to separate the pious hopes from the realistic assessments. Since realism can sometimes be a painful experience it is easy to equate it with pessimism. Nevertheless the Committee feels that our member societies should pursue this question within their disciplines and that the Council should also attempt a broader approach (see recommendations below).

It is safe to say that statistics that can be used with any degree of confidence are not available, and those numbers that are at hand can be selectively used to prove any point the user has in mind. From our studies to date some general observations can, however, be made.

- (a) The number of graduates from Canadian Universities has risen to approximate the requirements forecast by the Blais Report (1971, Special Study no. 13, Science Council of Canada, Table III. 2). There is some doubt whether this demand exists and growing evidence that currently it does not. There does not exist a quantitative analysis, based

on the Canadian economy, of what this demand should be.

- (b) The immigration of Earth Scientists has dropped steadily from 541 in 1967 to 173 in 1974, and preliminary figures indicate a further drop in 1975. The immigration numbers are now of the same order as those estimates of earth scientists leaving the country.
- (c) There is a decrease in demand for graduates in the resource industry.
- (d) There is a slight increase in demand in the geotechnical industry.
- (e) Increased government activity has generally taken experienced earth scientists from industry, however, a slight increase in the demand for graduates is expected. The numbers involved in this sector are small compared to industry and the effect minimal.

The Manpower Committee recommends to the Council that:

- (a) The Geoscience Council in conjunction with Federal and Provincial governments and industry instigate a move to have a "Highly Qualified Manpower Survey" (Statistics Canada 1973) conducted on a continuing basis, and further that input be requested from the users of such a survey (both industry and government) in order to properly define the categories of those surveyed.
- (b) In view of the above quotations from Science Council Report No. 7, the Science Council of Canada again bring this situation to the attention of the government.
- (c) The Geoscience Council confer with Statistics Canada with a view to improving the employment or occupation categories utilized in the census to prevent overlap and inappropriate categorization.
- (d) A study of supply and demand for earth scientists be undertaken similar to that recently published by the Technical Service Council entitled "Supply and Demand for New Graduates in Engineering, Chemistry, Business and Commerce".

Further to recommendation (d) it is estimated that such a survey would take at least a year and cost in the order of \$30 000. This figure for time and cost is considerably more than for the Engineers, etc. survey and is due to the expected difficulties involved in deriving valid figures for a group as amorphous as Earth Scientists.

P. J. Savage; Chairman,
Manpower Committee
December 29, 1975

Approximately seventy-five copies of the first edition of the Resource Document for teachers compiled by John Usher (Queen's University) were mailed. The total distribution of that edition was at least three hundred copies. The second edition of the Resource Document (66p., \$1.75) is now being distributed. A first print run of three hundred copies will be sent with the following policies established by the CGC executive: a) two free copies to member societies; b) free copy to professional and business journals listed in the document requesting a review; c) free copy to certain teachers and professionals at the discretion of the CGC education chairman; d) the document will be advertised in teacher bulletins requesting a \$1.00 charge to a Canadian address.

The National Association of Geology Teachers designated two teachers for their B.E.S.T. award at their meeting held at Waterloo '75, in May 1975. The CGC gave the two teachers – Philip Bate, Ottawa and Fred Kingrey, Kettering, Ohio – a copy of Zaslows "Reading the Rocks" in recognition of their efforts.

A policy and guidelines document on the EdGEO Conferences was compiled. Financial support by CGC for two EdGEO Workshops at Calgary and Wolfville was provided. Both workshops were a success, and although each followed the guidelines, the program for each was different. The cost to CGC for both conferences was about \$3300.

Future plans include two EdGEO Conferences to be held in Winnipeg (GAC sponsor – George Lammers and Jon Scoates) and Ottawa (CIM sponsor – George Armbrust). A conference for the Province of Quebec is in planning stages. A total budget of \$6000 has been approved.

C. G. Winder; Chairman,
Education Committee
January 21, 1976

Summaries of the Main Achievements of the
CGC Member Societies in 1975

The Association of Exploration Geochemists

The AEG marked its fifth birthday during 1975 with satisfying evidence of its success. Subscribers to the *Journal of Geochemical Exploration* – the Association's most important vehicle for dissemination of information in the field of exploration geochemistry – exceeded one thousand in its fourth year of publication. In response to supply and demand for high quality technical papers in the field, the Journal is to be expanded from four to six hundred pages per year.

A special issue of the Journal was devoted to *Conceptual Models in Geochemistry* which has been reprinted by Elsevier Publishing Company in a hard-cover volume as AEG Special Publication No. 3. 1975

also saw the publication of the 720 page hard-cover volume *Geochemical Exploration 1974* which contains the papers presented at the Fifth International Symposium held in Vancouver in 1974.

The Association has adopted as a formal policy the tradition of biannual International Symposia with every other meeting to be held in North America; the Sixth Symposium is to be held in Australia in August, 1976 and the Seventh will be in the U. S. A. in 1978.

A major new policy on meetings is the decision to sponsor regional meetings and workshops. The first workshop (on uranium exploration) was held at the Colorado School of Mines in November, 1975, and the first regional meeting (Exploration Geochemistry in the Appalachians) will be held at the University of New Brunswick in April, 1976.

The Association has undertaken a major role in the international meeting "Exploration 77" sponsored by the Canadian Geoscience Council to be held in Ottawa in 1977 through inviting geochemists to provide definitive contributions on aspects of geochemistry in exploration.

Numerous committees produced special reports during the year; perhaps the most important was the survey of teaching of exploration geochemistry in North American universities. This report showed a significant growth of the discipline since an earlier survey in 1971, and clearly reflects a growing acceptance of exploration geochemistry as a legitimate and important aspect of education in the earth sciences.

It should be emphasized that The Association of Exploration Geochemists is an international body which currently has a very strong and active Canadian membership. The Canadian members participate in the activities of the Canadian Geoscience Council with the support of the international membership. Other national groups within the Association, particularly in the United States, are also pursuing a policy of seeking representation on their national scientific bodies.

Canadian Geophysical Union

The Union has shown encouraging growth in its third year of existence, the membership increasing from near 200 to near 300. The principal scientific meeting of the year was held in conjunction with that of the Geological Association of Canada, one of our parent organizations, in Waterloo, Ontario in May. The CGU organized two symposia on *Permafrost* and one each on *Physical Properties of Rocks and Minerals*, on *Rock Magnetism and Paleomagnetism* and on general *Geophysics*, and joined with the GAC Structural Geology Division in organizing two symposia on *Precambrian Crustal Structure*. A second scientific meeting, on *Mathematical Geophysics*, was organized in conjunction with the annual meeting of our other parent organization, the Canadian Association of Physicists, which met in June at York University, Toronto. At the York meeting there were three symposia organized by CGU, covering topics in core dynamics, seismology, and related geophysical topics. In addition the CGU joined with the CAP in sponsoring an invited guest lecture on the Interior of the Earth by this year's CAP gold medallist, Professor

J. A. Jacobs. Among his many distinctions, Dr. Jacobs is a past Chairman of CGU.

Arrangements are well advanced for CGU meetings with CAP at Laval University, Quebec City in 1976 and with GAC in Vancouver in 1977. In addition CGU will join with the Seismological Society of America in organizing a meeting in 1976 at the University of Alberta, Edmonton.

Canadian Geotechnical Society

The Engineering Geology Division became established within the Society in 1975. This is the first technical division established within the Society and has over 130 members.

The 1975 R. F. Legget Award was presented to Mr. Carl B. Crawford, Director, Division of Building Research, National Research Council of Canada, for his contributions to geotechnique, on the occasion of the Annual Society Banquet at the 28th Canadian Geotechnical Conference. The Society Prize for the best paper in the *Canadian Geotechnical Journal* in 1974 was awarded jointly to P. LaRoche, B. Trak, F. Tavenas and M. Roy, of Laval University, for their joint paper entitled "Failure of a Test Embankment on a Sensitive Champlain Clay Deposit".

Canadian Institute of Mining and Metallurgy

1975 was a year of growth for the CIM. Membership by year-end had reached 11 000 for the parent organization, with Geology Division membership standing at roughly 2750. Many geoscientists belong to other CIMM Divisions or Societies, such as the Coal Division, the Industrial Mineral Division and the Petroleum Society, and still others are active in CIM's fifty-four local branches.

The most significant event in 1975 was the initiation of a strong campaign aimed at improving the public's knowledge and understanding of the mineral industry and all its components. A full-time public relations officer co-ordinates this program. A film, entitled *Resource in Crisis* has been prepared, and, it is hoped, will have wide distribution. A sample kit of slides has been assembled, and will be available for use in schools and at various meetings at which the mining industry's viewpoint can be presented.

The CIM General Committee on Education sponsored an education-information booth at the 1975 meeting of the National Council for Geographic Education in Toronto. Pamphlets, maps and ore samples were distributed free to the 1500 delegates.

Local CIM groups are being urged to follow the example set by the Newfoundland Branch, which encouraged public participation at its annual meeting in November.

With respect to publications, thirty-eight geoscience papers were presented orally at the two major CIM meetings during 1975. A further twenty-two papers pertaining to various geoscience disciplines were published in the *CIM Bulletin*. A special volume on the porphyry copper deposits of the Canadian Cordillera

has been prepared for publication, and will be dedicated to the late Charles Ney.

Canadian Rock Mechanics Group

The 10th Canadian Rock Mechanics Symposium, jointly sponsored by CIM, CRMG and Queen's University, took place in Kingston, Ontario, on 2-4 September 1975. The program included papers on: Rock mechanics related to environmental hazards and accident prevention; Pit slope stability as related to economic and social considerations; Subsidence problems; Strata control; Ground stresses below 3000 feet; Blasting studies; The environmental impact of very large scale projects. The proceedings of the Symposium are being published in two volumes and may be obtained from 10th Canadian Rock Mechanics Symposium, Goodwin Hall, Queen's University, Kingston, Ontario, K7L 3N6.

The 1974 Award of the Canadian Rock Mechanics Group was presented to D. F. Coates, Director General, and M. Gyenge, Research Scientist, of the Canada Centre for Mineral and Energy Technology for their monograph, "Incremental Design in Rock Mechanics", which was published in 1973 as Mines Branch Monograph 880 by the Department of Energy, Mines and Resources, Ottawa.

Canadian Society of Exploration Geophysicists

During 1975 the Canadian Society of Exploration Geophysicists (CSEG) enjoyed the fruits of several programs initiated in previous years. A very significant and potentially trend-setting event was "Exploration Update '75" where the CSEG combined with the Canadian Society of Petroleum Geologists to hold a National Convention. The event was very successful, in terms of technical cross-fertilization between the members of the two societies, of providing suppliers of both disciplines an opportunity to meet new potential users and of providing a source of funds which both societies will employ to subsidize other activities.

In addition to the close association enjoyed with the geologists at the joint convention, the multi-disciplinary aspects of exploration geophysics were also emphasized by providing a short course in Economics for Geophysicists. This proved popular and will be rerun in 1976.

An unheralded but major step taken by the Society in 1975 was the registration of the CSEG Scholarship Trust Fund as a Canadian Charitable Organization, thereby providing a vehicle for individuals as well as companies to make tax free donations to students at post secondary institutions. Six scholarships were awarded in 1975.

Another demonstration of Society maturity was evident when it accepted responsibility for preparing and publishing a History of Canadian Petroleum Geophysics from Inception to 1950. Dr. Easton Wren will be the author with publication planned for 1977.

The Society was pleased with the 1975 increase in geophysical activity in Alberta at a time when work being done in other parts of Canada was dropping off. The increase was partly due to industry acceptance of

Alberta's Geophysical Incentive Program which the CSEG designed at the government's request.

An apparently successful intervention was made by the CSEG in conjunction with other seasonal petroleum operators in British Columbia to have a variation approved eliminating onerous overtime (double time in excess of 206 hours per month) clauses in a new British Columbia Labour Act. Although the variation is not yet printed, top officials and Government Ministers have assured the Society that it will be done immediately.

Representations have been made to the Provincial and Federal governments suggesting that the present level of geophysical exploration is not high enough to have much effect on the hydrocarbon shortages predicted for Canada in the early 1980's. While the governments appear to accept and agree with this position, but with the exception of Alberta have not chosen to take significant steps to change the situation.

The Society awarded honorary membership to Roy O. Lindsleth; the best paper award for 1975 was presented to Art Dumont; and scholarships were given to one student at each of the Universities of Calgary, British Columbia, Saskatchewan and Alberta and the Northern and Southern Institutes of Technology.

Canadian Society of Petroleum Geologists

Throughout 1975 the Canadian Society of Petroleum Geologists continued to pursue the objective of furthering the advancement of Petroleum Geology and related sciences. This was accomplished through the efforts of individual members working in forty-seven committees, six divisions, and in eight areas. Membership in the Society continued to grow from 2154 in 1974 to 2225 in 1975.

A highlight of the year was the CSPG-CSEG Joint Convention "Exploration Update '75", attended by 1455 delegates and 70 exhibitors. The attendance of the Honourable Donald Getty as a luncheon speaker, and the Honourable Donald Macdonald, John Stoik of Gulf and Jack Pierce of Ranger at an afternoon discussion meeting on the role of a national oil company greatly enhanced public interest in the Convention.

Society members continued to show a sustained interest in field geology. There were three one-day field trips and one two-day field conference held during the year. A clastic reservoir core conference is proposed for fall 1976 and a major field conference for the Waterton area in 1977.

A major undertaking of the research committee has been a review of geological research in Canada. A questionnaire was circulated to major and independent oil companies, universities and federal and provincial agencies. A compilation of the results of this questionnaire will be published in an early issue of the CSPG Bulletin.

Publications that have appeared during 1975, in addition to the quarterly Bulletin and the monthly Reservoir, were Memoir 4 "Canada's Offshore and Continental Margins", two volumes of a reprint series "Devonian Reef Complexes of Canada", The Alberta Highways Map, and Guidebooks for the "Update '75"

Foothills field trip and the Southern Alberta Field Conference. The Alberta Highways Map, showing the surface geology of Alberta and the specific geology of the Alberta mountain passes, has created interest among members in other areas of Canada who intend to produce similar maps. Volume 23 of the Bulletin of Canadian Petroleum Geology consisted of a variety of petroleum oriented papers. Production problems continue to plague the editor, but an increased flow of high-quality papers will soon allow a longer lead time to printing. The monthly "Reservoir" newsletter continued as the "News" organ of the society. A feature of the "Reservoir" in 1975 is the publication of a year-end photo supplement of 1975 activities.

During 1975 honorary membership in the Society was awarded to Dr. Helen Belyea. The CSPG Medal of Merit was awarded to Dr. D.K. Norris for his paper "Structural Geometry and Geological History of the Northern Canadian Cordillera". The Link Award, for best oral presentation of the year, was presented to Dr. Norman C. Wardlaw for his paper, "Pore Systems in Carbonates as Revealed by Pore Casts and Capillary Pressure Data". Graduate Student awards were made to B.I. Chi for the best submitted Ph.D. thesis "Devonian Megaspores and Their Stratigraphic Significance in the Canadian Arctic" and to Frances J. Hein for the M.Sc. thesis "Gravel Transport and Stratification Origin, Kicking Horse River, British Columbia".

The specialist divisions of the society in paleontology, structural geology, geomathematics and geochemistry have provided a forum for specialist discussion and the presentation of technical papers of specific interest. Sedimentology and coal geology divisions are in the formative stages.

A mainstay of the Society is the Calgary noon luncheon technical speakers program. In 1975 there were 20 speakers on topics ranging from "Pore Systems in Carbonates" to "The View from Skylab". The attendance averaged 350 members. In addition to the luncheon meetings, one dinner meeting was held with Dr. A. A. Meyerhoff speaking on "Comparison of National and Private Oil Companies, Exploration Techniques, Philosophy and Success". As Dr. Meyerhoff has extensive experience both in the western world and the Soviet Union, he was able to make this comparison in an interesting way.

Looking ahead, in 1976 the Society will join with the Petroleum Society of the CIMM to host June 7-11, joint convention on Enhanced Recovery. As mentioned previously, a 1977 field conference is planned for the Waterton area, and in 1978 a convention with an international theme is planned for Calgary. The Society looks forward to a future bright with the need for intelligent application of the earth sciences to Canada's increasing energy needs.

Canadian Society of Soil Science

The Canadian Society of Soil Science continues to broaden its interest base and include workers in many fields of earth science ranging from agronomy through geochemistry and geomorphology to Quaternary geology

and clay mineralogy. Society members contributed to an Agricultural Institute of Canada's position paper on the state of Canada soil resources. During the year, the Society co-sponsored The Glacial Till Conference jointly with the National Research Council in which members of the Society participated.

During the year the Society published the Proceedings of the 1st International Conference on Land for Waste Management which it recently sponsored. The proceedings have proved popular and constitute a useful contribution to this somewhat scant field of literature.

Much of the Society's energies will be dispersed in preparing for the International Soil Science Congress to be held in Edmonton in 1978, at which a considerable variety of papers in a wide range of fields of geoscience will be presented.

Many members of the Society have made use of the Canada Soil Survey standard soil samples which are available. As these samples are now being analyzed by laboratories all over the nation it is hoped to gain useful basic information about standard soil analytical methods for Canadian soil materials. Members contribute field and analytical data to the CANSUS program which is a computer bank for all kinds of soil data: field as well as laboratory and includes vegetation and geomorphology. The soil mapping on local, county and regional scales proceeds with an increasing emphasis on soil mapping for environmental assessment purposes. An increasing number of soil scientists are contributing to foreign aid projects mainly in aspects of agriculture.

The Society supported journal – Canadian Journal of Soil Science – is now in three issues per year and it is gratifying that sufficient quality manuscripts are forthcoming to maintain this.

Canadian Well Logging Society

The most significant achievement of the Canadian Well Logging Society in 1975, was the Fifth Formation Evaluation Symposium. Adopting its theme "Focus on the Future", the keynote speaker was R. A. Meneley, Vice President for Exploration, Panarctic Oils Limited. Thirty-one technical papers were presented. These ranged from determining water quality from electrical self potentials in near-surface aquifers of Wyoming, to maximizing oil recovery through refined reservoir description. The program was, for the first time, co-ordinated with that of the Society of Professional Well Log Analysts, providing essentially world-wide exposure for the more important topics. Registration totalled 248, mostly from the province of Alberta (206); three came from out of province, 38 from the U. S. A. and one from the U. K. The U. S. counterpart attracted 379 registrants to New Orleans from nine different countries.

The Society membership approved the establishment of an annual award, known as the "President's Award", in the amount of five hundred dollars for the best paper on formation evaluation qualifying for publication in our annual journal. The decision to

grant an award will be the responsibility of an ad hoc committee appointed by the executive of the Society.

Geological Association of Canada

The membership of the Geological Association of Canada has continued to show an upward trend over the last year with a total membership count of 2516 in November, 1975. The annual meeting was held at the University of Waterloo in May 1975 in conjunction with the Mineralogical Association of Canada, the north central section of the Geological Society of America and the Paleontological Society, and the east central section of the National Association of Geology Teachers. Symposia covered topics related to Environmental Geology, Micropaleontology, Economic Geology, Volcanology, Structural Geology, Geophysics, Petrology and Mineralogy, whilst technical sessions provided a number of additional subject areas. The meeting was the largest so far held by GAC attracting over 1200 participants. The founding meetings of the Paleontology Division and the Structural Geology Division of GAC were held during the course of the annual meeting at Waterloo.

The Logan medal, the highest award of the GAC, was awarded to Dr. E. Irving for his outstanding contributions on rock magnetism and their application to major geological problems. The Past President's medal was awarded to Dr. R. G. Walker for his work on modern and ancient sediments, and the interpretation of sedimentary structures in Archean rocks.

GAC Special Paper 13 entitled "The Cretaceous System in the Western Interior of North America", edited by W. G. E. Caldwell, appeared as a 666 page volume in October, 1975. Special Paper 14 (Plate Tectonics and Metallogeny) edited by D. F. Strong is currently in galley-proof stage. GAC council received a final report from N. Allman on the "Status of Women Geoscientists in Canada" which will be published as an Information Circular of the Association.

The 1976 Annual Meeting will be held with MAC in Edmonton, May 19-21, 1976; the 1977 Meeting will be

held jointly with the Society of Economic Geologists in Vancouver, whilst the 1978 Annual Meeting will be held in conjunction with the parent body of the GSA in Toronto. The 1979 Meeting will be in Québec City and the 1980 Meeting has been arranged for Halifax, Nova Scotia.

Mineralogical Association of Canada

The year 1975 marked the continuing growth and success of our journal, the *Canadian Mineralogist*. Under our co-editors, Drs. L. J. Cabri and J. L. Jambor, the journal is a highly respected quarterly. In recognition of the efforts of our Editor Emeritus, Dr. L. G. Berry, an issue of the *Canadian Mineralogist* will be dedicated to him. This will appear in 1976.

Two symposia held at the Annual Meeting in Waterloo in May 1975 were most successful. These were: Water and Magma Genesis, organized by W. S. Fyfe and A. D. Edgar, and Aspects of Mineralogy and Sedimentary Geochemistry, organized by J. R. Kramer.

The first complete revision of our by-laws has been almost finished and a new set of by-laws should be voted on by the membership in 1976.

The MAC looks forward to increased income now that it has been granted a tax exempt gift status. All members and friends who wish to make a cash contribution to the MAC, now will be able to receive an income tax deduction for their gift.

Newly elected officers are Dr. L. G. Berry, President, Dr. R. B. Ferguson, Vice-President and Dr. Peter Cerny, Secretary. New members of the Executive Committee are: D. J. Bachinski, J. J. Fawcett, and P. B. Read. Other officers continuing in their positions are: Miss A. Sabina, Treasurer, Drs. L. J. Cabri and J. L. Jambor, co-editors, and Dr. R. I. Gait, Subscription Manager. Executive Committee members who continue to serve are: R. A. Alcock, E. C. Appleyard, G. Donnay, A. J. Naldrett, B. J. Skinner, and D. G. W. Smith.

TABLE V DATA ON MEMBER SOCIETIES OF CANADIAN GEOSCIENCE COUNCIL

SOCIETY AND MEMBERSHIP	OBJECTIVES	MEETINGS, ACTIVITIES AND COMMITTEES (attendance in parentheses)	PUBLICATIONS
<p>ASSOCIATION OF EXPLORATION GEOCHEMISTS c/o Dr. R. W. Boyle Geological Survey of Canada 601 Booth Street Ottawa, Ontario K1A 0E8</p> <p>Active membership 155 Student membership in Canada 8 Corporate members in Canada 5 World membership 526</p>	<p>To represent the professional interests of persons specializing in exploration geochemistry; to advance mineral exploration applications of geochemistry; to disseminate geochemical information and ideas among professional geochemists.</p>	<p>- Annual General Meeting (Ottawa) - Four Council Meetings - Workshop on Geochemical Exploration for Uranium (Golden, Colo.)</p> <p>COMMITTEES: Admissions Case History Geochemical Analysis Research and Education Bibliography Computer Applications Membership Technical Meetings</p>	<p><u>Journal of Geochemical Exploration</u> (quarterly) <u>Conceptual Models in Exploration Geochemistry</u>, Association of Exploration Geochemists Special Publication No. 3 (Amsterdam: Elsevier). <u>Geochemical Exploration 1974</u> (Amsterdam: Elsevier). News letter (approximately 4 issues per year members only)</p>
<p>CANADIAN EXPLORATION GEOPHYSICAL SOCIETY (KEGS) c/o Laurie E. Reed Selco Mining Corporation Ltd. 55 Yonge St. Toronto, Ontario M5E 1J4</p> <p>Active members in Canada 134 Members outside Canada 7 Student Members 12 Total 153</p>	<p>To promote mining geophysics, to encourage the flow of information between mining geophysicists, (broadly defined) engaged in research sales and use of mining geophysical services and equipment, to speak for this diverse group when possible in representation to governments on matters directly involved in the performance of mining geophysics, to promote high professional standing and fellowship among its members.</p>	<p>- Eight meetings (85), all business/technical are held on the second Tuesday of each month from October to May. A committee (3) is receiving suggestions on metric conversion, particularly with regard to mining geophysical surveys.</p>	<p>No formal journal. Abstracts, summaries and complete papers of talks given to KEGS are appended to the monthly notice of meetings and announcements mailed to all members.</p>
<p>CANADIAN GEOPHYSICAL UNION c/o Dr. R. F. Mereu (Secretary-Treas.) Department of Geophysics University of Western Ontario London, Ontario N6A 3K7</p> <p>Active membership in Canada 291</p>	<p>To advance the science of geophysics and to promote a better understanding thereof throughout Canada.</p>	<p>- Inaugural Symposium, Ottawa, 22 February 1974 (100) - Symposia (with CAP), 10-13 June 1974, St. John's (50) - Symposia (with GAC), May 1975, Waterloo (100) - Symposia (with CAP), June 1975, York (50)</p> <p>SUBDIVISIONS: Gravity, Seismology, and Physics of the Earth's Interior; Exploration Geophysics; Geomagnetism, Geochronology and Stable Isotope Studies; Geodesy; Mathematical Geophysics.</p>	<p><u>Canadian Geophysical Bulletin</u></p>
<p>CANADIAN GEOTECHNICAL SOCIETY c/o Mr. N. E. Wilson (Secretary) 2050 Mansfield Street, Montreal, P. Q.</p> <p>Members C. G. S. only 158 Eng. Ins. of Canada members 441 Total 599</p> <p>C. G. S. - E. I. C. members are usually engineers by training C. G. S. - only members may include those holding membership in another professional or learned society or having a university degree or its equivalent.</p>	<p>To stimulate activities and cooperation among engineers and other professionals for the advancement of knowledge in the geotechnical field in Canada. This includes the study of the properties of soil, rock, muskeg, snow and ice, the influence of environmental factors on such properties and the application of this knowledge in practice.</p>	<p>- 28th Annual Canadian Geotechnical Conference, Montreal - 8-10 October 1975 included annual business meeting and presentation of annual awards (290) - One session of Annual Congress of Engineering Institute of Canada arranged by C. G. S. - Board of Directors met twice - Local sections met approximately 9 times per year for technical sessions.</p>	<p><u>Canadian Geotechnical Journal</u> published by National Research Council is part of membership fees. Society Newsletter is circulated every other month.</p>

TABLE V (cont.)

AWARDS	BRIEFS AND POSITION PAPERS	ASSOCIATION WITH OTHER ORGANIZATIONS Canadian and (Non-Canadian)	OTHER INFORMATION
Constitution provides for Honorary Members	AEG has taken the position of defining the qualifications of the professional Exploration Geochemist and its distributing this information to membership. This definition will be used in future presentations to licensing bodies in an attempt to establish an equitable and satisfactory standard of professionalism in exploration geochemistry on a world-wide basis.	Canadian Geoscience Council	<p>The Association of Exploration Geochemists (AGE) was founded in 1970. The Association organized its first major meeting—the Fifth International Geochemical Exploration Symposium—in Vancouver in 1974. It had organized the Fourth Symposium in collaboration with the Institution of Mining and Metallurgy in London (U. K.) in 1972, and founder members of the AEG helped organize the First Symposium (Ottawa, 1966), the Second Symposium (Golden, Colorado, 1968) and the Third Symposium (Toronto, 1970) under the auspices of other organizations.</p> <p>The strength of the Canadian membership and the status of exploration geochemistry in Canada is indicated by the fact that five of the six presidents and approximately one-half of the Council members to date are Canadian-based geochemists.</p>
— <u>Don Salt Memorial Scholarship</u> is awarded the most promising third and fourth year students in geology or geophysics at the University of Toronto.	— None in 1975	Canadian Geoscience Council Society of Exploration Geophysicists	KEGS was formed June 8, 1953 by a small nucleus of mining exploration geophysicists in Toronto. Members probably represent, by their employment 90% of the mining exploration in Canada. Approximately 1/4 of the members now reside outside Toronto with members living in most provinces of Canada and as far abroad as South Africa.
		<ul style="list-style-type: none"> — Joint Division of the Geological Association of Canada and the Canadian Association of Physicists. — Canadian Geoscience Council. 	
<ul style="list-style-type: none"> — <u>R. F. Legget Award</u> to an individual for significant achievements to Canada in the field of geotechnical engineering; not given every year. — <u>Society Prize</u> awarded annually for the best paper published in the Canadian Geotechnical Journal. 		<ul style="list-style-type: none"> Canadian Geoscience Council Constituent Society of E. I. C. Close links with NRC Associate Committee on Geotechnical Research — (jointly with ACGR forms Canadian Section of International Society for Soil Mechanics and Foundation Engineering). — (Engineering Geology Division associated with International Association of Engineering Geology). 	12 local sections of CGS exist at major cities and are partially supported by a rebate from Headquarters. An Engineering Division was formed this past year.

TABLE V (cont.)

SOCIETY AND MEMBERSHIP	OBJECTIVES	MEETINGS, ACTIVITIES AND COMMITTEES (attendance in parentheses)	PUBLICATIONS
CANADIAN INSTITUTE OF MINING AND METALLURGY c/o E. G. Tapp (Executive Director) No. 906-1117 Ste. Catherine St. W. Montreal, Quebec H3B 1J3 Total CIM membership 11 000 In Geology Division 2 750	(Geology Division) To stimulate and advance the application of geology, geophysics, and geochemistry in the exploration for, and development and exploitation of, mineral resources by arranging technical discourses, lectures, and discussions; by publication of technical papers; by sponsoring field excursions; and by the promotion and encouragement of research and education in the earth sciences.	- 77th Annual General Meeting; Toronto; May 4-8 (2262) - 26th Annual Technical Meeting, Petroleum Society of CIMM; Banff, Alta; June 11-13 (700) - 14th Annual Conference of Metallurgists; Metallurgical Society of CIM; Edmonton; August 24-27 (415) - 27th Canadian Conference on Coal; co-sponsored by CIM Coal Division; Vancouver; September 23-26 (800) - 5th Annual Hydrometallurgical Meeting; Sudbury; October 5-8 (190) - Annual Western Meeting, CIM; Edmonton; October 26-29 (710) - Field Trip, Geology Division - Uranium Deposits of Saskatchewan; September 12-13 (35) - Numerous Branch Meetings COMMITTEES (Geology Division): Publications; University Visiting Lecturers; Technical Program; Barlow Memorial Medal; Mineral Deposits Research; Student Essays; Geophysics; Geochemistry; Distinguished Lecturers; Program Policy; GAC-SEG Liaison; Nominating.	The Canadian Mining and Metallurgical Bulletin (CIM Bulletin) - monthly The Journal of Canadian Petroleum Technology - quarterly The Canadian Metallurgical Quarterly - quarterly The CIM Directory - yearly Special Volumes - 14 to date
CANADIAN ROCK MECHANICS GROUP c/o Dr. W. M. Gray (Secretary-Treas.) Canada Centre for Mineral and Energy Technology 555 Booth Street, Ottawa, Ontario K1A 0G1 Individual members 138 Supporting members 11 Total 149	To develop the subject of rock mechanics, to coordinate research activities and to provide lines of communication between interested organizations and individuals.	SUBCOMMITTEES: Foundations, Subsidence, Rock Mechanics Exploration, Rock Breakage, Mine Fill, Geomechanics, Rock Mechanics Instrumentation, Slope Stability, Symposium Organizing, Award Panel. Technical Seminar and Symposium, 2-4 September, 1975 (130).	Newsletter, 3 or 4 per year to members only.
CANADIAN SOCIETY OF EXPLORATION GEOPHYSICISTS P. O. Box 117 Calgary, Alberta T2P 2G9 Active membership 1200+ Honorary and corporate members	To promote the science of geophysics especially as it applies to exploration in the fields of petroleum, mining, and groundwater, and to promote fellowship and cooperation among those persons and organizations	- One General Meeting per year (500) - One Executive (10), and one or more Technical Meetings per month (200) - One National Convention per year (500) COMMITTEES. Approximately 25 committees administer the professional technical and social affairs of the Society. - Registered Scholarship Fund to administer scholarships to deserving students.	Journal of the Canadian Society of Exploration Geophysicists - published annually on a regular basis plus special editions. Monthly newsletter.
CANADIAN SOCIETY OF PETROLEUM GEOLOGISTS c/o Mr. H. J. Stewart (Secretary) 612 Lougheed Building Calgary, Alberta T2P 1M7 Active members in Canada 1890 Active members - foreign 99 Associate members 45 Student members 18 Honorary members 84 Emeritus members 2 Total 2138 Corporate members 75	To advance the science of geology especially as it relates to fossil fuels; to promote the technology of exploration for these resources; to foster scientific research, to disseminate relevant information; to inspire and maintain a high standard of professional conduct.	- Annual Meeting (300) - Technical Meetings, 17 luncheon meetings (avg. 350) - Technical Symposia, two, one co-hosted with the Canadian Society of Exploration Geophysicists (1455) and a Geological Field Conference to South Western Alberta (Est. 75) COMMITTEES: Membership, Technical Program, Medal and Merit, Link Award, Geological Research, Stratigraphic Nomenclature, Discipline, Printing, Palaeontology Div., Structural Geology Division, Geochemistry Division, Geomathematics Division, Coal Division, 1976 CSPG/CIM Convention Committee, 1978 International Convention Committee. Approximately 40 special committees administer business, social and technical functions as well as liaison with other organizations.	Bulletin of Canadian Petroleum Geology - quarterly Reservoir - monthly newsletter Symposia and Memoirs on special subjects Field trip guide books

TABLE V (cont.)

AWARDS	BRIEFS AND POSITION PAPERS	ASSOCIATION WITH OTHER ORGANIZATIONS Canadian and (Non-Canadian)	OTHER INFORMATION
<p>CIM awards pertaining to Geology Division: <u>Distinguished Lecturer Award</u>, <u>Barlow Memorial Medal Prize</u>, <u>Student Essay Awards</u> and the <u>President's Gold Medal</u></p>		<p>Canadian Geoscience Council Canadian Standards Association (World Mining Congress) (Council of Commonwealth Mining and Metallurgical Institutions) (A. I. M. E. Council of Economics) Mining Society of Nova Scotia</p>	<p>The Geology Division is an integral part of CIM which is a technical society covering the entire range of mining and mineral processing technology. In addition to those in Geology Division, many geoscientists belong to other CIM Divisions and Societies, notably the Coal Division, the Industrial Minerals Division and the Petroleum Society. Large numbers of others participate in the activities of the 54 Branches.</p>
<p>- Annual competition for <u>best Canadian paper on applied rock mechanics</u> within the preceding three years.</p>		<p>Canadian and (Non-Canadian) Canadian Geoscience Council (The Canadian Rock Mechanics Group is the Canadian National Chapter of the International Society for Rock Mechanics).</p>	<p>The Canadian Rock Mechanics Group is administered by the Canadian National Committee on Rock Mechanics.</p>
<p>- <u>Best Paper Award</u>, <u>Honorary Membership</u> - <u>Student Scholarships</u></p>	<p>Annual reports to National Research Council Associate Committee on Geodesy and Geophysics Semi-Annual reports to both Provincial and Federal governments on Geophysical Activity in Canada Semi-Annual reports to both Provincial and Federal governments on seismic crew availability Annual reports to Provincial and Federal governments on geophysical data trading in Canada Annual report to Provincial and Federal governments on geophysical data processing in Canada Position papers as required.</p>	<p>Canadian Geoscience Council Association of Professional Engineers, Geologists and Geophysicists of Alberta Canadian Exploration Geophysical Society (As to statistics) Other geological, mathematical and physics Societies as to joint meetings (Society of Exploration Geophysicists) (World Petroleum Congress)</p>	<p>Was joint host (with Canadian Society of Petroleum Geologists) of "Exploration Update '75" a national convention Will host the Society of Exploration Geophysicists' International Convention in September, 1977.</p>
<p>- <u>Medal of Merit</u>, annual for best published paper related to geology of sedimentary areas of Canada. - <u>Link Award</u>, annual for best oral presentation of geological paper to the society by one of its members. - <u>Research and Graduate Student Awards</u> for postgraduate theses of merit. - <u>Undergraduate Award</u>, a certificate awarded to one undergraduate from each of the 34 degree-granting institutions in Canada for outstanding competence in petroleum geology or related fields. - <u>Western Inter-University Award</u>, annual for best oral presentation by a student at the Western Inter-University Geological Conference.</p>		<p>Canadian Geoscience Council Saskatchewan Geological Society Association of Professional Engineers, Geologists and Geophysicists of Alberta (American Association of Petroleum Geologists) (World Petroleum Congress)</p>	

TABLE V (cont.)

SOCIETY AND MEMBERSHIP	OBJECTIVES	MEETINGS, ACTIVITIES AND COMMITTEES (attendance in parentheses)	PUBLICATIONS
<p>CANADIAN SOCIETY OF SOIL SCIENCE c/o Dr. G. Wall, Department of Soil Science Guelph University Guelph, Ontario</p> <p>Total membership 354 Active in Canada 314 Honorary 17 Total 685</p>	<p>To foster all branches of soil science: to provide a forum to enable soil scientists to make known their views on matters pertaining to earth science: to voice concern over use of earth materials as a vital continuing natural resource in Canada.</p>	<p>- Annual Business Meeting Brandon, Manitoba. June 25, 1975 - Three Technical Sessions 23-25th June, 1975 - Two Council Meetings February and June, 1975 COMMITTEES: Journals, Awards, International Activities, Rules. SUBCOMMITTEES: Ad hoc committees for resolutions, collecting of data on members professional interests.</p>	<p>Canadian Journal of Soil Science Three issues per year. Average pages per issue. 150</p>
<p>CANADIAN WELL LOGGING SOCIETY c/o Secretary P. O. Box 6962, Postal Station D Calgary, Alberta T2P 2G2</p> <p>Active members 290 Honorary members 5 Corporate members 15 (about 5-10% eligible are members, most from the Calgary area)</p>	<p>To further the science of formation evaluation by providing regular meetings with discussion of related subjects and encouraging research and study.</p>	<p>- nine Luncheon Meetings (avg. 116) - Annual Meeting in February (75) - nine Executive Meetings - Fifth Formation Evaluation Symposium, held in Calgary, May 1975 COMMITTEES: Membership, Publication Sales, CWLS Journal Editor and Business Manager, Nominating, Award, 1977, Formation Evaluation Symposium Organizing, Water Resistivity Catalogue, Well Log Standards.</p>	<p>The CWLS Journal - annually CWLS Symposium transactions - published occasionally, next - 1977 Formation Water Resistivity Catalog - published occasionally revision in 1975 Guide on Metric Conversion for Well Logs</p>
<p>GEOLOGICAL ASSOCIATION OF CANADA c/o Dr. A. V. Morgan (Secretary) Department of Earth Sciences University of Waterloo, Waterloo, Ontario N2L 3G1</p> <p>Fellows: 1709 Associates 717 Honorary members 8 2434 Corporate members 82 2516</p>	<p>To advance the science of geology and closely related fields of study and to promote a better understanding thereof throughout Canada.</p>	<p>- Annual Meeting, May 1974, St. John's (705) - Annual Meeting, May 1975, Waterloo (1,213) - Council and Executive Meetings, Sections and Divisions meet independently COMMITTEES: Finance, Programme, Projects Membership, Editorial, Public Information, Professional Status, Status of Women, Education, Logan Medal, Past-Presidents' Medal</p>	<p>Geolog - Newsletter published quarterly Geoscience Canada - published quarterly Special Papers - Thirteen so far in series. Canadian Journal of Earth Sciences - published by National Research Council and included in GAC membership fees.</p>
<p>MINERALOGICAL ASSOCIATION OF CANADA c/o Secretary, Department of Mineralogy and Geology, Royal Ontario Museum 100 Queen's Park, Toronto, Ontario M5S 2C6</p> <p>Ordinary members 672 Life members 24 Student members 147 Corporate members 665 Sustaining members 35 Total membership 1543</p>	<p>To advance the knowledge of mineralogy, crystallography, petrography, geochemistry, economic geology and allied disciplines of the earth sciences.</p>	<p>- Executive Committee Meetings, March, May, September, November 1975 - Technical Meetings, May 1974 (St. John's) and May 1975 (Waterloo) - Business Meeting, May 1974 and May 1975 COMMITTEES: Finance, Membership, Nominating, By-Law Revision, Hawley Award and Standing Committees for Canadian Geoscience Council Annual Reports.</p>	<p>Canadian Mineralogist - quarterly newsletter -- semi-annually</p>

TABLE V (cont.)

AWARDS	BRIEFS AND POSITION PAPERS	ASSOCIATION WITH OTHER ORGANIZATIONS Canadian and (Non-Canadian)	OTHER INFORMATION
<p>– <u>Fellowship Award</u>, Fellow of the Canadian Society of Soil Science</p> <p>– CSSS has input into various Agricultural Institute of Canada awards, Royal Bank Award, and Ministry of State for Science and Technology award in Agriculture and Technology.</p>		<p>Agricultural Institute of Canada – affiliated, joint meetings and office services</p> <p>Canadian Geoscience Council</p> <p>SCITEC</p> <p>Canadian Society of Agronomy (International Soil Science Society (1978 ISSS Congress to be hosted by CSSS)</p> <p>(North East Section, American Society of Agronomy)</p>	
<p><u>President's Award</u> (\$500) for best paper in formation evaluation. First presentation expected in 1976.</p>		<p>Canadian Geoscience Council</p> <p>Annually a joint luncheon meeting is held with the Petroleum Society of CIM</p> <p>(Society of Professional Well Log Analysts – U. S. A.)</p>	
<p>– <u>Logan Medal</u>, annual for outstanding contributions to the Earth Sciences.</p> <p>– <u>Past President's Medal</u>, annual for a single outstanding achievement in the Earth Sciences.</p> <p>– <u>Youth Science Foundation</u>, two awards given annually for the best Earth Science exhibits at National Science Fair.</p>	<p>A report has been completed on the Status of Women Geoscientists in Canada. This will be published as an Information Circular of GAC.</p>	<p>Canadian Geoscience Council; SCITEC: Joint Annual meetings with Mineralogical Association of Canada and bi-annually with the Canadian Geophysical Union.</p> <p>Annual Meetings are frequently organized with other associations, 1975 the North Central Section of Geological Association of America; 1977 the Society of Economic Geologists; 1978 the Parent Body of the Geological Society of America, (American Commission on Stratigraphic Nomenclature); (World Petroleum Congress).</p>	<p><u>Divisions of GAC:</u> Environmental Earth Sciences, Geophysics (Canadian Geophysical Union), Paleontology, Structural Geology, Volcanology, Regional Sections of GAC exist in Edmonton, Newfoundland, Winnipeg and Vancouver (Cordilleran).</p>
<p><u>Hawley Award</u> – presented annually to the author(s) of the best paper printed in the Canadian Mineralogist during the preceding year.</p>		<p>Joint meetings with Geological Association of Canada</p> <p>Canadian Geoscience Council (International Mineralogical Association)</p> <p>(Joint Committee on Powder Diffraction Standards)</p> <p>(Joint meetings with Mineralogical Society of America).</p>	<p>It is interesting to note that of the ordinary membership, approximately 45% is in Canada, 40% in the U.S. and 15% in other countries.</p>